Behavioral motivations for self-insurance under different disaster risk insurance schemes

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Abstract

This paper presents a lab-in-the-field experiment with 2111 Dutch homeowners in floodplain areas to examine the impacts of financial incentives and behavioral motivations for self-insurance under different flood insurance schemes. We experimentally varied the insurance type (mandatory public versus voluntary private) and the availability of a premium discount incentive for investing in flood damage mitigation measures. This set-up allowed us to examine the existence of moral hazard, advantageous selection and the behavioral motivations of individual agents who face these different insurance types, without the selection bias that makes a causal inference from survey studies problematic. The main results show that a premium discount can increase investments in self-insurance under both private and public insurance. Moreover, we find no support for moral hazard in our natural disaster insurance market, but we do find a substantial share of cautious people who invest both in private insurance as well as in self-insurance, indicating advantageous selection. The results have implications for the design of insurance schemes to cope with increasing natural disaster risks.

Keywords: Self-insurance, Homeowners, Lab-in-the-field experiment, Disaster damage reduction, Flood preparedness

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1 Introduction

The impacts of natural hazards on society have increased in the past decades and are expected to increase further in the future, as a result of climate change as well as population and economic growth in disaster prone areas (IPCC, 2012; Munich RE, 2018). Of all weather-related disasters, flooding is considered to have the largest consequences both in number of people affected and in total economic cost (UNISDR, 2015). As a response to this problem, researchers have investigated potential risk reduction strategies, such as flood protection infrastructure like dikes (Kreibich et al., 2015) and disaster risk insurance schemes (Michel-Kerjan, 2010; Kunreuther, 2015; Hudson et al., 2016). In the EU, a variety of arrangements exist in member states for compensating flood losses, including public insurance which is often mandatory and private market insurance which is often voluntary (Schwarze et al., 2011; Paudel et al., 2012). In various countries it has been debated whether these arrangements should be reformed to provide policyholders stronger incentives to limit the risk. Stimulating individuals to invest in self-insurance - defined as measures that reduce the size but not the probability of a loss (Ehrlich and Becker, 1972) - is an additional promising approach in the attempt to decrease expected damages from natural disasters (Den et al., 2017).

In the case of flood risk, various cost-effective measures can be taken by private homeowners to prevent flood damage. These measures fall into three broad categories: dry flood proofing (shielding a house to prevent water from entering), wet flood proofing (minimizing damage once water has invaded a house), and the elevation of structures. However, investments in self-insurance by individual homeowners are still rare, even though these measures can be cost-effective (Bubeck et al., 2012; Poussin et al., 2015).

There are three main explanations for low investments in self-insurance: namely, the availability of insurance, the features of insurance, and the behavioral characteristics of individual agents. A behavioral explanation for low investments in self-insurance in the context of flood risk is that individuals have difficulties understanding low-probability high-impact (LPHI) risks, such as flood risk, and underestimate these risks when they do not personally experience such disasters (Kunreuther and Pauly, 2004). They might only respond to the risk when a certain threshold level of concern is reached (McClelland et al., 1993) or generally underweight the probability in their insurance decision. Such underweighting of risk can be accommodated by Prospect Theory (Kahneman and Tversky, 1979), which is a frequently used model for decisions under risk that has been used to explain behavior related to natural disasters (Page et al., 2014; Koetse and Brouwer, 2016). Under Prospect Theory, risk attitudes are defined by a combination of utility curvature, loss aversion and probability weighting. While a large existing literature has examined probability weighting of LPHI risks and loss aversion (see e.g. Barberis, 2013), the current paper focuses on the influence of insurance and financial incentives on individual investments in self-insurance.

Other behavioral explanations include incorrectly high perceived costs of implementing self-insurance measures, a present bias that leads to procrastination of long-term investments or a potential moral hazard effect arising from insurance (Michel-Kerjan, 2010). Economic theory predicts that individuals invest less in self-insurance under insurance coverage, unless they are incentivized to make such investments through premium discounts (Ehrlich and Becker, 1972). However, individuals may respond differently to insurance features, such as a premium discount, when the insurance offered is mandatory (public insurance), rather than voluntary (market insurance), which is nearly impossible to study with non-experimental data. Furthermore, the results provided in Cutler et al. (2008) suggest that less risk reducing behavior is associated with lower insurance take-up, which could be due to low risk aversion. Similarly, de Meza and Webb (2001) showed that highly risk averse individuals tend to purchase insurance and also take other measures to limit risks. The importance of the role of risk preferences is also recognized by Corcos et al. (2017) who conduct a lab experiment on the conditional demand for insurance under premium variations, while controlling for risk preferences. In our study, we investigate the influence of financial incentives and behavioral motivations on the level of self-insurance against LPHI risk.

The current paper focuses on incentives for self-insurance in the domain of flood risk, both in the presence and absence of flood risk insurance, to offer insights into all three categories of explanations. A large online experiment with homeowners in floodplain areas was conducted. The homeowners were randomly assigned to face either a public or private insurance scheme, which rules out potential endogeneity bias. In the field, different types (e.g. with regards to risk attitudes and self-insurance) may have access to different types of insurance schemes, which makes it difficult to make correct causal claims about the effect of a typical insurance scheme on investments in self-insurance. Homeowners in the river delta in the Netherlands with relatively high flood probabilities seem to be a suitable sample to study flood risk mitigation of households. To the best of our knowledge we are the first to study self-insurance behavior experimentally under both public and private insurance schemes, accounting for both insurance features and behavioral characteristics of the decision-makers. Furthermore, we use a large sample size such that the group of respondents who self-select into insurance coverage will be large enough to make valid comparisons with the publicly insured experimental subjects.

The main results show no difference in self-insurance investments between respondents with public (mandatory) versus private (market) insurance. With regards to the features of insurance, we find that a premium discount increases investments in self-insurance under both private and public insurance. Moreover, we find no support for moral hazard in our natural disaster insurance market, but we do find a substantial share of cautious people who invest both in private insurance as well as in self-insurance, indicating advantageous selection. These cautious people take their investment decision consciously and are primarily motivated by the efficacy of mitigation measures, social norms and risk aversion, as well as by a lower trust in dike maintenance.

The remainder of this article is organized as follows: Section 2 gives a short overview of the literature on behavioral insurance in the low probability context, Section 3 describes the experimental design, Section 4 derives hypotheses for each of the treatments. Finally, Section 5 presents results, Section 6 discusses the results and their implications and concludes.

2 Literature review

A growing body of empirical research has examined factors contributing to private self-insurance decisions and preventive behavior in the context of natural disaster risk. In this section, we briefly review the papers most relevant to our study (for more detailed literature reviews see Bubeck et al., 2012; Koerth et al., 2017).

2.1 Presence of insurance

Insurance companies generally do not expect policyholders to self-insure, due to the existence of information asymmetries between the insurer and the insured. This implies risk reduction behavior of policyholders is not observed by insurers and hence not reflected in premiums (Arrow, 1963; Arnott and Stiglitz, 1988). In theory, such a moral hazard effect removes individuals' motivation to self-insure if they have insurance coverage, as they expect to be compensated in case of damage irrespective of their risk reduction efforts. In this case the expected benefits of self-insurance remain at the insurer level. The moral hazard effect has been studied empirically in different insurance markets and appears to vary with the type of insurance product and the magnitude of asymmetric information (Cohen and Siegelman, 2010). For example in the health insurance market, Einav et al. (2013) identified an ex-post moral hazard effect in data of insurance coverage and medical spending of a large U.S. company. In contrast, Chiappori and Salanié (2000) found no evidence for moral hazard in the automobile insurance industry. If the asymmetric information involves private information on the side of the policyholder about the probability of loss, it is essential that this information is correctly understood to be of any advantage to the policyholder.[1] Moreover, as shown by de Meza and Webb (2001) behavioral characteristics can explain why a moral hazard effect may not occur, for example, when people who are highly risk averse purchase insurance and also take other measures to limit risks. This has been demonstrated in the U.S. long term care insurance market, where individuals with more insurance coverage were on average not higher risk (Finkelstein and McGarry, 2006).

Previous work in the domain of natural hazards found no moral hazard effect using statistical methods to analyze survey data of flood insurance coverage and the implementation of flood risk reduction measures in Germany and the United States (Hudson et al., 2017). The empirical analyses by Carson et al. (2013) have found no evidence for a substitution effect between self-insurance and market insurance to protect homes in Florida against storms. Petrolia et al. (2015) surveyed homeowners in coastal areas of the United States and found no moral hazard effect either: the same respondents who buy wind insurance also invest more in wind risk mitigation. Likewise, Osberghaus (2015) showed that German individuals who think they have flood insurance coverage are also more likely to invest in flood risk mitigation measures. While the high external validity of field survey data is very valuable, the disadvantage of this type of empirical research is that it is hard to find

[1] In the automobile insurance example, drivers have private information about their personal driving skills. However, if a large majority (mistakenly) thinks their driving is extraordinarily safe compared to others, the private information about risk is less accurate. This inaccurate private information may explain why the correlation between coverage and risk is not universally present across insurance markets (Cohen and Siegelman, 2010).

causal relationships, as different insurance plans are not allocated randomly to homeowners. Moreover, these survey studies were not able to identify the behavioral mechanisms that may explain why a moral hazard effect was absent (Hudson et al., 2017).

2.2 Features of insurance

The moral hazard problem is often dealt with by shifting part of the risk to the policyholder, for instance by introducing a deductible. A deductible is thus an example of a financial incentive to stimulate self-insurance. Furthermore, it has been proposed that risk-based premiums could encourage investments in self-insurance by offering premium discounts to policyholders who limit flood risk to their property (Kunreuther, 1996; Botzen and van den Bergh, 2008; Kleindorfer et al., 2012). Such incentives towards self-insurance are common in health insurance, for example when policyholders are stimulated by financial incentives to increase physical activity or quit smoking (see Tambor et al. (2016) for a review). Previous empirical research based on hypothetical stated preference survey data suggests that a premium discount may affect homeowners' decisions to invest in low cost flood mitigation measures (Botzen et al., 2009b).

A higher level of control can be accomplished by a (quasi-)experimental design. So far, little experimental research has been conducted on incentives for individual damage reduction in a flood insurance context, which is characterized by low probabilities and high expected damages. An exception is Mol et al. (2018), who studied the impact of different mandatorily public flood insurance schemes and related financial incentives on risk reduction behavior in a controlled lab experiment with mainly students as participants (N=357). The results showed that investments in damage reduction increased with higher probabilities of loss, higher deductibles and a premium discount. Interestingly, moral hazard was found to be less of a problem in the scenarios with low probabilities of loss.

Although this design had a high degree of control, one drawback is that students are not representative of the decision makers in the flood insurance context. For example, students are inexperienced with the purchase of homeowners insurance and their individual characteristics (such as risk attitudes and time preferences) may differ from the population. Moreover, Mol et al. (2018) did not examine self-insurance in the context of voluntary private insurance, like we do here.

