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An experimental study of charity hazard: The effect of risky and ambiguous government compensation on flood insurance demand

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Abstract
This paper examines the problem of "charity hazard", which is the crowding out of private insurance demand by government compensation. In the context of flood insurance and disaster financing, charity hazard is particularly worrisome given current trends of increasing flood risks as a result of climate change and more people choosing to locate in high-risk areas. We conduct an experimental analysis of the influence on flood insurance demand of risk and ambiguity preferences and the availability of different forms of government compensation for disaster damage. Certain and risky government compensation crowd out demand, confirming charity hazard, but this is not observed for ambiguous compensation. Ambiguity averse subjects have higher insurance demand when government compensation is ambiguous relative to risky. Policy recommendations are discussed to overcome charity hazard.

Keywords: Ambiguity preferences; charity hazard; economic experiment; flood insurance demand; risk preferences.

JEL classification: C91; G52.

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1. Introduction

Individuals typically underinsure low-probability/high-impact natural disaster risks (Kunreuther and Pauly, 2004). These risks tend to be underestimated by individuals (Viscusi and Zeckhauser, 2006). Systematic behavioural biases and heuristics can explain lack of demand for insurance and protective measures, as well as low risk perceptions (Slovic et al., 1977; Meyer and Kunreuther, 2017). However, underinsurance by individuals may also result from rational expectations that governments provide compensation after disaster strikes. The "Samaritan's dilemma" describes a situation whereby the receipt of unconditional financial assistance from the government incentivizes individuals not to take protective measures (Buchanan, 1975). Crowding out of private insurance by government compensation for disaster damage has also been termed the "charity hazard" (Browne and Hoyt, 2000). Reliance on government compensation can have negative efficiency effects (Coate, 1995). This is partly due to weak incentives by governments to manage resources carefully, and to examine where disaster relief is most needed (Raschky and Weck-Hannemann, 2007). Another source of inefficiency relates to politically motivated government compensation payments. For example, Garrett and Sobel (2003) find that disaster expenditures made by the Federal Emergency Management Agency (FEMA) as well as U.S. presidential disaster declarations are politically motivated, and in particular depend on election years and states considered important to the outcome of elections.

This study focusses on insurance against flood risk, which is the most costly natural disaster risk worldwide (Miller et al., 2008). During the 2017 Atlantic hurricane season, which ranked as one of the most destructive in U.S. history (Chew et al., 2018), National Flood Insurance Program (NFIP) policyholders filed approximately 133,000 claims. Moreover, FEMA paid more than $2 billion in federal disaster assistance, which is a form of ad hoc government compensation for uninsured losses.[3] The co-existence of the NFIP and disaster compensation by FEMA means that the charity hazard is a potential issue for the flood insurance market in the U.S., like is also the case in many European countries (Porrini and Schwarze, 2014).

In the Netherlands (our policy context) the government may provide partial compensation for flood damage via the Calamities and Compensation Act (WTS[4]) (Botzen and van den Bergh, 2008). However, the WTS has no established funds and no clear rules outlining under what circumstances flood damage will be compensated and by how much. Moreover, there is no legal obligation for the Dutch government to compensate damages. Therefore, it is currently ambiguous whether households will receive compensation for flood damages in the Netherlands (Surminski et al., 2015). Efforts have been made in recent years to make private flood insurance more widely available, but this insurance is purchased by only a small fraction of the Dutch population (Suykens et al., 2016). In addition to the high costs of offering flood insurance in the Netherlands, the potential for charity hazard may slow the uptake of this insurance by homeowners. Given increasing flood risks from climate change and socio-economic developments (IPCC, 2012), having adequate flood insurance coverage becomes more important for offering financial protection against residual flood risk, which implies that the charity hazard is especially problematic. Therefore, it is relevant to understand under which conditions charity hazard occurs, which is the focus of this paper.

[3] These data are available on the FEMA website.

[4] Acronym in Dutch.

Other forms of government compensation for natural disaster damages exist across Europe. Contrary to the ad hoc Dutch compensation scheme, Austria accumulates funds through mandatory taxation, to be used for financing relief payments to cover flood damages (Schwarze et al., 2011). Although individuals have no legal entitlement to government compensation, the well-functioning nature of the Austrian catastrophe fund generates certainty about compensation receipt according to Raschky et al. (2013). In other countries like Germany, relief is not controlled by formal legislation, and payout can depend on factors like media coverage and election years (Thieken et al., 2006). Nevertheless, high levels of compensation have typically been granted in Germany following flood events in the past (Surminski and Thieken, 2017). Other examples of high levels of government relief to homeowners can be found in Hungary, where extensive compensation was provided after the 2001 Tisza flood (Vari et al., 2003). Similar to the U.S. but in contrast to the other European examples, France requires an official natural disaster declaration before individuals can receive compensation. However, this is not based on pre-defined levels of flood damage, so compensation is also ambiguous in France (Paudel et al., 2012). Given the apparent differences in the extent and degree of riskiness and/or ambiguity in government compensation across different countries, it is relevant to examine which forms of compensation crowd out private demand for insurance the least.

According to Jaspersen (2016) and Robinson and Botzen (2019), we define a decision under risk as a situation where the probability of each possible outcome is known. If the probabilities are not known, and a distribution of probabilities over possible probabilities is not known either, the decision is considered one under ambiguity. Ambiguity and/or riskiness in government compensation is perhaps also relative to the number of times individuals have received flood-related compensation in the past. If individuals have been flooded many times in the past, it may be easier for them to accurately assign a probability to the likelihood of receiving compensation (it becomes riskier vs. more ambiguous). On the contrary, if somebody has never been flooded in the past it may be very difficult to assign a precise probability to the likelihood of receiving government compensation. The latter is more relevant to the Dutch context where experience with flooding is scarce due to high levels of flood protection.

So far empirical evidence on the charity hazard is rather mixed (Andor et al., 2017). Contrary to expectations, Browne and Hoyt (2000) showed with NFIP policies-in-force data, that disaster relief expenditures by FEMA positively relate to flood insurance demand. The authors proposed that their positive result can arise because their analysis insufficiently controls for risk exposure which affects both demand for insurance and the receipt of government relief. Another potential source of endogeneity in their dataset concerns reverse causality, i.e., the more insured an area is, the less government compensation may be required after a flood. Kousky et al. (2018) control for endogeneity by employing a two-stage least squares analysis.[5] Their instrumental variable is an interaction term between timing of presidential elections and states considered important for the outcome of elections. According to Garrett and Sobel (2003), the variable provides a useful exogenous source of variation in relief payments. Kousky et al. (2018) showed that individual assistance grants have a negative impact on flood insurance demand once endogeneity has been controlled for.

[5] See also Deryugina and Kirwan (2018).

Survey research conducted in coastal regions by Petrolia et al. (2013) in the U.S. find that perceived eligibility for post-disaster relief has a positive effect on the probability of holding flood insurance, in contrast to the charity hazard. In light of these findings, the authors suggested that their measure of disaster assistance expectations may be biased if individuals relying on this assistance are ashamed to admit it. In a follow-up study using the same survey data, Landry et al. (2019) instrumented for post-disaster relief expectations using data on congressional members that served on subcommittees which have direct oversight of FEMA spending, as well as payment history of the FEMA public assistance grant program. They found that perceived eligibility for post-disaster relief has a negative effect on flood insurance demand in the follow-up analysis. In another survey study by Botzen et al. (2019), the purchase of flood insurance in the U.S. is negatively related to previous receipt of federal disaster assistance. Moreover, Botzen and van den Bergh (2012) reported in a stated preference study in the Netherlands that when hypothetical flood insurance demand is elicited in a survey version which may grant government compensation, demand is less than a version in which compensation is not available.

Raschky et al. (2013) conducted a survey about flood insurance demand in Austria where partial certain government compensation is provided, and in Germany which has granted full ambiguous government compensation in the past. Their survey results show that expectations about disaster relief crowd out insurance demand more in Austria than in Germany. We aim to re-examine this finding in an experimental setting, allowing for better control over extraneous factors, which are typically challenging to control for in the field. For example, other factors of influence on flood insurance demand, like objective risk levels, may differ between Germany and Austria and partly drive the results by Raschky et al. (2013), while our experimental setting controls for such factors. In general, experimental studies which have an explicit environmental context can be useful to study the impact of certain types of variables (Gsottbauer and van den Bergh, 2011), like the influence of government compensation on insurance demand.

Despite the relatively large literature on insurance demand in experimental research (Jaspersen, 2016), to our knowledge Brunette et al. (2013) are the only ones to have directly incorporated government compensation into their design. They also find that partial certain government compensation crowds out demand for insurance.[6] However, their evidence is based on a hypothetically incentivized experiment, even though incentives have been shown to significantly reduce insurance demand choice anomalies (Laury et al., 2009; Jaspersen, 2016). Moreover, Brunette et al. (2013) implement uncertainty in the probability of loss, whereas we investigate how ambiguity in government compensation affects insurance decisions. This is relevant because in practice government compensation for disaster damage is often ambiguous, albeit to different degrees.

We employ an incentivized experiment to study several theoretical predictions related to the charity hazard hypothesis, risk preferences, ambiguity preferences and insurance pricing. Our theory analysis is informed by previous studies by Kelly and Kleffner (2003) and Raschky and Weck-Hannemann (2007), who investigated the effect of government compensation on insurance demand in an Expected Utility framework. However, our analysis also examines the charity hazard under imprecise knowledge about government compensation, for which we utilize the

[6] Their examination of the charity hazard was conducted within-subjects, so contrast effects cannot be ruled out (Greenwald, 1976).

Klibanoff et al. (2005) smooth model of decision making under ambiguity. Some examples of ambiguity preference elicitation under this model are Chakravarty and Roy (2009) and Attanasi et al. (2014).[7] An examination such as ours highlights the usefulness of an experiment to disentangle the effect of different schemes of government compensation (certain, risky and ambiguous compensation), which is a challenge when using data for actual insurance purchases as well as hypothetical survey methods.

Our experimental findings show that flood insurance demand is negatively impacted by anticipated government compensation, except when the compensation is ambiguous. We also find that ambiguity averse subjects have higher demand for insurance when government compensation is ambiguous relative to risky, according to ambiguity preferences elicited using multiple price list tasks. Furthermore, ambiguity preferences elicited in the gain domain predict a unique effect on insurance demand better under ambiguous government compensation, relative to those elicited in the loss domain. Regarding risk preferences, a stated risk aversion measure which has been shown to correlate well with risk taking behaviour in practice better predicts flood insurance demand and aversion to mean-preserving spreads than risk preferences elicited in multiple price list tasks. Moreover, we do not find that risk averse subjects demand more insurance when the compensation provided is risky as opposed to certain. Lastly, the insurance loading factor has a negative impact on flood insurance demand, as expected.

The paper is structured as follows: Section 2 outlines the theoretical framework and hypotheses. Section 3 describes our experimental design and implementation. Section 4 reports the experimental findings based on a non-parametric and parametric analysis. Section 5 discusses these findings in relation to the hypotheses, and suggests several recommendations for policy. Section 6 concludes the paper.

2. Theory and hypotheses

An individual with initial wealth, W, faces a loss, $L \in (0, W)$, with probability p $(0 < p < 1)$ and no loss with probability $1 - p$ (we assume that the probability of loss is objectively known, as it is in our experiment). The individual has a strictly increasing utility function $U(\cdot)$, defined on final wealth. Insurance coverage, $V = L\alpha$, may be purchased to protect against potential loss, where $\alpha \in (0,1)$ is the extent of coverage. The insurance premium is $P = L\alpha p\lambda$, and the loading factor is λ, where $\lambda = 1$ for actuarially fair insurance, $0 \leq \lambda < 1$ for subsidized insurance and $\lambda > 1$ for commercial (positively loaded) insurance. Without government compensation the individual will choose a level of α to maximize his/her Expected Utility (EU):

$$EU = pU\big[W - P(\alpha) - \big(L - V(\alpha)\big)\big] + (1 - p)U[W - P(\alpha)] \quad (1)$$

Assuming the individual anticipates the government will provide compensation, θ $(0 < \theta < 1)$, to pay for a proportion of the uninsured damage, equation 1 is modified to:

[7] The Klibanoff et al. (2005) smooth model has also been applied in various empirical and theoretical papers, such as Bajtelsmit et al. (2015), Snow (2011), Conte and Hey (2013) and Qiu and Weitzel (2016).

$$EU = pU\big[W - P(\alpha) - (1-\theta)\big(L - V(\alpha)\big)\big] + (1-p)U[W - P(\alpha)] \quad (2)$$