2.3 Behavioral motivations for self-insurance

A commonly examined behavioral motivation to decide upon precautionary action in general is risk attitude. For example, Cutler et al. (2008) analyzed the relationship between risk aversion, risk reducing activities and insurance purchases in five different types of insurance markets. The authors demonstrated that less risk reducing behavior was associated with lower insurance take-up and argue that this is due to low risk aversion. More recently, Corcos et al. (2017) examined the premium sensitivities in demand for insurance, both theoretically and experimentally. They found that an increase in premiums causes risk loving subjects to leave the market, while the conditional demand (the level of coverage demanded) does not change. Their careful examination of the risk loving types indicated that this behavior is related to gambling and opportunism. In the context of natural disaster insurance markets, Hudson et al. (2017) provided evidence that individuals with insurance-coverage in these markets were more likely to have undertaken disaster preparations, although the role of risk aversion was not examined directly in that study.

Considering that self-insurance in our flood risk context is often a large lump-sum investment with expected benefits spread over a time-span of about 25 years into the future, time preferences might also influence the decision to self-insure (see e.g. Michel-Kerjan, 2010; Kunreuther and Michel-Kerjan, 2015). Other behavioral motivations are more focused on the self-insurance measures themselves, such as response efficacy, response cost and self-efficacy of these measures, where the latter refers to the subjective feeling of being able to install the measures in practice. Grothmann and Reusswig (2006) showed that coping appraisal, and in particular a combination of high response efficacy, low response costs and high self-efficacy, positively influences precautionary action against flooding.

An interesting behavioral motivation for preventive behavior is the psychological construct internal locus of control, which refers to the trade-off between one's own efforts and external factors (e.g., fate) in determining life outcomes. Individuals with an internal locus of control feel more inclined to take protection in their own hands. Locus of control has been shown to impact hurricane preparedness in the U.S. (Sattler et al., 2000), but also in preventive health behaviors (Conell-Price and Jamison, 2015). Furthermore, investments in self-insurance could be motivated by emotional factors, such as high worry of flooding (Bubeck et al., 2012) and anticipated regret about not prevented or uninsured losses (Krantz and Kunreuther, 2007).

Finally, the behavior of others may be an important behavioral motivation to take action against flood risk (van der Linden, 2015). Social norms concern expectations of what others think one should do ('prescriptive social norms'), what others would approve ('injunctive social norms') or what is typically done ('descriptive social norms') (Cialdini and Goldstein, 2004). Social norms have been shown to have a positive influence on behavioral intentions across domains (Doran and Larsen, 2016; Nyborg et al., 2016) and with the visible construction works to flood-proof a house, individuals might well be influenced by their personal environment (e.g. family, friends, neighbors) to invest in self-insurance themselves.

3 Experimental design

Individual flood preparedness decisions may be largely influenced by individual risk attitudes and perceptions that are specifically related to flooding, such as worry about floods, flood risk perceptions due to climate change, social norms regarding mitigation measures and response efficacy of these measures. Such perceptions may differ substantially between student samples and homeowners in flood-prone areas. To measure the effects of these behavioral motivations for flood risk reduction, a large sample of inhabitants of flood-prone areas is needed. A large sample size also allows for an analysis of investments in risk reduction in (voluntary) market insurance, as it is expected that a small fraction of participants are willing to pay the premium for insurance against low probability flood risk. Selection into private market insurance might be affected by the anticipated behavioral response to insurance; risk and/or loss averse individuals with a high risk perception who expect to claim more under insurance coverage might be willing to pay more for insurance coverage (Einav et al., 2013). Such individuals may also invest more in risk reduction measures, even if they have insurance coverage. A treatment with voluntary insurance would allow for a comparison between self-insurance decisions of mandatory insured individuals and voluntarily insured individuals. Preferences for insurance, risk tolerance and private information about risk could contribute independently to the decision to self-select into insurance (Cutler et al., 2008). Relating the individual characteristics of these voluntarily insured people helps to understand why some cautious people insure and perhaps also take other measures to reduce risks, while others do not insure nor reduce risk at all.

We intended to do a large experiment to examine homeowners' investments in damage reduction under different insurance conditions (exogenous variation) and behavioral characteristics (endogenous variation). However, due to large travel costs and higher incentives to convince individuals to participate, it would be very costly to invite large groups of homeowners to the lab. Moreover, a selection effect might be unavoidable with such a lab experiment, when the type of participants (those willing to travel) is related to one of the individual variables of interest. To address these concerns, a short experiment was embedded in a survey and conducted online. The survey consisted of 30 questions that examined flood experience, flood risk perception, response efficacy of mitigation measures, social norms with regards to flood protection, related insurance purchases and demographic data.

The survey questions were based on surveys about flood risk perceptions and flood preparedness decisions in Canada, Germany, the U.S. and the Netherlands (Thistlethwaite et al., 2018; Bubeck et al., 2013; Botzen et al., 2015, 2009b). While risk and time attitudes may be measured with incentive-compatible experimental tasks, these tasks are often too costly and complex to perform in surveys among a large, representative sample. Recent studies have addressed this problem by investigating the predictive power of qualitative survey items that elicit risk and time attitudes on behavior in paid real-stakes lotteries in representative and cross-cultural samples (Dohmen et al., 2011; Vieider et al., 2015). These studies found that the (non-incentivized) survey measures have approximately similar descriptive power in explaining risk and time preferences compared with the incentive-compatible experimental tasks. Furthermore, recent evidence indicates that the survey measure of risk attitudes correlates with risky behavior outside the lab, such as geographical mobility and occupational choice (see e.g. Fouarge et al., 2014; Bauernschuster et al., 2014). As we faced similar time and complexity constraints as other surveys, we adopted the qualitative survey instruments of Falk et al. (2018) to assess risk and time preferences in our survey. The survey question used to elicit risk attitudes was "In general, are you a person who is willing to take risks?" and the answers ranged from 0 (= completely willing) to 10 (= completely unwilling). The question used to assess present biased time preferences was "In general, are you willing to give up something now in order to profit from that in the future?" where the answers ranged from 0 (= completely willing) to 10 (= completely unwilling). In addition, we used the number of insurances held by a respondent[2] as a proxy variable for risk aversion in the insurance domain. For instance, Botzen and van den Bergh (2012) find that the number of insurance held by Dutch homeowners positively relates to their demand for flood insurance. The self-reported voluntary health insurance deductible is included as a proxy variable for risk seeking attitudes in the insurance domain. In the Netherlands, citizens have a mandatory deductible of €385 per year for their health insurance. Beyond this mandatory deductible, individuals may opt for an additional voluntary deductible of €100, €200, €300, €400 or €500 in exchange for a premium discount. A voluntary health insurance deductible might indicate risk seeking in the insurance domain (Dillingh et al., 2016).

A clear advantage of these revealed preferences questions is that they involve real life outcomes with high stakes. A potential drawback is that these insurance decisions may be affected by other factors, which may lead to unobserved heterogeneity in preferences. A detailed overview of all other questions used in the statistical analysis (including their coding) can be found in Appendix A.

The investment game was a simplified and translated version of a previous lab experiment (Mol et al., 2018) and was embedded in the middle of the survey questions. The currency used in the investment game was ECU (Experimental Currency Units). All respondents were paid a fixed participation fee of 62,000 points[3] (equivalent to approximately €1), while one participant was randomly selected for a large payment. This payment corresponded to the participant's bank balance at the end of the main scenario at a conversion rate of

[2] Continuous variable. Total number of boxes checked in the question "Which insurance(s) do you hold at the moment?" (Appendix C, question 17).

[3] These points refer to the currency of the survey company and they are not related to our experimental currency units.

100 ECU = €1, which could be up to €650. The online experiment was preregistered.[4]

3.1 Investment game

In the investment game, respondents were asked to imagine owning a house in a floodplain for the next 25 years[5] and a savings balance of 65000 ECU. All payments in the game were subtracted from this balance. A scenario started with instructions (see Supplementary Material) and the introduction of the parameters: the yearly flood probability (1%), the maximum damage to the participant's house in case of flooding (50,000 ECU), the savings balance (65000 ECU) and whether flood risk insurance was available ("No"/"Yes, with 5% deductible").

Table 1: Investment options in ECU.

Investment	0	1000	5000	10,000	15,000
Reduced damage	50,000	45,242	30,327	18,394	11,157
Discount on yearly premium[6]	0	49	190	304	373

Figure 1 shows the first page (*Investment*) of a scenario: respondents could choose to invest in damage reduction measures with accompanying benefits in terms of a reduced damage from flooding and a premium discount in case they are in the Premium Discount treatment (see Table 1). Next, the *Pay premium* page was shown to individuals in the Insurance treatments: here the actuarially fair premium was (automatically) paid from their savings balance for all 25 years at once. The *Flood risk result* page showed a grid with 100 houses, where the house of the participant was indicated with a square. All houses flooded (according to the yearly 1% flood probability) at least once in the 25 years of the scenario were highlighted in blue. In case a participant's house was one of these, the

[4]See the AEA RCT Registry entry: `https://www.socialscienceregistry.org/trials/2966/`.
[5]In 25 years, most flood damage mitigation measures are cost-effective, see Poussin et al. (2015).
[6]Only in the Premium Discount and Voluntary + Discount treatments.

deductible (or damage in the No Insurance treatment) was paid from the savings balance. Finally, the *Overview of results* page showed the history of the savings balance (65000 ECU - premiums - deductible/damage - investment). The scenario covered 25 years, but decisions were made only once to facilitate a short and simple version of the investment game, suitable for our consumer panel participants.[7] An additional advantage of this setup is that it corresponds to the long lifetime of many flood risk mitigation measures, which has been estimated to be between 10 up to 50 years (Poussin et al., 2015). This lifetime of about 25 years means that once the measure is taken by a homeowner, it would be present in their house and reduce the flood risk over this lifetime, which is consistent with the setup of our experiment. We acknowledge that the current design does not capture learning over time, while in practice decision makers are able to observe peers and experience potential losses. The instructions were supported by graphics and were always available as a pop-up screen throughout the experiment.

The investment game started with a test scenario to allow participants to be come more familiar with the decision screens. To ensure the participants' understanding of the game and the savings balance, the test scenario was followed by a few comprehension questions, conditional on the treatment (see Appendix B). The answers were available in the pop-up instructions. The number of times these pop-up instructions were opened was stored by the software, as well as the number of attempts to answer the comprehension questions correctly. These counts were used as experimental control variables in the regression analysis. After answering all comprehension questions correctly, subjects could start with the main scenario.

[7]In a previous lab experiment (Mol et al., 2018), participants played the investment game for multiple years (experimental rounds). While this design allowed us to study the effect of flood damage experience on mitigation investments, it was rather complex and repetitive for participants. We anticipated that the consumer panel participants in the current study might be irritated or get bored when being asked to make their choice repeatedly, which could lead to lower completion rates and erratic choices.