If the individual decides not to purchase insurance, her/his EU_{NI} (EU with no insurance) is:

$$EU_{NI} = pU[W - (1-\theta)L] + (1-p)U[W] \quad (3)$$

We denote willingness-to-pay for full insurance ($\alpha = 1$) as WTP, defined by:

$$EU_{NI} = U[W - WTP] \quad (4)$$

We assume that the individual is willing-to-purchase full insurance if and only if $WTP \geq P(1)$, otherwise the individual will choose not to insure. Under linear $U(\cdot)$ (risk neutrality), EU_{NI} is equal to the utility of the expected value:

$$U[W - WTP_{RN}] = EU_{NI} = U[p[W - (1-\theta)L] + (1-p)[W]] \quad (5)$$

Under concave $U(\cdot)$ (risk aversion), EU_{NI} is less than the utility of the expected value:

$$U[W - WTP_{RA}] = EU_{NI} < U[p[W - (1-\theta)L] + (1-p)[W]] = U[W - WTP_{RN}] \quad (6)$$

Under convex $U(\cdot)$ (risk seeking), EU_{NI} is greater than the utility of the expected value:

$$U[W - WTP_{RS}] = EU_{NI} > U[p[W - (1-\theta)L] + (1-p)[W]] = U[W - WTP_{RN}] \quad (7)$$

Assuming p, θ, α and λ remain constant across levels of risk aversion, we can infer from equations 5, 6 and 7 that $U[W - WTP_{RA}] < U[W - WTP_{RN}] < U[W - WTP_{RS}]$, hence $WTP_{RS} < WTP_{RN} < WTP_{RA}$. That is, willingness-to-pay for full insurance increases with the degree of risk aversion.[8]

H1: Willingness-to-pay for full insurance is positively related to the degree of risk aversion.

We assume that the individual will purchase full insurance if her/his EU with full insurance is greater than EU without insurance, therefore $WTP > P(1)$:

$$EU_{NI} = U[W - WTP] < U[W - P(1)] \quad (8)$$

[8] This is true for any insurance coverage level $\alpha \in (0,1)$. We consider full insurance is a pure simplification.

More insurance premium loading reduces EU with full insurance because $P(1) = Lp\lambda$ is increasing in λ.[9] Consequently, the gap between EU with full insurance and EU without insurance becomes smaller. There is a critical value of λ where EU without insurance becomes greater than the EU with full insurance, and so the individual chooses not to insure, i.e., $WTP < P(1)$.

H2: Willingness-to-purchase full insurance is negatively related to the loading factor.[10]

Consider two risks of loss, $R_1(p_1, L_1)$ and $R_2(p_2, L_2)$, i.e., a loss L_1 (L_2) occurs with probability p_1 (p_2). The two risks have the same expected value, but $L_2 > L_1$ and $p_2 < p_1$. That is, R_1 and R_2 have equal mean but R_2 has higher variance than R_1. Under concave $U(\cdot)$ (risk aversion), without insurance EU across the two scenarios are:

$$EU_{NI}^1 = p_1 U[W - (1-\theta)L_1] + (1-p_1)U[W] = U(W - WTP_{RA}^1) \quad (9)$$

$$EU_{NI}^2 = p_2 U[W - (1-\theta)L_2] + (1-p_2)U[W] = U(W - WTP_{RA}^2) \quad (10)$$

When loss occurs, since $L_2 > L_1$:

$$U[W - (1-\theta)L_1] > U[W - (1-\theta)L_2] \quad (11)$$

For both R_1 and R_2, the alternative utility without loss is the same ($U[W]$). Also, $U[W] > U[W - (1-\theta)L_1] > U[W - (1-\theta)L_2]$. Under concave $U(\cdot)$ (risk aversion), $EU_{NI}^1 > EU_{NI}^2$, hence $U(W - WTP_{RA}^1) > U(W - WTP_{RA}^2)$ and $WTP_{RA}^1 < WTP_{RA}^2$.

H3: Willingness-to-pay for full insurance is negatively related to the probability of loss for risk averse individuals, holding the expected value of loss constant.

Consider again equation 4. Higher levels of government compensation increases the EU without insurance because the share of uninsured loss L becomes lower.[11] Consequently, $U[W - WTP]$ increases, leading to a decrease in WTP. This result follows from the charity hazard highlighted in the introduction section.

H4: Willingness-to-pay for full insurance is negatively related to government compensation.

Assume now that there is an objective probability of receiving government compensation equal to π. When ambiguity is present, there is a second-order probability distribution, $F(\bar{\pi})$, where $\bar{\pi}$ is a possible value of π.[12] For

[9] An increase in the loading factor (λ) increases the insurance premium of full insurance ($P(1)$) and hence reduces the utility of buying full insurance ($U[W - P(1)]$).

[10] Mossin (1968) and Smith (1968) showed that risk averse EU maximizers should demand full insurance when $\lambda = 1$, although partial coverage is optimal when $\lambda > 1$. However, in our experiment we observe only full insurance and zero insurance.

[11] An increase in government compensation (θ) leads to an increase in final wealth in the loss state ($W - (1-\theta)L$), and the corresponding EU without insurance.

[12] For simplicity, the extent of relief, θ, is assumed to be objectively known to the individual, as it is in our experiment.

now assume that the individual faces a decision under risk, with the likelihood of receiving government compensation known, in which case EU is:

$$EU = \pi\{pU[W_{LG}] + (1-p)U[W_{NL}]\} + (1-\pi)\{pU[W_L] + (1-p)U[W_{NL}]\} \quad (12)$$

We define $W_{LG} = W - P(\alpha) - (1-\theta)\big(L - V(\alpha)\big)$ as final wealth in the loss with government compensation state. Similarly, let $W_L = W - P(\alpha) - \big(L - V(\alpha)\big)$ be final wealth in the loss state without government compensation, and $W_{NL} = W - P(\alpha)$ be final wealth in the no loss state. Note that $W_{LG} > W_L$ when $\theta > 0$.[13] There is a risk of government compensation $G(\pi, \theta)$ in equation 12, i.e., the individual receives government compensation θ with probability π in the event of a loss. Assume two risks of government compensation, $G_1(\pi_1, \theta_1)$ and $G_2(\pi_2, \theta_2)$ with the same expected value, but $\theta_2 > \theta_1$ and $\pi_2 < \pi_1$. Under concave $U(\cdot)$ (risk aversion), without insurance EU across the two scenarios are:

$$EU_{NI,1} = \pi_1\{pU[W-(1-\theta_1)L] + (1-p)U[W]\} + (1-\pi_1)\{pU[W-L] + (1-p)U[W]\}$$
$$= p\{\pi_1 U[W-(1-\theta_1)L] + (1-\pi_1)U[W-L]\} + (1-p)U[W] = U[W - WTP_{RA,1}] \quad (13)$$

$$EU_{NI,2} = \pi_2\{pU[W-(1-\theta_2)L] + (1-p)U[W]\} + (1-\pi_2)\{pU[W-L] + (1-p)U[W]\}$$
$$= p\{\pi_2 U[W-(1-\theta_2)L] + (1-\pi_2)U[W-L]\} + (1-p)U[W] = U[W - WTP_{RA,2}] \quad (14)$$

Comparing $\pi_1 U[W-(1-\theta_1)L] + (1-\pi_1)U[W-L]$ with $\pi_2 U[W-(1-\theta_2)L] + (1-\pi_2)U[W-L]$, because $\theta_2 > \theta_1$, we can infer that $W-(1-\theta_2)L > W-(1-\theta_1)L$ and $U[W-(1-\theta_2)L] > U[W-(1-\theta_1)L]$. Moreover, $W-L < W-(1-\theta_1)L < W-(1-\theta_2)L$, therefore $U[W-L] < U[W-(1-\theta_1)L] < U[W-(1-\theta_2)L]$. Similar to **H3**, the concavity of $U(\cdot)$ implies that $EU_{NI,1} > EU_{NI,2}$, or equivalently $U[W - WTP_{RA,1}] > U[W - WTP_{RA,2}]$, hence $WTP_{RA,1} < WTP_{RA,2}$.[14]

H5: Willingness-to-pay for full insurance is negatively related to the probability of government compensation for risk averse individuals, holding the expected value of government compensation constant.

Next we follow the Klibanoff et al. (2005) smooth model, and assume an individual with ambiguity preference, represented by the strictly increasing function, $\varphi(\cdot)$ defined over EU.[15] Under ambiguous government compensation, decisions can be made in accordance with the second order EU function, which we shall call the Klibanoff et al. smooth model value (KMM):

[13] In our experiment we consider equation 12 evaluated at $\pi = 0.5$ and $\theta = 1$ (risky full government compensation), as well as equation 12 evaluated at $\pi = 1$ and $\theta = 0.5$ (certain half government compensation).

[14] This holds so long as $U[W-(1-\theta_1)L] > \pi_2 U[W-(1-\theta_2)L] + (1-\pi_2)U[W-L]$, which always holds in our experiment under risk aversion where we compare $\pi_1 = 1$ and $\theta_1 = 0.5$ to $\pi_2 = 0.5$ and $\theta_2 = 1$.

[15] In our experiment, we examine attitude towards ambiguity due to the existence of multiple non-excludable priors.

$$KMM = E\left\{\varphi\left\{\bar{\pi}\{pU[W_{LG}] + (1-p)U[W_{NL}]\} + (1-\bar{\pi})\{pU[W_L] + (1-p)U[W_{NL}]\}\right\}\right\} \quad (15)$$

$E(\cdot)$ is the expectation with respect to $F(\bar{\pi})$. In our experiment, under ambiguous government compensation, there are two possible objective probability distributions regarding $\bar{\pi}$, either probability 1 is assigned to $\{pU[W_{LG}] + (1-p)U[W_{NL}]\}$, or probability 1 is assigned to $\{pU[W_L] + (1-p)U[W_{NL}]\}$. That is, either an individual is compensated by the government fully in case of a loss with certainty, or she/he is not compensated by the government. There are subjective probability beliefs represented by $\sigma = (\sigma_1, \sigma_0)$, where σ_1 is the belief that the probability of government compensation is certain and σ_0 is the belief that the probability of no government compensation is certain, and $\sigma_1 + \sigma_0 = 1$. Evaluation of the insurance decision is then given by:

$$KMM = \sigma_1\varphi\{pU[W_{LG}] + (1-p)U[W_{NL}]\} + \sigma_0\varphi\{pU[W_L] + (1-p)U[W_{NL}]\} \quad (16)$$

If the individual decides not to purchase insurance:

$$KMM_{NI} = \sigma_1\varphi\{U[W]\} + \sigma_0\varphi\{pU[W-L] + (1-p)U[W]\} = E\left\{\varphi\{EU(\bar{\pi})\}\right\} \quad (17)$$

Under linear $\varphi(\cdot)$ (ambiguity neutrality):

$$\varphi\{U[W - WTP_{AN}]\} = KMM_{NI} = \varphi\left\{E\left(EU(\bar{\pi})\right)\right\} \quad (18)$$

Under concave $\varphi(\cdot)$ (ambiguity aversion):

$$\varphi\{U[W - WTP_{AA}]\} = KMM_{NI} < \varphi\left\{E\left(EU(\bar{\pi})\right)\right\} = \varphi\{U[W - WTP_{AN}]\} \quad (19)$$

Under convex $\varphi(\cdot)$ (ambiguity seeking):

$$\varphi\{U[W - WTP_{AS}]\} = KMM_{NI} > \varphi\left\{E\left(EU(\bar{\pi})\right)\right\} = \varphi\{U[W - WTP_{AN}]\} \quad (20)$$

We can infer from equations 18, 19 and 20 that $\varphi\{U[W - WTP_{AA}]\} < \varphi\{U[W - WTP_{AN}]\} < \varphi\{U[W - WTP_{AS}]\}$, therefore $WTP_{AS} < WTP_{AN} < WTP_{AA}$. That is, willingness-to-pay for full insurance increases with the degree of ambiguity aversion under ambiguous government compensation.

H6: Willingness-to-pay for full insurance is positively related to the degree of ambiguity aversion when government compensation is ambiguous.