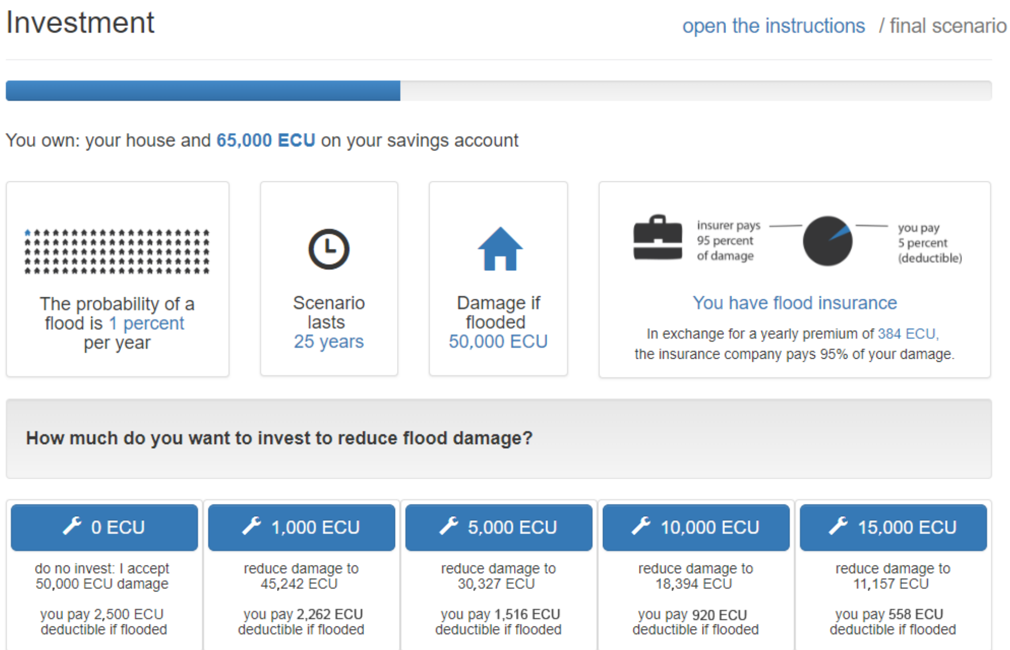

Figure 1: Screen shot of the investment page. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

3.2 Treatments

Each respondent was randomly selected by the software into one of the five treatment groups: No Insurance, Mandatory Insurance, Premium Discount, Voluntary Insurance and Voluntary + Discount (see Table 2 for details). Respondents in the No Insurance treatment played the Investment game without insurance. Respondents in the Mandatory Insurance and Premium Discount treatments played the Investment game with mandatory insurance coverage at a premium of 384 ECU per year.[8] Respondents in the Voluntary and Voluntary + Discount treatments were asked whether they would be willing to buy flood insurance

[8]The actuarially fair premium of 480 ECU was slightly subsidized to increase the sample of voluntarily insured respondents. Besides, subsidizing the premium is a realistic assumption under a mandatory insurance scheme which are often public insurance systems, such as the National Flood Insurance Program in the United States.

(deductible: 5%) at the actuarially fair premium of 480 ECU per year (40 ECU per month). The *Willingness to pay* page showed the yearly costs, as well as the monthly costs and the total costs for 25 years of insurance (see Supplementary Material for screen shots). The willingness to pay (WTP) was not restricted. Subjects gave answers between 0 and 150 ECU per month (see Figure 4). The scenario lasted for 25 years: total costs to spend on insurance were $25 \times 12 \times$ WTP. Participants were informed that monthly insurance costs were constant over the 25 years. For the example of 32 ECU (the subsidized premium) the total costs would be $25 \times 12 \times 32 = 9600$ ECU, which would equal 96 euro. Those who agreed to the actuarially fair premium were insured for the rest of the game, while those who refused were asked again at a subsidized premium of 384 ECU per year (32 ECU per month). Respondents who agreed to the subsidized premium were insured for the rest of the game. Individuals who rejected the insurance offer again were forwarded to the No Insurance treatment of the investment game. After the binary insurance take-up question(s), an open-ended question followed to ask for the exact maximum willingness to pay. To facilitate comparisons across treatments, all respondents insured in the investment game (Mandatory, Voluntary agreed to actuarially fair premium, Voluntary agreed to subsidized premium) were confronted with the same - subsidized - premium of 384 ECU per year. In the Premium Discount treatment, respondents were offered a premium discount that equals the expected value of the damage reduction (probability $\times$ damage) of their self-insurance investment. The optimal investment in self-insurance based on simple expected value calculations was 0 ECU in the Insurance treatments, 1000 ECU in the No Insurance treatment and 5000 ECU in treatments with Premium Discount.

A sample size analysis assuming a significance level of 0.05 and a power of 80% indicated that we would need a sample size of at least 252 participants in the Mandatory Insurance and No Insurance treatments. This sample size would allow us to detect the effect sizes found in the scenario of a previous lab experiment (Mol et al., 2018), closest to our current parameters, with a Wilcoxon Mann Whitney test. All treatment groups received versions of the survey that shared the same structure, starting with socioeconomic questions and flood perception questions (see Appendix C). The investment game was followed by a final set of questions (see Appendix D) to gather data on risk preferences, time preferences and other behavioral factors that could be important characteristics related to flood risk, such as flood experience and trust in dike maintenance. Figure 2 gives an overview of the flow of the experiment, starting from each of the five treatments.

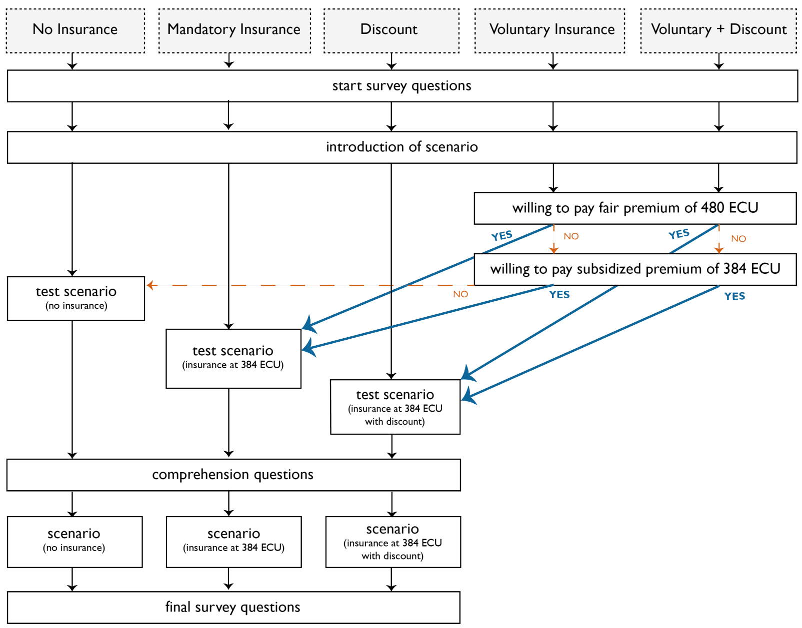

Figure 2: Overview of the experiment, by treatment.

3.3 Procedure

The experimental part of the survey was a simplified version of an earlier lab experiment (Mol et al., 2018) which was extensively pretested by 25 participants and completed by 357 participants in November 2017. The current set-up was pretested with flood hazard experts at the Institute for Environmental Studies (IVM) and a sample of 10 Dutch homeowners. After the pretest, a few minor adjustments were made in the formulation of the survey questions and the instructions of the investment game. The response rate of the final survey was 25.3%. To determine the optimal sample size for each of the treatments, we ran a pilot with a sample of 100 respondents in the Voluntary Insurance treatment to determine voluntary insurance take-up rates. 74 out of 100 individuals indicated they were unwilling to pay at least 384 ECU for insurance; they played the No Insurance version of the game. The residual 26 individuals selected into insurance.

Table 2: Implementation of treatments.

	No Insurance	Mandatory Insurance	Discount	Voluntary	Voluntary+Discount	Total
Mandatory No Insurance	261	0	0	0	0	261
Mandatory Insurance	0	300	0	0	0	300
Mandatory Discount	0	0	351	0	0	351
Self-selected No Insurance	0	0	0	439	411	850
Self-selected Insurance	0	0	0	159	0	159
Self-selected Discount	0	0	0	0	190	190
Total	261	300	351	598	601	2111

Notes: This table shows the distribution of treatments and the number of observations.

The Dutch online experiment was distributed by the survey company Panelinzicht in May and June 2018 and was completed by 2122 unique respondents. Eight responses were deleted because of missing answers in the final survey. Three responses were excluded because of unreasonable outliers in WTP value: monthly premiums above 216 ECU could not be paid from the bank balance. This left 2111 responses for analysis (see Table 2 for details). The sample specifically targeted homeowners who were located in the river delta areas of the Netherlands with a flood probability standard of 1 in 1250.[9] The survey was

[9]We could sample 1846 responses in the dike rings corresponding to the 1:1250 protection standard. We

administered over the Internet using the experimental software oTree (Chen et al., 2016) and started with a selection question to ensure that only respondents who owned a house in the river delta zip-code areas could continue answering the rest of the survey. The investment game was optimized for tablets and desktop computers.[10]

4 Hypotheses

We first consider the case where the availability of flood insurance is publicly determined. A government offers public insurance which has to be mandatorily purchased by its citizens who then face only the (in our case 5%) deductible as expected damage. Alternatively, if no flood insurance is available, citizens face the expected damage of the full loss. Clearly, in this case the uninsured have a higher incentive to invest in self-insurance than the insured.

From a cost benefit analysis perspective[11], the investments of publicly insured individuals in self-insurance should approach zero. However, the combination of very small probabilities of loss and very high potential damages in a natural disaster insurance situation may still lead to investments by individuals with specific behavioral motivations, like high risk aversion or high loss aversion and probability overweighting in Prospect Theory. Previous survey studies in the context of low probability disaster risks have found no evidence for a moral hazard effect (Thieken et al., 2006; Osberghaus, 2015). Therefore, our first hypothesis concerns the non-existence of moral hazard:

Hypothesis 1a *Investments in self-insurance in the Mandatory treatments do not differ between individuals with insurance coverage and without insurance coverage.*

sampled the remaining 265 responses from the zip-codes of the 1 in 2000 flood probability standard. We ran additional analyses without these 265 responses. The results do not change qualitatively. A dummy for sample area has been included in the regression analyses.

[10] A warning was given to all participants attempting to start the survey from a mobile device. Mobile device users were not excluded from taking the survey, but the software saved browser details of each respondent to control for mobile devices in the analyses.

[11] With the benefits being the expected value of avoided flood damage.

Hudson et al. (2017) suggest that natural disaster insurance markets may give rise to advantageous selection; some individuals both purchase insurance coverage and take available protective measures. However, advantageous selection is very hard to test empirically as it is often not possible to control for behavioral characteristics between the self-selected and the mandatory insured policyholders. The current large-scale online experiment intended to fill this gap with different between-subject treatments with mandatory (public) insurance and voluntary (private market) insurance. We hypothesize that advantageous selection leads to higher investments in self-insurance in the voluntary insurance treatments in comparison to respondents with mandatory insurance, and no insurance.

Hypothesis 1b *Self-insurance investments from individuals self-selected into Insurance are higher than those from individuals in the Mandatory Insurance treatment.*

Hypothesis 1c *Investments in self-insurance are higher for people who select into purchasing voluntary private insurance than for people who choose not to insure.*

In order to design an affordable insurance scheme for natural disasters and encourage the taking of cost-effective risk reduction measures, researchers and policymakers have suggested premium discounts to promote individual investments in protective measures (Kunreuther, 1996; European Commission, 2013; Surminski et al., 2015). Some empirical evidence suggests that premium discounts might be effective in convincing homeowners to invest in flood mitigation measures of low cost (Botzen et al., 2009b). These initial findings were supported by Mol et al. (2018) with a student sample.