Under risky full government compensation (equation 12 evaluated at $\pi = 0.5$ and $\theta = 1$), and without insurance EU becomes:

$$EU_{NI,RF} = 0.5U[W] + 0.5\{pU[W-L] + (1-p)U[W]\} = U[W - WTP_{RF}] \quad (21)$$

Assuming $\sigma = (0.5,0.5)$,[16] under ambiguous full government compensation, without insurance KMM becomes:

$$KMM_{NI} = 0.5\varphi\{U[W]\} + 0.5\varphi\{pU[W-L] + (1-p)U[W]\} = \varphi\{U[W - WTP]\} \quad (22)$$

Under linear $\varphi(\cdot)$ (ambiguity neutrality), the individual is a (subjective) EU maximizer:

$$U[W - WTP_{RF}] = EU_{NI,RF} = KMM_{NI} = \varphi\{U[W - WTP_{AN}]\} \quad (23)$$

Under concave $\varphi(\cdot)$ (ambiguity aversion):

$$U[W - WTP_{RF}] = EU_{NI,RF} > KMM_{NI} = \varphi\{U[W - WTP_{AA}]\} \quad (24)$$

Under convex $\varphi(\cdot)$ (ambiguity seeking):

$$U[W - WTP_{RF}] = EU_{NI,RF} < KMM_{NI} = \varphi\{U[W - WTP_{AS}]\} \quad (25)$$

We can infer from equations 23, 24 and 25 that $\varphi\{U[W - WTP_{AA}]\} < \varphi\{U[W - WTP_{AN}]\} = U[W - WTP_{RF}] < \varphi\{U[W - WTP_{AS}]\}$, therefore $WTP_{AA} > WTP_{AN} = WTP_{RF} > WTP_{AS}$.[17]

H7: Willingness-to-pay for full insurance is higher under ambiguous full government compensation vs. risky full government compensation for ambiguity averse individuals.

H6 and **H7** are robust to other ambiguity theories like Maxmin EU (Gilboa and Schmeidler, 1989), because an ambiguity averse individual following Maxmin EU will consider the minimal EU under ambiguous full compensation, which is EU under no government compensation. Note that Maxmin EU is a special case of the Klibanoff et al. (2005) smooth model, where φ places all of the weight on the worst EU. Appendix A provides a welfare evaluation of the insurance decision over the experimental parameters involved in our study using simulations that illustrate our hypotheses numerically.

[16] See Chakravarty and Roy (2009, pp.215-216) for a discussion of this assumption. More specifically, the assumption has the potential to confound ambiguity preference parameters. Indeed, values of σ may be impacted by factors like fear and hope (Viscusi and Chesson, 1999). We acknowledge, as do Chakravarty and Roy (2009), that the assumption is a limitation of our study.

[17] Note that this also holds under the more general condition: $\sigma = \pi$.

3. Experiment

A sample of 200 subjects were recruited to participate in this study from the student population of VU University Amsterdam. Prior to the experiment implementation, we conducted several pre-tests to refine the experiment instructions. We did not have sufficient study data on every condition to conduct a power analysis to choose our sample sizes. Instead we used observations per condition in Laury et al. (2009) to inform our overall sample size. Moreover, an advantage of our panel data setup (compared to cross-section data) is multiple observations per individual, which allows us to control for unobserved heterogeneity and increases the precision and efficiency of estimators (Cameron and Trivedi, 2005).

55.5% of subjects were male, 62% were Dutch and the average age was 22.3 years. Subjects were also from a wide range of disciplines. The experiment consisted of two phases, the first of which elicited risk and ambiguity preferences (Section 3.1). In the second phase, subjects faced a series of flood insurance purchase decisions with different types of government compensation available to cover uninsured flood damages (Section 3.2).[18] Section 3.3 describes how the subjects in the experiment were paid (see Appendix B for a detailed overview of the experiment instructions).

3.1 Phase one

3.1.1 Earnings task

At the beginning of phase one, subjects were told that they would be paid a participation fee of €15, and that this payment would not be at risk during the experiment. Subjects were then informed that there would be four decision making tasks in the first phase, and that the first two tasks would involve losses. To make sure subjects could not make a net loss and owe money to the experimenters, they were given the opportunity to earn an endowment. The endowment was earned by opening boxes on their computer screen (for each box that contained money subjects received 2,000 CU – currency units). Once thirty boxes containing money had been opened, subjects could proceed with the first decision making task with their endowment of 60,000 CU to be used in both the first and second tasks.[19]

3.1.2 Risk preference elicitation

To elicit risk preferences we developed a modified version of the multiple price list (MPL) task of Drichoutis and Lusk (2016), as well as eliciting a stated measure of risk preference according to Dohmen et al. (2011). An advantage of the MPL measure over the stated measure is that it is an incentivized measure which can be used to elicit (bounds of) risk preference parameters under EU. It can be argued that in order to associate actual risky behaviour with risk preferences their elicitation should be incentivized so that they reflect true preferences towards risk (Charness

[18] It was a design choice to elicit risk and ambiguity attitudes first, then insurance choices. One could argue that subjects have some subconscious motivation to restate their risk and ambiguity preferences in their insurance decisions for some desire to be consistent. We could have studied order effects, although Harrison and Ng (2016) mention that it is likely to be empirically unimportant whether insurance choices or preferences are elicited first. Moreover, we randomly select one decision from either phase one or phase two to be paid, so it was in subjects' best interest to treat all decisions independently as the only one that they were facing (Papon, 2008). We acknowledge that there are also possible disadvantages of only paying one choice (see e.g., Cubitt et al., 1998).

[19] The rationale for this earnings task was to eliminate the potential for a "house money effect", where subjects are more risk taking when endowed with a prior monetary gain (Thaler and Johnson, 1990).

et al., 2013). However, MPL measures have been criticized because they are complex which may result in a high incidence of decision making errors (Dave et al., 2010). A stated measure of risk preference may overcome the latter concern. Moreover, Dohmen et al. (2011) showed that a stated general measure of risk preference is a good all-round predictor of risky behaviour across a number of real-life domains of risk taking.

The MPL task involves a series of ten decisions between two prospects with constant probabilities, but modifying outcomes.[20] We favored their format over the MPL developed by Holt and Laury (2002) which varies probabilities instead of outcomes, because the measure used by Drichoutis and Lusk (2016) has been shown to have greater consistency and more predictive power (Csermely and Rabas, 2016). Csermely and Rabas (2016) advise using this task over all other commonly used MPL tasks to derive risk preferences.

In Drichoutis and Lusk's (2016) MPL, the probability of all outcomes are held constant at 0.5. Using this framework we developed the MPL in Table 1 for the first decision making task. We set the highest absolute outcome in this task equal to the greatest loss subjects could face in the second phase. Subjects could switch between preferring Option A to preferring Option B only once (similar to other tasks in this phase). If a subject chose to switch at either decision line 5 or 6, they were presented with a follow-up question asking whether they are indifferent between prospects (0.5: -480 CU, 0.5: -720 CU) and (0.5: -1,200 CU, 0.5: 0 CU), yes or no.[21] That way we could determine whether subjects had risk neutral preferences which is consistent with being indifferent between these prospects.