Hypothesis 2a *Average self-insurance investments are higher in the Discount treatments compared to investments in the Insurance Baseline treatments.*

The current design also allows to test for an interaction effect between voluntary insurance and premium discounts. We expect that because of behavioral characteristics of individuals selecting into voluntary flood insurance (e.g. high risk aversion, high risk perception), those individuals are already more motivated to invest in flood risk reduction measures. Hence, the additional positive effect of the insurance premium discount in terms of stimulating risk reduction measures is less strong for this sub-group compared with the mandatory insured group: we hypothesize a larger effect of the premium discount in the Mandatory Insurance treatment.

Hypothesis 2b *The effect of a premium discount on investments in self-insurance is larger for respondents with mandatory insurance than for respondents who self-selected into insurance.*

We now turn to several behavioral motivations to invest in self-insurance. An important motivation to invest in self-insurance is risk aversion. Following the literature summarized in Section 2, we expect that respondents with a high willingness to pay (WTP) for flood insurance as proxy for risk aversion in the flood risk domain are more likely to invest in self-insurance.

Hypothesis 3a *Risk-averse individuals will invest more in self-insurance than risk-neutral individuals, while risk-seeking individuals will invest less.*

As the expected benefits of a large self-insurance investment may spread over a time-span of 25 years or more, time preferences might be an important factor in the decision process (Michel-Kerjan, 2010; Kunreuther and Michel-Kerjan, 2015). When individuals place too much value on current costs, they might neglect the future benefits of self-insurance investments.

Hypothesis 3b *Individuals with present-biased time preferences will invest less in self-insurance than individuals who report neutral time preferences.*

Furthermore, a vast body of literature in both psychology and economics has shown that emotions can influence economic decisions (see e.g. Lerner et al., 2004; Lin et al., 2006; Hanley et al., 2017). A relevant emotion in the context of protective behavior is worry (see e.g. Slovic, 2010; Peters et al., 2006). Schade et al. (2012) conclude from a large insurance experiment with LPHI risks that worry explains more variation in WTP for insurance than the subjective probability of loss. Meyer et al. (2013) also study the role of worry in a computer-mediated environment with a simulated storm. They find that those subjects with the highest levels of worry are the fastest to gather information and indicate the intention to take protective action. Previous survey studies have shown that positive relationships exist between worry about flooding and perceived flood probabilities and damages (Botzen et al., 2015) as well as flood risk mitigation activities (Bubeck et al., 2012).

Hypothesis 3c *Individuals with high levels of worry about flooding will invest on average more in self-insurance than individuals who do not worry.*

Some researchers have argued that social norms are positively related with flood insurance purchases (Lo, 2013). Moreover, both descriptive and prescriptive norms have been found to influence risk perceptions of climate change such that individuals with peers who recognize climate change, have higher climate risk perceptions (van der Linden, 2015). Others have found no support for the impact of social networks and social norms on risk mitigation decisions and flood insurance demand (Harries, 2012; Poussin et al., 2014). The final survey of the current study contains a question about investments in the social network, prescriptive norms as well as injunctive norms.

Hypothesis 3d *A higher level of approval concerning self-insurance investments by peers increases*
self-insurance investments.

A different emotion that has been shown to affect preventive behavior is anticipated regret about facing a large loss that could have been prevented (Braun and Muermann, 2004). Anticipated regret could increase all types of protective investments (Krantz and Kunreuther, 2007), including investments in self-insurance.

Hypothesis 3e *Individuals who anticipate regret about not preventing flood losses will invest on average more in self-insurance than individuals who do not anticipate regret.*

Our large sample size and extensive final questionnaire allows us to take a closer look at the individuals who drive this potential advantageous selection effect. Traditionally, a combination of insurance and preventive behavior - defined here as cautious types- has been explained by risk tolerance preferences. In their seminal paper, de Meza and Webb (2001) argued that people do not have identical (risk) preferences with regards to the risks they are exposed to. Cautious people may prefer both insurance coverage and self-insurance, while 'bold' types prefer less of both. Talberth et al. (2006) found advantageous selection in an experiment in the context of wildfire risks. One other influential factor in their findings was response efficacy of mitigation measures. Fang et al. (2008) have examined the origins of advantageous selection in the context of health insurance, where they found no effect of risk preferences. They do find that education level, cognitive ability and financial numeracy are important predictors of advantageous selection.

Hypothesis 3f *Cautious types express higher levels of risk aversion, are more highly educated, and perceive self-insurance measures as more effective than non-cautious types.*

5 Results

In this section we present the experimental findings. The main outcome of interest is the discrete level of investment in self-insurance. In addition, we analyze willingness to pay (WTP) for flood insurance by participants in the Voluntary treatments. We first present descriptive statistics and aggregated treatment effects of insurance and insurance features. This is followed by an Ordered Probit estimation to analyze the effects of behavioral motivations and the interactions with incentives on self-insurance investments.

Table 3: Descriptive statistics per treatment group.

	No Insurance	Mandatory Insurance	Discount	Voluntary	Voluntary+Discount	Total
Gender (1 = female)	0.53	0.43	0.48	0.50	0.49	0.49
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Age in years	52.88	54.49	53.50	55.34	53.96	54.22
	(14.97)	(15.24)	(14.66)	(14.43)	(14.05)	(14.56)
Education (1 = Master's degree)	0.10	0.11	0.10	0.10	0.09	0.10
	(0.30)	(0.31)	(0.30)	(0.29)	(0.29)	(0.30)
Home value (1 = above €500,000)	0.04	0.06	0.06	0.07	0.05	0.06
	(0.20)	(0.23)	(0.24)	(0.26)	(0.22)	(0.24)
Nr of extra insurances	5.44	5.49	5.44	5.51	5.53	5.49
	(2.19)	(2.06)	(1.87)	(1.98)	(2.05)	(2.02)
Browser (1 = smartphone)	0.15	0.10	0.11	0.10	0.16	0.13
	(0.36)	(0.30)	(0.31)	(0.31)	(0.37)	(0.33)
Observations	261	300	351	598	601	2111

Note: Table displays means, SD in parentheses.

Table 3 presents some descriptive statistics of our sample. Demographic variables are largely identical in each treatment group, except for small differences in age and browser type.[12] On average, respondents are 54 years old and approximately 49% are female. The average after-tax household income is the answer category "between €2500 and €2999 per

[12]This may be caused by the distribution of respondents into treatments per session, where some sessions were larger than others. We therefore cluster standard errors in the regressions at session level. Note that by 'session' we do not mean a typical laboratory session, but we refer to a wave of participation invitations sent out by the survey company. Most sessions held approximately 100 subjects.

month", which would include the average after-tax household income of homeowners in the Netherlands, namely €2933 per month (Netherlands Statistics, 2018a). The average home value is the answer category "between €250,000 and €299,000", which is close to the average home value in the Netherlands, namely €216,000 (Netherlands Statistics, 2018b).

5.1 Presence of insurance

To investigate Hypothesis 1a we compared the investment levels in the mandatory treatment without insurance with investments in the mandatory insurance treatment. The results are illustrated by Figure 3. A one-sided t-test revealed that the average investment in the Mandatory Insurance treatment was significantly higher than 0 ($t = 14.89$, $df = 299$, $p < 0.000$). In other words, self-insurance and mandatory insurance are not complete substitutes. A Mann-Whitney-Wilcoxon (MWW) test showed that the investments in No Insurance ($M_{M-no} = 5099.62$) are not significantly different from Mandatory Insurance ($M_{M-ins} = 4743.33$, $z = 1.137$, $p = 0.256$), indicating no moral hazard effect. Therefore, we find support for 1a: investments in self-insurance in the Mandatory treatments do not differ between individuals with insurance coverage and individuals without coverage. To examine Hypothesis 1b we compared the investments in self-insurance in the Mandatory Insurance treatment with the investments of respondents who self-selected into Insurance ($M_{S-ins} = 4477.99$) with a MWW test. The results indicate that no significant difference is supported by the data ($z = 0.837$, $p = 0.403$). The difference between the Mandatory Discount ($M_{M-dis} = 5857.55$) and self-selected Discount ($M_{S-dis} = 6321.05$) is not significant at the 5% level either ($z = 1.667$, $p = 0.096$). We do not find support for Hypothesis 1b: self-insurance investments from individuals self-selected into Insurance are not significantly higher (nor lower) than individuals in the Mandatory Insurance treatment. In contrast, Hypothesis 1c is clearly supported by the data: investments in self-insurance

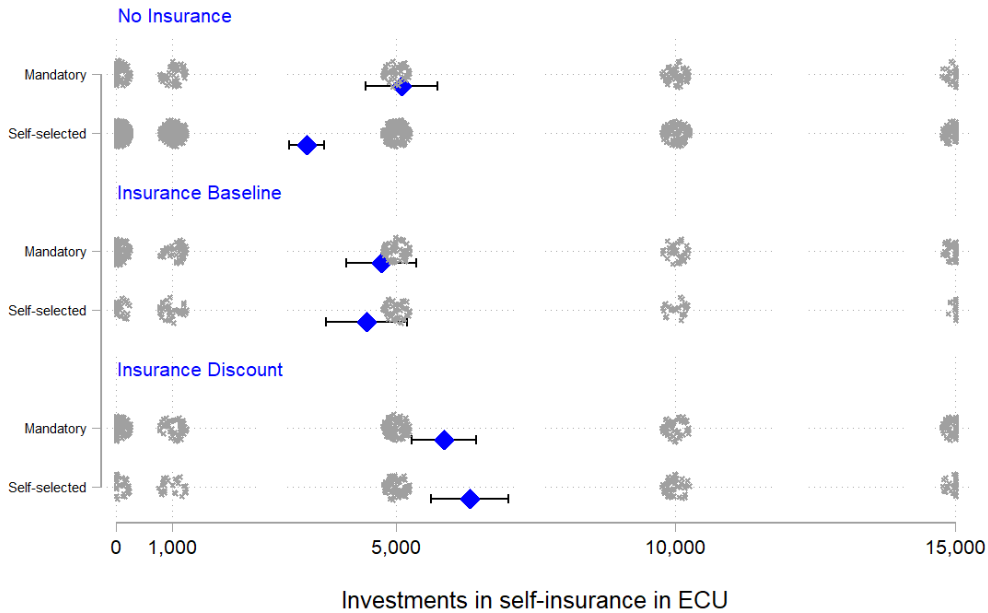

Figure 3: Investments in self-insurance over treatments. *Notes:* Each observation is indicated with a gray cross with 4% random jitter to facilitate readability. Diamonds indicate means with confidence intervals.

in the self-selected Insurance treatment are significantly higher than in the self-selected No Insurance treatment ($M_{S-ins} = 4477.99$, $M_{S-no-ins} = 3405.88$, $z = -4.386$, $p < 0.000$). Note that the probability of loss was equal for all respondents in our experiment. If we consider that risk = probability × damage, individuals with high investments in self-insurance lowered their risk, while individuals with low investments in self-insurance can be classified as high risk. Following this argument, the effect of lower self-insurance (= high risk) by individuals who selected no insurance coverage, indicates advantageous selection.

5.2 Features of insurance

We examined the effect of a premium discount both in the Mandatory treatments and in the Voluntary treatments, as well as pooled data across these treatments. We find that a premium discount increases investments under Mandatory insurance ($M_{M-ins} = 4743.33$, $M_{M-ins-disc} = 5857.55$, $z = -3.072$, $p = 0.002$), as well as under Voluntary insurance ($M_{S-ins} = 4477.99$, $M_{S-disc} = 6321.05$, $z = -3.715$, $p < 0.000$). This pattern is confirmed when the investments in both discount treatments are pooled ($z = -5.109$, $p < 0.000$). We can confirm Hypothesis 2a: a premium discount increases investments in self-insurance.

Figure 3 shows that the effect of a discount is slightly larger for individuals with self-selected insurance coverage than for the mandatorily insured respondents. To analyze this result more formally, we ran regressions with treatment dummies and other explanatory variables.[13], such as demographics and behavioral motivations for investment in self-insurance in Table 4. The models have an Ordered Probit specification to account for the discrete investment options. Model 1 restricts the analysis to the subsample of respondents who were insured during the investment game: i.e. respondents in the Mandatory Insurance and Mandatory Discount treatments, as well as respondents who self-selected into the Voluntary Insurance and treatments. This model confirms our findings from the non-parametric tests concerning Hypothesis 2a: the premium discount is effective in increasing self-insurance investments, both in the Mandatory insurance treatment, as well as among respondents who self-selected into insurance.

We ran a Wald test for equality of estimates to test the interaction[14] between the discount and insurance type and found no significant difference ($F(1, 965) = 0.79$,

[13]To rule out issues of multicollinearity, we checked all explanatory variables for high correlations; most were smaller than 0.5, indicating no problematic variables (Field, 2009) For the pair level of worry vs. threshold of concern ($\rho = 0.537$) we included only worry in the model, as this question was directly related to Hypothesis 3c.

[14]Null hypothesis: Mandatory Discount - Mandatory Insurance = Self-selected Discount - Self-selected Insurance

$p = 0.373$). Because the increase in self-insurance by a premium discount does not differ between mandatorily and voluntarily insured individuals, we cannot confirm Hypothesis 2b, i.e. there is no evidence that the effect of a premium discount on investments in self-insurance is larger for respondents with mandatory insurance than for respondents who self-selected into insurance.

5.3 Behavioral motivations for self-insurance

Next, we investigate the behavioral motivations to invest in self-insurance against flood risk. Hypothesis 3a concerned the risk attitude of respondents as measured by their willingness to pay (WTP) for flood insurance. Respondents in the Voluntary and Voluntary + Discount treatments were asked to specify their monthly WTP for flood insurance. Figure 4 shows that a majority (71% of the sample) is not willing to pay at least the subsidized premium, which according to Prospect Theory suggests that many people underweight the flood probability in their insurance decision.

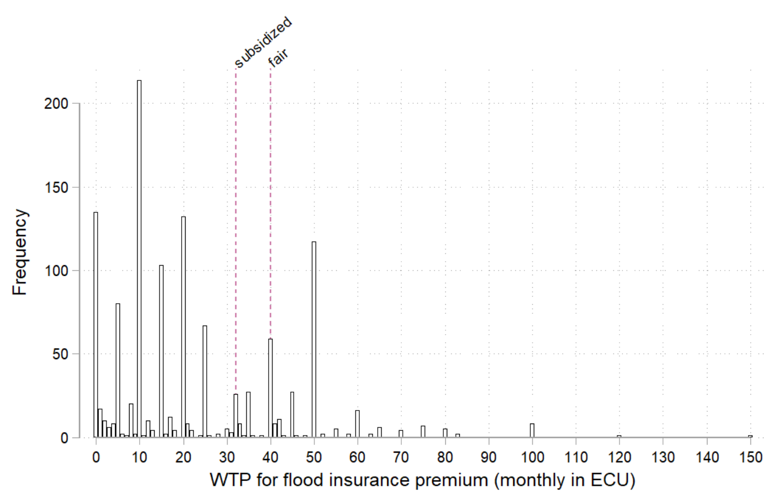

Figure 4: Frequency distribution of monthly WTP for flood insurance. *Note:* Dotted lines indicate subsidized and fair premium.

Table 4 shows the results of a regression analysis on the effects of behavioral motivations on investment in self-insurance. The table presents treatment dummies, demographics and variables related to our hypotheses (worry, anticipated regret and social norms, risk and time preferences). For the risk and time preferences, we did not classify subjects into 'risk averse', 'risk neutral' or 'risk seeking', but used the reported values for the proxies as predictors in the regression analysis (see Appendix A). We suppress coefficients of other flood beliefs and control variables for brevity. Note that we report McFaddens Pseudo R^2, because the R^2 statistic is not defined for our nonlinear (probit) model. In general, Pseudo R^2 statistics of models of flood preparedness decisions are low (Botzen et al., 2009a), indicating large individual differences in factors of influence on these decisions. The pseudo R^2 values reported in Table 4 and Table 5 are in a typical range for models with binary dependent variables of flood preparedness decisions reported in other studies (e.g. Hudson et al., 2017; Osberghaus, 2017; Peacock et al., 2005; Botzen et al., 2009b).

While Model 1 restricts the analysis to respondents with insurance during the investment game, Model 2 includes only respondents without insurance coverage: i.e. respondents in the Mandatory No Insurance treatment, pooled with respondents who self-selected into Voluntary No Insurance. In this regression we include a dummy variable for the respondents who self-selected to have no insurance coverage.

Table 4: Ordered Probit regression of investments in self-insurance.

	Dependent variable: Discrete investment in self-insurance			
	(1) Insurance	(2) No insurance	(3) Voluntary	(4) Pooled
Treatments				
Mandatory No Insurance		0		0
		(.)		(.)
Mandatory Insurance	0			-0.0879
	(.)			(0.0992)
Mandatory Discount	0.234***			0.142
	(0.0757)			(0.129)
Self-selected No Insurance		-0.213***	0	-0.262***
		(0.0827)	(.)	(0.0806)
Self-selected Insurance	-0.0428		-0.760***	-0.169
	(0.0630)		(0.0763)	(0.111)
Self-selected Discount	0.314***		-0.431***	0.168*
	(0.0914)		(0.120)	(0.101)
Risk and time preferences				
Willingness to pay for flood insurance			0.0243***	
			(0.00277)	
Risk averse self-reported	0.0403**	0.0722***	0.0379**	0.0556***
	(0.0177)	(0.0170)	(0.0153)	(0.0121)
Nr of extra insurances	0.0273**	0.0134	0.0332*	0.0200*
	(0.0133)	(0.0168)	(0.0186)	(0.0119)
Raised health insurance deductible	0.172	0.0759	0.163	0.121
	(0.117)	(0.104)	(0.137)	(0.0865)
Present biased self-reported	-0.0441***	-0.0460**	-0.0451***	-0.0468***
	(0.0105)	(0.0212)	(0.0158)	(0.0135)
Demographics				
Gender (1 = female)	-0.0469	0.134	0.0396	0.0492
	(0.0491)	(0.108)	(0.0638)	(0.0654)
Age in years	0.00124	-0.00650***	-0.00530*	-0.00182
	(0.00180)	(0.00195)	(0.00272)	(0.00178)
Master's degree	0.279**	0.202	0.272**	0.257***
	(0.109)	(0.149)	(0.119)	(0.0844)
Home > €500,000	-0.0270	-0.353**	-0.249	-0.175
	(0.162)	(0.165)	(0.161)	(0.116)
Hypothesized flood beliefs				
Worried about floods	0.0176	0.0362	0.0260	0.0350
	(0.0522)	(0.0564)	(0.0547)	(0.0374)
Social norm approve	0.0699	0.110**	0.128***	0.0949**
	(0.0654)	(0.0436)	(0.0440)	(0.0419)
Anticipated regret	0.0429	0.0477	0.0333	0.0484***
	(0.0417)	(0.0384)	(0.0261)	(0.0174)
Observations	1000	1111	1199	2111
AIC	3056.1	2999.9	3233.0	6079.3
Log likelihood	-1508.0	-1479.0	-1597.5	-3018.7
Pseudo R^2 (McFadden)	0.0442	0.0894	0.106	0.0690
Controls	✓	✓	✓	✓

Notes: Standard errors clustered at session level in parentheses (* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$). Controls: mobile device, reopened instructions, wrong attempts understanding questions, dummy very difficult, time in minutes, sample area, property includes ground floor. Suppressed coefficients: high income, availability response efficacy, response cost, self-efficacy, climate risk will increase, subjective flood probability, locus of control, neighbors measures, nr of measures implemented, trust in dikes, high expected damage, house damaged in past.

The significantly negative estimate for this dummy confirms that self-insurance investments by respondents without coverage in a voluntary (market) insurance scheme are lower than in a situation where no flood insurance is available. The third model examines the full sample, but includes WTP for flood insurance as an explanatory variable, which restricts the sample to the subjects who were offered voluntary (market) insurance. The WTP coefficient indicates that investment in self-insurance is positively related to higher WTP values for flood insurance. This WTP variable reflects individual risk aversion for flood risk, but can also capture some other behavioral motivations for reducing flood risk, like anticipated regret for flood damage, like a subsequent analysis reported in Table 5 shows. We therefore base our assessment on several indicators for risk aversion. The coefficients of the self-reported general risk aversion question are positive and significant at least at the 5% level across models of investments in self-insurance. The coefficient of number of insurances points into the same direction; for every additional insurance policy in real life, subjects invest more in self-insurance in the game, although the effect is not always significant. Overall, these results suggest that individuals who show a higher level of risk aversion are likely to invest more in self-insurance, which is in line with Hypothesis 3a. The self-reported measure regarding time preferences shows that present biased individuals are significantly less willing to invest in self-insurance in the game, as in Hypothesis 3b. This may seem obvious, but note that although the time horizon of the investment game describes 25 years, the results are realized within a couple of minutes.

The last model in Table 4 includes the full sample, with dummies for each of the treatments, where Mandatory No Insurance is the reference category. We do not find support for Hypothesis 3c: no significant coefficient of worry about flood on the average investment in self-insurance is found in either of the four models. We find a positive effect of social norms on investments in self-insurance, confirming Hypothesis 3d. However, we need to acknowledge the possibility that subjects answer consistently with their chosen investment level in the experiment[15] as the social norms question was part of the final survey. The social norms estimate is not significant in the Insurance only sample (Model 1). For anticipated regret, the regression results indicate that a strong feeling of anticipated regret leads to higher investments, as predicted by Hypothesis 3e. Nonetheless, the effect is only significant in the pooled model.

Other behavioral motivations In addition to the behavioral motivations which we expected to affect investments in self-insurance, we observe some other important factors in our models. The demographic variables indicate that there is no gender effect, but that more highly educated respondents invest more in self-insurance. All else equal, we find that both older individuals and those who own an expensive home (> €500,000) invest less in self-insurance, although this seems to be mainly the case if no insurance coverage is available. The low investment behavior of older individuals could be explained by the time horizon of 25 years that was presented in the game. As one participant mentioned in the feedback field at the end of the questionnaire: *"If you are 30 years old, the 25 years are within your scope, but I am 71 and that makes me think I will not outlive those investments."*

To understand the determinants of self-selection into insurance coverage, we ran an additional Tobit[16] model with WTP as the dependent variable (Model 1) and a Probit model to predict self-selected insurance coverage (Model 2), which are presented in Table 5. To facilitate comparison of coefficient estimates, we used the same set of variables in all four models, even though some variables (such as response efficacy of mitigation measures)

[15]See Appendix D for the final survey and Appendix C for the questions asked before the start of the investment game.