Risk preferences were derived in both the gain and loss domains. Assuming outcomes are processed in the gain domain, under constant relative risk aversion the utility function equals $U[x] = x^r$, and when outcomes are processed as losses, the utility function is $U[x] = -(-x)^b$. In addition to the MPL utilized in Table 1, we presented subjects an analogous MPL in the gain domain in the third decision making task, with all outcomes converted into gains and the left hand outcomes of Option A and B presented in reverse order. More risk averse subjects chose the left hand option, with less variable potential outcomes, a greater number of times in the first and third tasks. It is an open question whether subjects in our experiment integrated their endowment and (possible) government compensation into potential losses, or viewed flood losses in isolation in deciding whether or not to insure (e.g., Read et al., 1999). Risk preferences elicited in the gain (loss) domain would better predict the former (latter) type of mental accounting.

The stated measure of risk preference was elicited at the end of the experiment (after phase one and two) with the question: "How do you see yourself: are you generally a person who is willing to take risks or do you try to avoid taking risks? Please use a scale from 1 to 10, where a 1 means you are "completely unwilling to take risks", and a 10 means you are "very willing to take risks". You can also answer values in-between to indicate where you fall on the scale." Note that we reverse-coded the data for the analysis so that higher values represent more risk aversion.

[20] For an earlier risk preference elicitation where probabilities are held constant see also Wakker and Deneffe (1996).

[21] The prospects are written: (probability: monetary outcome in currency units, probability: monetary outcome in currency units).

Table 1: Multiple price list used to elicit risk preferences in the loss domain, with the probability (Pr.) of outcomes in currency units (CU) and expected value (EV) differences as well as loss domain risk preference parameters (b)

	Option A				Option B					
#	Pr.	CU	Pr.	CU	Pr.	CU	Pr.	CU	EV difference	b implied by indifference
1	0.5	-560	0.5	-720	0.5	-60,000	0.5	0	29,360	0.15
2	0.5	-540	0.5	-720	0.5	-5,600	0.5	0	2,170	0.32
3	0.5	-520	0.5	-720	0.5	-2,400	0.5	0	580	0.51
4	0.5	-500	0.5	-720	0.5	-1,560	0.5	0	170	0.73
5	0.5	-480	0.5	-720	0.5	-1,200	0.5	0	0	1
6	0.5	-460	0.5	-720	0.5	-1,000	0.5	0	-90	1.33
7	0.5	-440	0.5	-720	0.5	-876	0.5	0	-142	1.78
8	0.5	-420	0.5	-720	0.5	-795	0.5	0	-172.5	2.42
9	0.5	-400	0.5	-720	0.5	-744	0.5	0	-188	3.56
10	0.5	-380	0.5	-720	0.5	-720	0.5	0	-190	No solution

3.1.3 Ambiguity preference elicitation

In the second decision making task we used another type of MPL to elicit ambiguity preferences in the loss domain according to procedures in Chakravarty and Roy (2009). Their MPL experiments allow for the derivation of ambiguity preferences given the Klibanoff et al. (2005) smooth model framework. Subjects were told that there exists two bingo cages, bingo cage X and bingo cage Y. Bingo cage X contains 5 black balls and 5 white balls, and bingo cage Y contains 10 balls which are either all black or all white. Subjects were then asked to bet on one colour (black or white). They were also asked to imagine that a ball will be drawn from bingo cage X if Option X is chosen, or bingo cage Y if Option Y is chosen on a given decision line. Subjects expressed their preferences between the two options in the MPL in Table 2.

Bingo cage X induces a risky prospect which we assume subjects evaluate in terms of its EU. Chakravarty and Roy (2009) showed that bingo cage Y induces two potential degenerate prospects, which are two prospects yielding one fixed outcome with probability 1, i.e., (1: 0 CU, 0: -28,000 CU) and (0: 0 CU, 1: -28,000 CU). Assuming the subjective probability belief over the set: {B: all-black, W: all-white}, which is represented by $\sigma = (\sigma_B, \sigma_W)$, and $\sigma_B + \sigma_W = 1$, for a subject betting on black, Option Y is evaluated as follows:

$$KMM = \sigma_B \varphi\{U[0]\} + \sigma_W \varphi\{U[-28{,}000]\} \quad (26)$$

If φ also takes the power form, such that $\varphi(z) = -(-z)^c$, for losses we have:

$$KMM = -(1 - \sigma_B)[28{,}000]^{bc} \quad (27)$$

Equation 27 can be used to derive c given that we assume, similar to Chakravarty and Roy (2009), that $\sigma = (0.5{,}0.5)$ and EU when subjects evaluate bingo cage X. In the gain domain, preferences towards ambiguity can be elicited in a similar way. More ambiguity averse subjects preferred the risky Option X more times than the ambiguous Option Y. The fourth decision making task elicited ambiguity preferences in the gain domain. Analogous to the second

task, subjects were invited to bet on either one of two coloured balls (blue or red), and then made a series of decisions between two options (Option V and Option W). Ambiguity preferences may differ in the gain and loss domains in addition to risk preferences (Trautmann and van de Kuilen, 2015), which provides sufficient reasoning to elicit them in both decision domains to test their relative predictive power. To the best of our knowledge there exists no widely used stated measure of ambiguity preferences, therefore we did not elicit stated ambiguity aversion.

Table 2: Multiple price list used to elicit ambiguity preferences in the loss domain, with outcomes in currency units (CU) and loss domain ambiguity preference parameters (*c*)

	Option X (Cage X: 5 black, 5 white)				**Option Y (Cage Y: either all black or all white)**				
#	**Colour match**	**CU**	**Colour match**	**CU**	**Colour match**	**CU**	**Colour match**	**CU**	***c* implied by indifference**
1	Yes	0	No	-800	Yes	0	No	-28,000	0.65
2	Yes	0	No	-3,700	Yes	0	No	-28,000	0.8
3	Yes	0	No	-12,000	Yes	0	No	-28,000	0.92
4	Yes	0	No	-17,000	Yes	0	No	-28,000	0.95
5	Yes	0	No	-22,000	Yes	0	No	-28,000	0.98
6	Yes	0	No	-28,000	Yes	0	No	-28,000	1
7	Yes	0	No	-35,000	Yes	0	No	-28,000	1.02
8	Yes	0	No	-43,000	Yes	0	No	-28,000	1.04
9	Yes	0	No	-50,000	Yes	0	No	-28,000	1.06
10	Yes	0	No	-60,000	Yes	0	No	-28,000	1.07

3.2 Phase two

The setup of phase two of the experiment was close to Laury et al. (2009), who examined whether individuals insure low-probability/high-impact risks more often than high-probability/low-impact risks with the same expected value of loss. Their design provided a useful setup for our experiment because homeowners in the Netherlands who face low-probability flood risks can experience very costly flood damages, whereas homeowners located in high-probability areas typically experience lower flood water levels and damages due to property elevation (de Moel et al., 2014). We adapt the basic features of the Laury et al. (2009) experiment to our study, i.e., subjects first faced an earnings task, and then insurance decisions from an endowed bank balance involving different loading factors and loss probabilities (holding expected values of loss constant).