[16]The Tobit model accounts for possible censoring at zero, as respondents were not allowed to enter negative WTP values.

mainly intended to explain cautious and uncautious types in Model 3 and 4. We find that risk averse individuals have a higher willingness to pay for flood insurance, as indicated by the self-reported measure. Respondents who decreased their health insurance coverage by raising the deductible in exchange for a lower premium, have a lower likelihood to select flood insurance coverage in the investment game. This may indicate their general dislike of insurance, although there does not seem to be any effect of additional insurance policies. Present biased respondents not only invest less in self-insurance, they also have a lower WTP for flood insurance.

While we find no gender effect in the previous analyses, men have a higher WTP for flood insurance and are more likely to select coverage in the game. Older respondents have a lower WTP for flood insurance and are less likely to self-select into flood insurance. No significant coefficient estimates were found for education level and home value.

Social norms and anticipated regret increase both WTP and coverage, while worry about floods only increases coverage. Both efficacy variables show there is a positive relation between WTP for flood insurance and response efficacy of mitigation measures, but a negative effect with self-efficacy. These findings suggest that individuals who think that it is effective to invest in flood risk mitigation measures, also have a high demand for flood insurance, but that those who think that implementing mitigation measures is an easy way for coping with floods only mitigate risk. The coefficient sizes show the former effect dominates the latter. WTP for flood insurance is positively related with the number of implemented flood risk mitigation measures, which is consistent with the positive relation between insurance demand and self-insurance observed in the experiment.

Trust in the maintenance of Dutch dikes decreases WTP for flood insurance, but not to such an extent that it decreases coverage in the experiment. The feeling of having control over one's life (locus of control) increases WTP and flood insurance coverage, while the statement that flood risk will increase due to climate change does not have any effect. Interestingly, respondents who are certain that they live in a floodplain area, select significantly less often into insurance coverage than respondents who think they live outside a floodplain area. Note that all respondents do live in a floodplain and that we have controlled for the "real" floodplain where respondents live ("sample area") as well as for past flood experience ("availability"). The fact that respondents' neighbors have implemented damage reducing measures increases WTP for flood insurance slightly, although the coefficient is insignificant in the Probit models. When asked about their strategy in the investment game, many respondents' answers included words like "analyze", "budget", "calculation" and "compare". The answers could be roughly categorized into those who used words related to calculations and those who did not. This dummy variable is strongly significant, indicating that the calculating types have a higher WTP for flood insurance and subsequently select more often into insurance coverage. Interestingly, Figure 7 shows that calculating types did not select the optimal (i.e. maximizing expected value) investment in self-insurance more often than respondents with other strategies. However, calculating types over-invest more and under-invest less than the other types and vice versa.

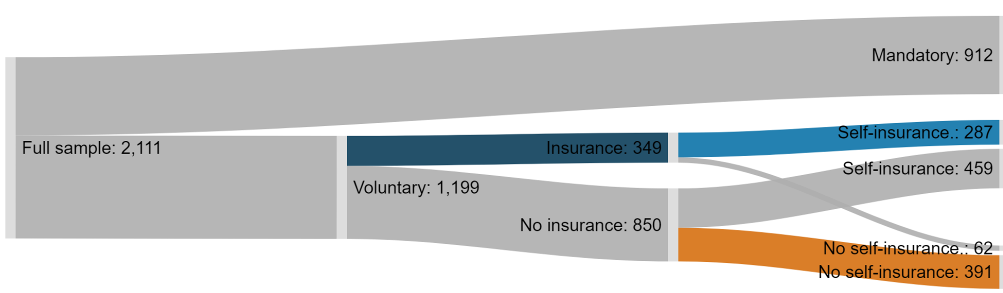

Figure 5: Self-selection into insurance and self-insurance. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Cautious and uncautious types Finally, we examine the sources of advantageous selection by a classification of extremely cautious and uncautious types. Out of 1199 subjects who were offered voluntary insurance, 349 selected insurance coverage, of which 287 also invested at least 1000 ECU (the lowest possible non-zero investment) in self-insurance. These respondents are classified as the cautious type. Out of the 850 self-selected non-insured respondents, 391 decided to invest 0 ECU in self-insurance, so we classify this sub-group as uncautious. Figure 5 illustrates the proportion of cautious (light blue) and uncautious (red) types.

We analyzed the behavioral motivations of these types through a Probit model of cautious types and uncautious types (Model 3 and Model 4 respectively in Table 5). The estimates changing from column 2 to column 3, indicate the difference between only purchasing insurance coverage (dark blue sample in Figure 5) and additional investments in self-insurance. Recall that we hypothesized that cautious types are more risk averse, higher educated and perceive self-insurance measures as more effective than non-cautious types. Comparing columns 2 and 3 in Table 5), we observe that the estimates of self-reported risk aversion, response efficacy and education level indeed change in the expected direction. Cautious types have higher coefficients for risk aversion, response efficacy and Master's degree as compared to the estimates of respondents with only coverage.

Table 5: Regressions on WTP, coverage and types.

	(1) Tobit WTP	(2) Probit coverage	(3) Probit cautious	(4) Probit uncautious
Risk and time preferences				
Risk averse self-reported	2.648***	0.0447***	0.0425***	-0.0363***
	(0.342)	(0.00598)	(0.00621)	(0.00582)
Nr of extra insurances	-0.363	-0.00819*	-0.00234	-0.000835
	(0.253)	(0.00454)	(0.00408)	(0.00634)
Raised health insurance deductible	-0.360	-0.0665**	-0.0170	0.00769
	(1.800)	(0.0321)	(0.0364)	(0.0505)
Present biased self-reported	-1.148***	-0.0289***	-0.0272***	0.0168**
	(0.264)	(0.00519)	(0.00346)	(0.00653)
Demographics				
Gender (1=female)	-2.355***	-0.0291*	-0.0528***	0.00421
	(0.833)	(0.0158)	(0.0148)	(0.0276)
Age in years	-0.223***	-0.00416***	-0.00396***	0.00419***
	(0.0396)	(0.000756)	(0.000947)	(0.000776)
Master's degree	-0.341	-0.0434	-0.0286	-0.0734*
	(1.871)	(0.0387)	(0.0386)	(0.0412)
Home > €500,000	-1.218	-0.0369	-0.0515	0.103
	(2.523)	(0.0471)	(0.0524)	(0.0644)
Hypothesized flood beliefs				
Worried about floods	1.051	0.0360***	0.0244**	-0.0110
	(0.805)	(0.0135)	(0.0111)	(0.0187)
Social norm approve	2.418***	0.0300**	0.0432***	-0.0427***
	(0.757)	(0.0124)	(0.0134)	(0.0140)
Anticipated regret	1.692***	0.0358***	0.0217	-0.0262***
	(0.608)	(0.0124)	(0.0138)	(0.00902)
Other behavioral motivations				
Response efficacy of mitigation measures	2.036***	0.0196*	0.0294***	-0.0960***
	(0.564)	(0.0105)	(0.0111)	(0.0113)
Self efficacy to implement measures	-1.151**	-0.0192	-0.0109	0.0363***
	(0.467)	(0.0129)	(0.0120)	(0.0124)
Nr of mitigation measures implemented	0.851***	0.0109**	0.00869*	-0.0169***
	(0.209)	(0.00458)	(0.00509)	(0.00587)
Trust in dikes	-0.891**	-0.000317	-0.0170	-0.0219**
	(0.422)	(0.0103)	(0.0118)	(0.00956)
Locus of control	0.581*	0.0142*	0.00904	-0.0255***
	(0.330)	(0.00778)	(0.00575)	(0.00736)
Climate risk will increase	1.050	-0.00141	-0.0138	-0.0516**
	(1.375)	(0.0265)	(0.0204)	(0.0248)
Sure live in flood plain	-2.235	-0.105***	-0.0901**	0.0392
	(1.533)	(0.0379)	(0.0407)	(0.0302)
Neighbors measures	2.964*	0.0646	0.0395	0.0265
	(1.781)	(0.0444)	(0.0491)	(0.0554)
Calculating strategy	3.650***	0.0902***	0.0587***	-0.127***
	(1.080)	(0.0188)	(0.0204)	(0.0260)
Observations	1199	1199	1199	1199
AIC	9534.5	1215.3	1112.2	1183.2
Log likelihood	-4748.2	-588.6	-537.1	-572.6
Pseudo R^2 (McFadden)	0.0373	0.186	0.186	0.244
Controls	✓	✓	✓	✓

Notes: Marginal effects; Standard errors clustered at session level in parentheses (* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$). Additional controls: mobile device, dummy very difficult, sample area, understanding questions. Cautious type defined as: selected both coverage and self-insurance. Uncautious type defined as: selected no coverage and no self-insurance. Suppressed coefficients ($p > 0.1$): response cost, house damaged in past, high expected damage, subjective flood probability, high income, availability.

Additionally, we find that the estimates of injunctive social norms and trust in dike maintenance also change across models. The differences in scores of those five variables are illustrated by Figure 6. A lower trust in the Dutch dike maintenance might motivate respondents to take all possible measures to protect their house against water. Education level does not seem to affect cautious behavior. We conclude that cautious types are more motivated by social approval, have higher response efficacy regarding mitigation measures, higher risk aversion and lower trust in dike maintenance than their single' cautious counterparts (who only select insurance coverage), partially validating Hypothesis 3f.

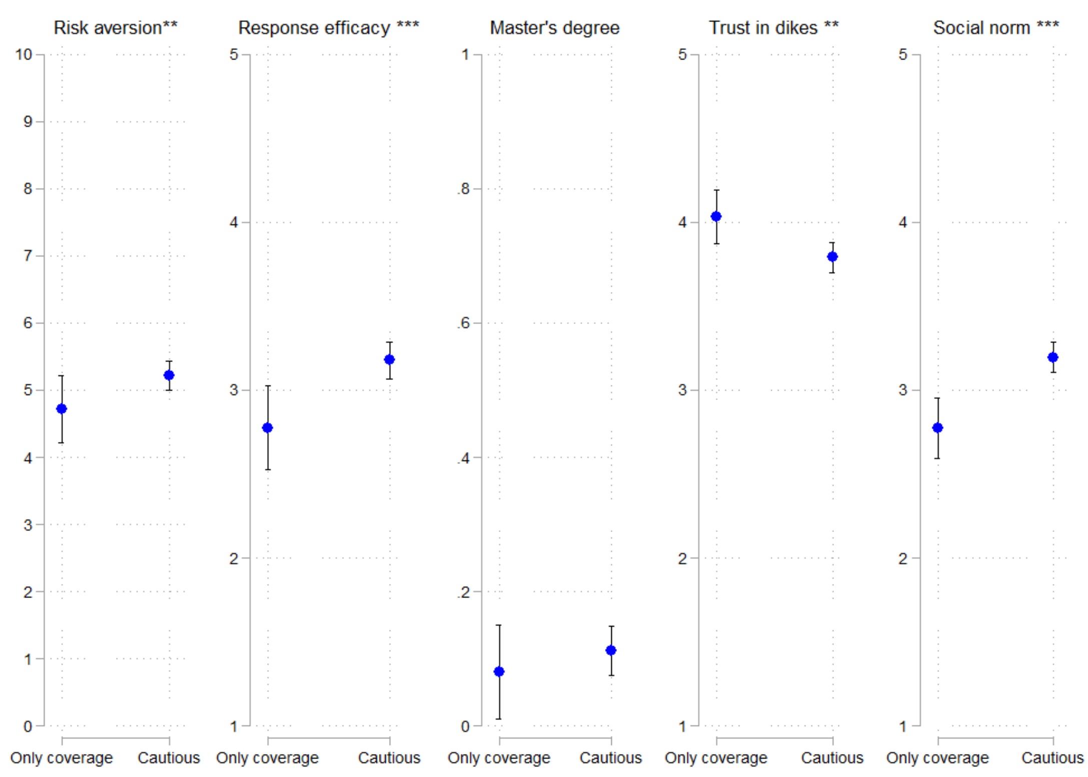

Figure 6: Variable (top) means by cautious type (bottom). *Notes:* Stars indicate significant differences by MWW tests ** $p < 0.05$, *** $p < 0.01$.

Following our result of low investments in self-insurance by individuals who self-selected no insurance coverage, we analyzed the uncautious types in Model 4. Although we did not construct hypotheses about this type, we observe some reassuring results: almost all estimates have opposite signs when compared to the cautious types in Model 3. Additionally, we find that uncautious types score significantly lower on trust in Dutch dike maintenance and internal locus of control. They are also significantly less likely to think that flood risk due to climate change is likely to increase. The uncautious types regard damage reducing measures as significantly less effective but also easier to implement (self-efficacy). The dummy for calculating strategy has a strongly significant negative value for uncautious types, while it is significantly positive for cautious types and subjects who select insurance coverage. This suggests that the uncautious types do not make their decision based on calculations, but have more emotional motivations, such as an external locus of control and the feeling that flood risk will not increase due to climate change.

6 Conclusion

In response to the growing expected damages of flooding, academics and flood risk managers have recently started to examine different flood risk reduction strategies and cost-effective self-insurance measures in particular. Previous studies have indicated that individual flood preparedness decisions may be largely influenced by individual flood risk perceptions and behavioral motivations (Kunreuther and Pauly, 2004). Empirical research in health insurance markets has indicated that heterogeneity in preferences may explain the appearance of either adverse or advantageous selection (Cutler et al., 2008). This study offered a careful examination of the interplay between financial incentives and behavioral motivations for investing in self-insurance on a group of relevant decision makers (homeowners in floodplains). To the best of our knowledge we are the first to study self-insurance behavior experimentally under both public and private insurance schemes, accounting for insurance features and behavioral characteristics of the decision-makers. Furthermore, our large sample size allowed for an in-depth analysis of heterogeneous behavioral motivations among respondents.

Our analysis started with the impacts of the presence or absence of insurance: we find no support for moral hazard in our data. As expected, we find that a premium discount can increase investments in self-insurance, although it does not matter whether this insurance is provided in a public or private market. A small majority of individuals in the voluntary insurance treatments are not willing to pay the subsidized insurance premium, but we do find a substantial share of cautious types, indirectly indicating advantageous selection. Important behavioral motivations stimulating investments in self-insurance are response efficacy, social norms and risk aversion. When we examine the sources of advantageous selection by a classification of extremely cautious and uncautious types, we find that cautious types tend to take their decision based on some sort of calculation, although the calculating respondents are more inclined to invest more than optimal amounts. These individuals are particularly motivated by response efficacy, social approval by their peers and risk aversion, as well as by a lower trust in dike maintenance. In contrast, uncautious types have opposite motivations and can be characterized by a lower locus of control and the belief that flood risk will not increase due to climate change. Even though all our respondents were floodplain inhabitants, only a minority of subjects stated confidently that their house was located in a floodplain and many did not consider damage reducing measures as cost-effective. Although our design differs in some key points[17] from the experiment of Corcos et al. (2017), it is interesting to compare the results. Our split

[17] Due to the simple online set-up in order to achieve a high sample size, we were not able to measure risk preferences with an incentive compatible task, but rely on a general self-reported measure and two insurance related questions instead. The WTP task was part of the incentivized investment game, but it was only present in the Voluntary treatment sample.

between cautious and uncautious types suggests that the cautious types make decisions based on calculation, while the split between risk lovers and risk averters of Corcos et al. (2017) indicated strategic gambling rather than a lack of interest in insurance by the risk lovers. A careful examination of the strategic motivations such as opportunism and strategic ignorance of the uncautious types requires further research. The limited length of our survey restricted the explanatory variables to simple survey questions, while it would have been interesting to take a closer look at risk attitudes, by differentiating between utility curvature, probability weighting and loss aversion as in Prospect Theory (Kahneman and Tversky, 1979). Previous research indeed indicates that many individuals underweight the low probability of flooding and that this behavior may be explained by Prospect Theory (Botzen and van den Bergh, 2012; Barberis, 2013). Nevertheless, probability weighting seems to be different for precautionary decisions about real life hazards compared to simple monetary gambles (Kusev et al., 2009). An interesting topic for future research is to examine how loss aversion, utility curvature, and probability weighting can explain individual investments for self-insurance against flood risk.

Regarding policy implications, these results may justify the strengthening of purchase requirements for flood insurance as we found no support for moral hazard and voluntary take-up rates in our experiment are low. Furthermore, the result that the uncautious types (who do not believe that flood risk will increase, nor that they should take action) select less insurance coverage could lead to substantial claims for government support which may drain public resources. These could be important topics for informational campaigns aimed at improving flood preparedness, which should be focused on explaining possible cost-effective measures, rather than on increasing awareness about flood risk in general. Our analysis also indicated that individuals who used calculations in the decision-making process were more inclined to select insurance coverage and (over-)invest in self-insurance. The fact that reporting a calculating strategy does not increase optimal investments may indicate either miscalculation or preferences for over-investment. Further research will have to show whether calculation tools could help to increase investments in cost-effective self-insurance measures among cautious as well as uncautious types. As our results suggest, changing the social norm for self-insurance by means of information and communication measures may be another policy lever to stimulate a wider uptake of these cost-effective measures. Finally, our finding that there is no moral hazard in this LPHI insurance market suggests that high deductibles may not be necessary to limit such an effect. This is in line with previous survey results of Hudson et al. (2017) who found that a majority of (hurricane insurance) policyholders are not even aware of having a deductible and that deductibles played a minor role in hurricane preparedness activities. Using premium discounts is likely to be a more effective way for insurers to stimulate policyholders to reduce natural disaster risk in general and flood risk in particular. These results support the ongoing debates and reforms aimed at linking flood insurance coverage with risk reduction in the European Union (Surminski et al., 2015; Hochrainer-Stigler et al., 2017) and the United States (Tullos, 2018).

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Appendix A Explanatory variables

Table 6: Summary overview of the variables used in the statistical analysis

Risk and time preferences	
Risk averse self reported	Categorical variable (range 0-10) *In general, are you a person who is willing to take risks?*, 0 = completely willing, 10 = completely unwilling
Nr of extra insurances	Continuous variable. Total number of boxes checked in the question 'which insurance(s) do you hold at the moment' (Appendix C question 17). Used as a proxy for risk aversion in the insurance domain.
Voluntary deductible	Dummy voluntary health insurance deductible (1 = yes). In the Netherlands, citizens have a mandatory deductible of €385 per year for their health insurance. Beyond this mandatory deductible, individuals may opt for an additional voluntary deductible of €100, €200, €300, €400 or €500 in exchange for a premium discount. A voluntary health insurance deductible might indicate risk seeking in the insurance domain (Dillingh et al., 2016).
Present biased self reported	Categorical variable (range 0-10) *In general, are you willing to give up something now in order to profit from that in the future?* (0 = completely willing, 10 = completely unwilling)
Demographics	
Gender (1=female)	Dummy variable gender (1 = respondent is female)
Age in years	Continuous variable, age in years
Master's degree	Dummy variable education level (1 = holds Master's degree)
High income	Dummy variable income (1 = monthly household after-tax income is within the highest category > €5,000)
Expensive house	Dummy variable house value (1 = house value is within the highest category > €400,000)
Flood beliefs	
Worried about floods	Categorical variable (range 1-5), *Worried about danger of flooding at current residence* (1 = strongly disagree, 5 = strongly agree)
Social norm approve	Categorical variable (range 1-5), *People in my direct environment would approve an investment in damage reducing measures* (1 = strongly disagree, 5 = strongly agree)
Anticipated regret	Categorical variable, Response to statement *I would feel regret if my house flooded and I had not taken any measures* (1 = strongly disagree, 5 = strongly agree)
Response efficacy	Categorical variable (range 1-5), *How effective do you consider investing in flood protection measures that limit flood damage* (1 = very ineffective, 5 = very effective)
Response cost	Categorical variable (range 1-5), *How costly do you think it is to take flood protection measures?* (1 = very cheap, 5 = very expensive)
Self-efficacy	Categorical variable (range 1-5), *How difficult do you think it is to take flood protection measures?* (1 = very difficult, 5 = very easy)
Nr of measures implemented	Continuous variable, number of flood protection measures already implemented at home
Trust in dikes	Categorical variable (range 1-5), *Dikes in Netherlands are well maintained* (1 = strongly disagree, 5 = strongly agree)
Locus of control	Categorical variable (range 4-20) combined 4 locus of control questions (4 = extremely external LOC, 20 = extremely internal LOC)
Climate risk will increase	Dummy consequences for flood risk at your current residence (1 = flood risk will increase)
Sure live in flood plain	Dummy flood-prone (1 = *I am certain that I live in a flood-prone area*)
Neighbors measures	Dummy respondent knows people who have invested in damage reducing measures (1 = yes)
Calculating strategy	Dummy respondent used words such as 'analyze', 'budget', 'calculation' and 'compare' in answer to open question regarding strategy in the investment game, indicating a calculating strategy (1 = calculating)
House damaged in past	Dummy property damaged due to floods in the past (1 = yes)
High expected damage	Dummy high expected damage (1 = respondent expects damage > €50,000 in case of flooding at residence)
Subjective flood probability	Continuous variable, log of estimated flood probability by respondent
Availability	Dummy availability (1 = Yes, I can recall high water levels)
Controls	
Time	Time from the first to the last page in the experiment in minutes
Mobile device	Dummy browser dimensions of respondent (1 = mobile device)
Dummy difficult	Dummy difficult (1 if respondent answered 'difficult' or 'very difficult' to the question *How easy or difficult did you find it to make a choice in the investment game presented to you?*)
Sample area	Dummy sample area (0 = 1:1250 floodplain, 1 = 1:2000 floodplain)
Understanding questions	Continuous variable, number of wrong attempts to answer understanding questions
Property ground floor	Dummy property of respondent includes ground floor (1 = yes)
Reopened instructions	Continuous variable, number of times respondent reopened pop-up screen with instructions

Appendix B Comprehension questions

Correct answers are marked in **bold**.

Question asked in all treatments

- What was the flood risk in the test scenario?

  (a) **1% per year**
  (b) 3% per year
  (c) 5% per year
  (d) 10% per year
  (e) 15% per year
  (f) 20% per year

Extra question in the No Insurance treatment

- What happens if you are flooded and you did not take protective investments?

  (a) **I have to pay the full damage: 50.000 ECU**
  (b) I have to pay a small fee
  (c) The government will compensate me

Extra question in all Insurance treatments

- What was your deductible (eigen risico) in the test scenario?

  a) **5 percent** b) 15 percent c) 20 percent
  d) 50 percent

- What is the benefit of a protective investment?