3.2.1 Earnings task

Subjects completed fifteen general knowledge multiple choice questions to earn their endowment in the second phase. If eight or more questions were answered correctly, subjects were endowed a bank balance of 60,000 CU, and otherwise they were paid 30,000 CU.[22] The endowments were equal to the highest flood loss subjects could face in the insurance decisions to avoid bankruptcy concerns. Subjects could either pay for flood insurance or flood damages from their endowment within a given insurance decision. We chose a relatively easy knowledge task to avoid confounding the endowment with knowledge (Laury et al., 2009), and to ensure the task required approximately the

[22] 60,000 CU was endowed to all subjects since every subject answered eight or more questions correctly.

same level of effort as the phase one earnings task. Requiring subjects to complete the phase one earnings task again may have been perceived as monotonous and confusing.

3.2.2 Flood insurance purchase decisions

Upon completion of the earnings task, subjects were randomly assigned to face one of several versions of phase two, based on the following written information:

Insurance purchase decision instructions

A current insurance policy for house and contents in the Netherlands does not cover damage caused by flooding from dike failure. The government can provide compensation for flood damage, however, this compensation may be influenced by political decision making.

Suppose that it is now possible to buy flood insurance [text about government compensation that differs between versions.]

You will now make a series of decisions about purchasing flood insurance in situations with different levels of flood risk.

Our experiment is a framed one (i.e., in the context of flood risk), therefore some context was warranted regarding the source of certain, risky and ambiguous government compensation. There are advantages to framing an insurance experiment in a specific context as summarized in a recent literature review by Robinson and Botzen (2019), such as external validity and in the absence of contextual framing individuals may make up their own. We tried to keep the source of certain, risky and ambiguous government compensation as neutral as possible, because offering more contextual richness (e.g., political factors and flooding experience), may have lead subjects to based their priors about government compensation more on contextual elements rather than the riskiness and ambiguity by and of itself.

In one version, (52) subjects read the following text about government compensation: "… it is no longer possible to receive compensation for flood damage via the government." This serves as our baseline condition, from which we will evaluate the influence of several government compensation schemes.[23] In total there were three government compensation schemes, certain half government compensation, risky full government compensation, and ambiguous full government compensation. Each scheme had the following respective texts about government compensation: "There are two political commentators, who both agree that you will be compensated by the government for flood damages for certain. You will be compensated for 50% of damages in the event you are flooded and don't hold insurance." (certain half); "There are two political commentators, who both agree that your chances of being compensated by the government for flood damages are 1 in 2. You will be compensated for 100% of damages in the event you are flooded, don't hold insurance and compensation is approved by the government." (risky full);

[23] More subjects were randomly assigned to the baseline condition to increase statistical power, given that subjects in this condition faced half as many insurance decisions as in the other conditions. Subjects were 1.5 times more likely to face the baseline condition than either of the other conditions. Otherwise, there was an equal chance subjects would face the other government compensation conditions according to the random assignment.

"There are two political commentators, who disagree about whether you will be compensated by the government for flood damages. The first commentator believes that you will be compensated for 100% of damages in the event you are flooded and don't hold insurance for certain. The second commentator believes that you will not receive any compensation. It is uncertain which commentator is the most trustworthy." (ambiguous full).[24] Immediately prior to the insurance decisions, we asked subjects to complete four questions to ensure that they fully understood the procedures.

For subjects assigned to face the government compensation versions, midway through the flood insurance decisions subjects were informed that given a change in political circumstances, the type of government compensation would change. One follow-up question was then asked to ensure subjects understood the policy change. 36 subjects faced risky full government compensation first, then certain half. A further 39 subjects faced the schemes in the opposite order. This enables us to examine whether subjects' risk preferences influenced their flood insurance decisions, given the mean-preserving spread in government compensation. Moreover, 32 subjects were exposed to risky full government compensation first, then ambiguous full. The remaining 41 subjects faced the latter schemes in the opposite order. This allows us to investigate whether subjects' ambiguity preferences influenced their flood insurance decisions, given the varying degrees of ambiguity in government compensation. Table 3 displays the distribution of subjects over the experiment versions. Given that subjects did not face certain half government compensation, then ambiguous full or vice versa, we cannot compare these conditions at the individual level.

In a given decision period, subjects faced one of three flooding probabilities, 0.001, 0.01 and 0.1. These probabilities represent realistic flood risks for the Netherlands. For example, in dike-ring areas in the River Rhine delta, the likelihood of river dike failure is 1 in 1,250, although 1 in 1,000 may be less cognitively challenging for individuals to imagine. For homeowners located in less protected areas, the annual probability of flooding can exceed 1 in 100, and reach as high as 1 in 10, although flood damages are likely to be less severe due to both low flood water velocity and depth (Ermolieva et al., 2017). Higher probabilities like 0.1 are also useful to incorporate, because previous experiments report a large change in the proportion of subjects purchasing insurance when the likelihood reaches this level (Slovic et al., 1977). This allows for sufficient variation in our data to estimate the effect of flood probability on insurance demand.

The loading factor, λ, was fixed at either 0.5, 0.75, 1 or 4. We include 0.5 because Appendix A reports that this level of loading is the threshold by which risk averse (seeking) subjects insure (do not insure) when government compensation is present. The latter two loading factors are included in the study by Laury et al. (2009), who showed a significant negative effect of insurance loading on insurance demand.

Combining the three flooding probabilities with the four loading factors provides the twelve flood insurance purchase decisions displayed in Table 4 for subjects who earned 60,000 CU (every subject). Subjects faced these decisions in a random order. In the government compensation conditions subjects faced twenty four insurance decisions in total (twelve under each scheme).