  (a) A reduced damage in case of a flood
  (b) A lower premium
  (c) Both reduced damage and a lower premium
  (d) None of the above

The correct answer is:
(a) in Insurance Baseline
and
(c) in Insurance Discount

Appendix C Start survey (translated from Dutch)

1. Are you male or female?
   • *Male* • *Female*
2. What is your age?
3. What is the highest level of education you have completed?
   - *No diploma*
   - *Primary school*
   - *Lower vocational education (VBO, LBO)*
   - *Lower general secondary education (ULO, MULO, VMBO, MAVO)*
   - *Lower vocational secondary education (MBO)*
   - *Higher general secondary education or pre-university education (HAVO, VWO, HBS)*
   - *Higher vocational and university education (HBO, WO Bachelor)*
   - *Master's degree (WO Master)*
   - *Doctorate, PhD (Promotie-onderzoek)*
   - *Other: [text box for open answer]*
4. Do you live in a flood-prone area at the moment?
   - *I am certain that I live in a flood-prone area*
   - *I think that I live in a flood-prone area, but I am not sure*
   - *No, I am certain that I do not live in a flood-prone area*
   - *Don't know*
5. Have you ever been evacuated due to a threat of flooding?
   • *Yes* • *No*

   In case subject answered *Yes* in question 5:

5.a Do you think your experience with evacuation makes it easier to imagine a flood in the nearby future?
   - *Yes, I can now imagine that a flood is very likely*
   - *No, I cannot imagine that a flood is very likely*
   - *I do not think that this experience has changed my thoughts on the likelihood of a flood*

6. Have you ever experienced damage to your house due to a flood?
   • *Yes* • *No*
7. How large or small do you think the probability is that your house will be flooded?
   - *The probability is zero*
   - *Very low*
   - *Low*
   - *Not low/not high*
   - *High*
   - *Very high*
   - *Do not know*

8. What consequences of climate change for flood risk do you expect at your current residence?
    - *Flood risk will increase*
    - *Flood risk will remain constant*
    - *Flood risk will decrease*
    - *Don't know*
9. Do you recall any situations of exceptionally high water levels in rivers close to your residence?

    - *Yes, I can recall high water levels*
    - *I cannot recall high water levels*
10. Imagine your neighborhood is flooded, how what height do you think the water would reach in your house?
    - *The water would not reach my house*
    - *Low (1-10 cm)*
    - *Pretty high (11-50 cm)*
    - *Fairly high (50-100 cm)*
    - *High (1-2 m)*
    - *Very high (whole floor flooded)*
11. To what extent do you agree with the following statement?
    "I would feel regret if my house flooded and I had not taken measures"
12. What is your household monthly income (after taxes)?
    - *Less than €499*
    - *Between €500 and €999*
    - *Between €1,000 and €1,499*
    - *Between €1,500 and €1,999*
    - *Between €2,000 and €2,499*
    - *Between €2,500 and €2,999*
    - *Between €3,000 and €3,499*
    - *Between €3,500 and €3,999*
    - *Between €4,000 and €4,499*
    - *Between €4,500 and €4,999*
    - *€5,000 or more*
    - *Don't know*
    - *Rather not say*
13. What is approximately the market value of your home?
    - *Less than €100,000*
    - *Between €100,000 and €149,000*
    - *Between €150,000 and €199,999*
    - *Between €200,000 and €249,000*
    - *Between €250,000 and €299,999*
    - *Between €300,000 and €349,000*
    - *Between €350,000 and €399,999*
    - *Between €400,000 and €449,000*
    - *Between €450,000 and €499,999*
    - *Between €500,000 and €549,000*
    - *Between €550,000 and €599,999*
    - *Between €600,000 and €649,000*
    - *Between €650,000 and €699,999*
    - *Between €700,000 and €749,000*
    - *Between €750,000 and €799,999*

- *€800,000 or more*
- *Don't know*
- *Rather not say*

14. What is your postcode in numbers and letters? [18]
15. Please indicate in what kind of property you live.
    - *House*
    - *Ground floor apartment*
    - *Apartment on 1st floor or higher*
    - *Other*
16. How much damage do you expect to your house and contents in case you would be flooded?
    - *Less than €1,000*
    - *Between €1,000 and €4,499*
    - *Between €5,000 and €9,999*
    - *Between €10,000 and €49,999*
    - *Between €50,000 and €99,999*
    - *Between €100,000 and €499,999*
    - *€500,000 or more*
    - *Don't know*
    - *Rather not say*
17. Could you indicate which insurance(s) you hold at the moment?

    ☐ *Dentist insurance*

    ☐ *Other extra option in health insurance (e.g. physiotherapy, glasses)*

    ☐ *Home contents insurance*

    ☐ *House insurance*

    ☐ *All risk car insurance*

    ☐ *Continuous travel insurance*

    ☐ *Life insurance*

    ☐ *Legal counsel insurance*

    ☐ *Bike insurance*

    ☐ *Occupational disability insurance*

    ☐ *Other: [text box for open answer]*

    ☐ *None*
18. In your Dutch health insurance, what do you think was your deductible in 2018?
    - *385 euro, the minimum set by the Dutch government*
    - *485 euro, I raised it by 100 euro*
    - *585 euro, I raised it by 200 euro*
    - *685 euro, I raised it by 300 euro*
    - *785 euro, I raised it by 400 euro*
    - *885 euro, I raised it by 500 euro (the maximum)*
    - *I do not know*
    - *I do not have Dutch health insurance*

[18] This answer was not required for privacy reasons.

Appendix D Final survey (translated from Dutch)

1. Can you indicate which measures you have taken to protect your house against flood damage?

   ☐ *No valuables in basement*

   ☐ *Water-resistant furniture on ground floor*

   ☐ *Elevated ground floor*

   ☐ *Strengthened foundation*

   ☐ *Walls made of water-resistant materials*

   ☐ *Floor of ground floor made of water-resistant materials (e.g. tile floor)*

   ☐ *Raised power sockets on ground floor*

   ☐ *Anti-backflow valves*

   ☐ *(Empty) sand bags or flood barriers*

   ☐ *Elevated electrical appliances*

   ☐ *Elevated boiler*

   ☐ *Raised electricity meter*

   ☐ *Bought separate flood insurance*

   ☐ *Other: [box for open answer]*

   ☐ *None*

2. Do you know anyone in your close environment who has taken one or more of these measures?

   • *Yes* • *No*

   In case subject answered *Yes* in question 2:

2.a Could you indicate your relationship to the person who invested in one or more damage reducing measures?

   - *Partner*
   - *Friend*
   - *Parent*
   - *Aunt/Uncle*
   - *Son/Daughter*
   - *Cousin*
   - *Neighbor*
   - *Acquaintance*
   - *Other: [Text box for open answer]*

3. How effective to you consider investing in flood protection measures that limit flood damage?[19]

4. How costly do you think it is to take flood protection measures?

5. How difficult do you think it is to take flood protection measures that limit flood damage?

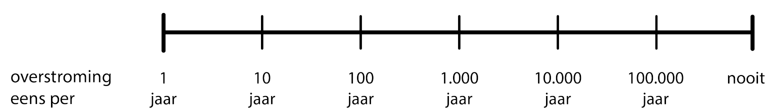
[19] This question was taken from Poussin et al. (2014)

6. Please tell me, how willing or unwilling you are to take risks if it concerns floods?

7. How willing are you to give up money today in order to benefit more from that in the future?

8. To what extent do you agree with the following statements?
   (a) I am worried about the danger of flooding at my current residence
   (b) I am confident that the dikes in the Netherlands are maintained well
   (c) I felt regret about not investing in protection when a flood occurred in the game[20]
   (d) People in my direct environment would approve an investment in damage reducing measures
   (e) People in my direct environment think that I should invest in damage reducing measures
   (f) When I get what I want, it is usually because I am lucky[21]
   (g) It is not always wise for me to plan too far ahead because many things turn out to be a matter of good or bad fortune
   (h) I believe that there are a number of measures that people can take to reduce their risk
   (i) I can pretty much determine what will happen in my life
   (j) The probability of flooding at my current residence is too low to be concerned about

9. The government is responsible for the maintenance of dikes. A dike in your neighborhood should be strong enough such that a flood does not happen more than once each 1250 years. The scale below shows different flood probabilities.
   What is according to you the probability of a flood in your neighborhood?



   - *Flood on average once every ... years*
   - *Never*

10. How easy or difficult did you find it to make a choice in the investment game presented to you?

   - *Very easy* • *Easy* • *Not easy/not difficult* • *Difficult* • *Very difficult*

   In case subject answered *Difficult* or *Very difficult* in question 10:

10.a Could you describe what made the investment game difficult for you?

11. What is according to you the probability of a cloudy sky in your residence tomorrow?

12. What is according to you the probability of a cloudy sky and rain in your residence tomorrow?

13. Could you briefly explain how you made your decisions in the investment game?

14. This is the end of the survey. If you have comments, you can write them below.

[20] If the subject did not experience a flood during the experimental phase, this question was phrased as "When in the scenario no flood occurred, I felt regret about paying for protection"

[21] These four questions are developed to measure locus of control (see Sattler et al., 2000)

Appendix E Additional analysis

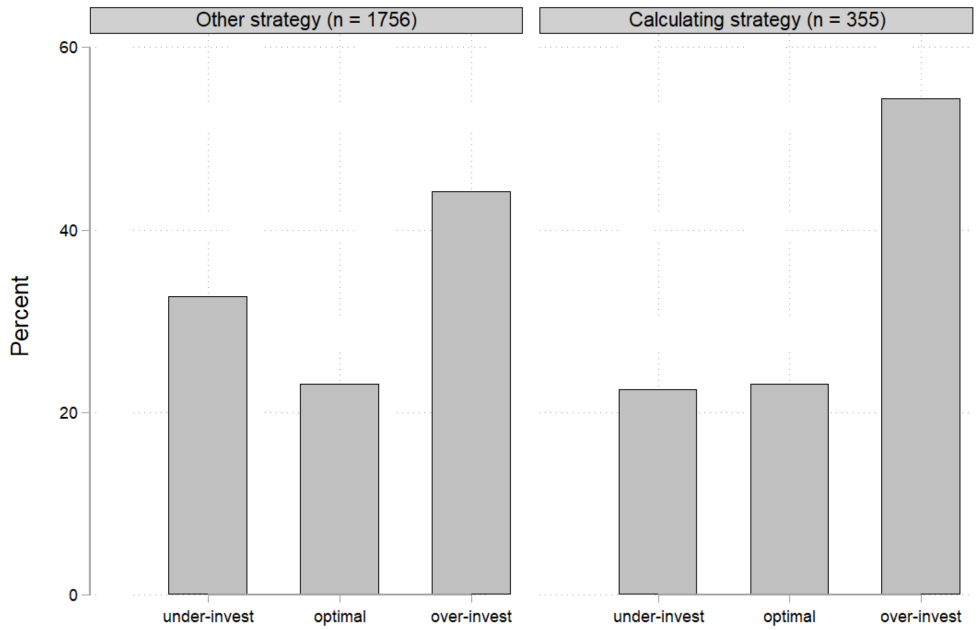


Figure 7: Proportion of optimal and sub-optimal investments, by self-reported strategy.