[24] We acknowledge that there are potential confounding variables, given our flood risk context. We do not claim our results are transferrable to other contexts.

Table 3: Distribution of subjects over the experiment versions	
Subjects	**Government compensation scheme**
52	Baseline no government compensation
36	Risky full then certain half government compensation
39	Certain half then risky full government compensation
32	Risky full then ambiguous full government compensation
41	Ambiguous full then risky full government compensation

Table 4: Flood insurance purchase decisions				
#	**Loading Factor**	**Flood loss (CU)**	**Flooding probability**	**Premium (CU)**
1	0.5	60,000	0.001	30
2	0.75	60,000	0.001	45
3	1	60,000	0.001	60
4	4	60,000	0.001	240
5	0.5	6,000	0.01	30
6	0.75	6,000	0.01	45
7	1	6,000	0.01	60
8	4	6,000	0.01	240
9	0.5	600	0.1	30
10	0.75	600	0.1	45
11	1	600	0.1	60
12	4	600	0.1	240

3.3 Payment

Below we describe the mechanisms by which subjects could earn money in the experiment. These mechanisms were explained to subjects in detail throughout the experiment instructions. We used a variety of visualizations to explain how payments would be calculated based on bingo cage drawings, for example. We favored manual operationalization methods like bingo cage drawings to less transparent computerized randomizations.

In addition to the participation fee of €15, a randomly selected group of subjects were paid according to one of their decisions selected at random from either phase one or phase two. That is, subjects were informed that sealed envelopes would be distributed at random after the experiment, which would contain either a green, an orange or a red card. 151 subjects received an envelope containing a red card, and were not paid based on their experiment decisions. 1 subject received a green card, and was paid at an exchange rate of 1% (10,000 CU = €100), therefore they could earn up to €600. 48 subjects received an orange card and the exchange rate was .1%, so they could earn up to €60.[25] In some previous experimental studies, high-impact losses are implemented without performance-based payment (Etchart-Vincent, 2004; 2009; Brunette et al., 2013; Kunreuther and Pauly, 2018). Our mechanism of paying

[25] In a recruitment flyer individuals were told that in addition to the participation fee, they have ~ 25% chance of earning up to €60 based on their decisions, and a small chance of earning up to €600 based on the one randomly selected subject. In addition to the €15 participation fee, the green card subject earned €599.70. On average the orange card subjects earned €53.73 (min: €0, max: €60).

only a subgroup of subjects according to an exchange rate is consistent with Kunreuther and Michel-Kerjan (2015) who also implemented high numerical losses. According to Charness et al. (2016), there is little difference empirically between paying a subgroup of subjects vs. paying everybody in terms of decisions made. Given budget constraints we could only pay a subgroup.

One of the two phases was selected at random using a two-sided coin flip. In phase one, a decision making task was selected by rolling a four-sided die. According to the selected task, we made random bingo cage drawings to determine payment.[26] Given the second phase was selected to be paid, one insurance choice was selected according to a randomly drawn lottery ticket. Drawings of balls from a bingo cage decided whether or not subjects were flooded in the chosen decision, as well as whether government compensation covered uninsured flood damages in the risky full and ambiguous full versions.

4. Experiment results

Section 4.1 conducts non-parametric tests to examine whether insurance demand differs under the alternate probabilities of flooding and different versions of government compensation. Section 4.2 uses a parametric regression analysis, to investigate the impact of government compensation, flooding probability, loading factor, risk preferences and ambiguity preferences on insurance demand.

An overview of descriptive statistics and coding of the dependent and independent variables is included in Table C1 in Appendix C. Figure C1 displays the distribution of risk and ambiguity preferences in the gain and loss domains according to the MPL tasks. On average, subjects are slightly risk seeking in the loss domain and slightly risk averse in the gain domain. Subjects are also on average more ambiguity averse in the gain domain than in the loss domain, where they are closer to ambiguity neutral. These results are broadly in line with previous studies (Wakker, 2010; Trautmann and van de Kuilen, 2015). Figure C2 displays the distribution of risk preferences according to the stated measure of risk preference. Subjects appear to be slightly risk averse on average according to the stated measure.

4.1 Non-parametric analysis

In Figure 1 we display the mean of flood insurance purchase under probabilities 0.001, 0.01 and 0.1, per government compensation version and loading factor. McNemar tests are conducted to investigate whether significant differences exist between insurance purchase under flood probability 0.1 vs. 0.01 and 0.001, because the comparisons are within-subjects.

Under the two lowest loading factors (0.5 and 0.75), there are no significant differences in flood insurance demand under probability 0.1 compared to lower probabilities (p-values > 0.05). For actuarially fair insurance, only in the no government compensation (baseline) condition is there a significant positive difference in demand under flood probability 0.001 relative to 0.1 (p-value < 0.05). With respect to loading factor 4, positive significant differences exist in seven of the eight comparisons under flood probabilities 0.001 and 0.01 compared to 0.1 (p-values < 0.05). These findings of higher insurance demand under probabilities lower than 0.1 are consistent with Laury et al. (2009,

[26] If subjects were risk neutral, i.e., indifferent between the risky prospects with the same expected value in the risk preference tasks, we flipped a coin to decide which option would decide payment (in the case that the decision line was selected for payment).

Figure 2), who showed that the impact of probability on insurance demand is the greatest when loading factor is 4. Moreover, for the greatest expected loss in Laury et al. (2009), which may remove subjects' entire endowment when the probability is low, there is an insignificant effect of loss probability on insurance demand when insurance is subsidized or actuarially fair.[27]

Additionally, in most cases subjects insure slightly less when the flood probability is 0.001 relative to 0.01 despite theoretical predictions. It is sometimes hypothesized that risks are ignored when the perceived probability of that risk is below a threshold level of concern (Slovic et al., 1977; Kunreuther and Pauly, 2004; Robinson and Botzen, 2018). We speculate that a sub-group of subjects find flood probability 0.001 to be below their threshold level of concern.

There is a general trend of lower flood insurance demand under higher loading factors. Between loading factors 0.5 and 0.75 as well as 0.75 and 1, there is a lower incremental reduction in demand, compared to 1 and 4. This is unsurprising given that the relative flood insurance premium increases more in the latter case. In only three of the possible thirty six loading factor comparisons the impact of loading factor is not in the predicted direction.

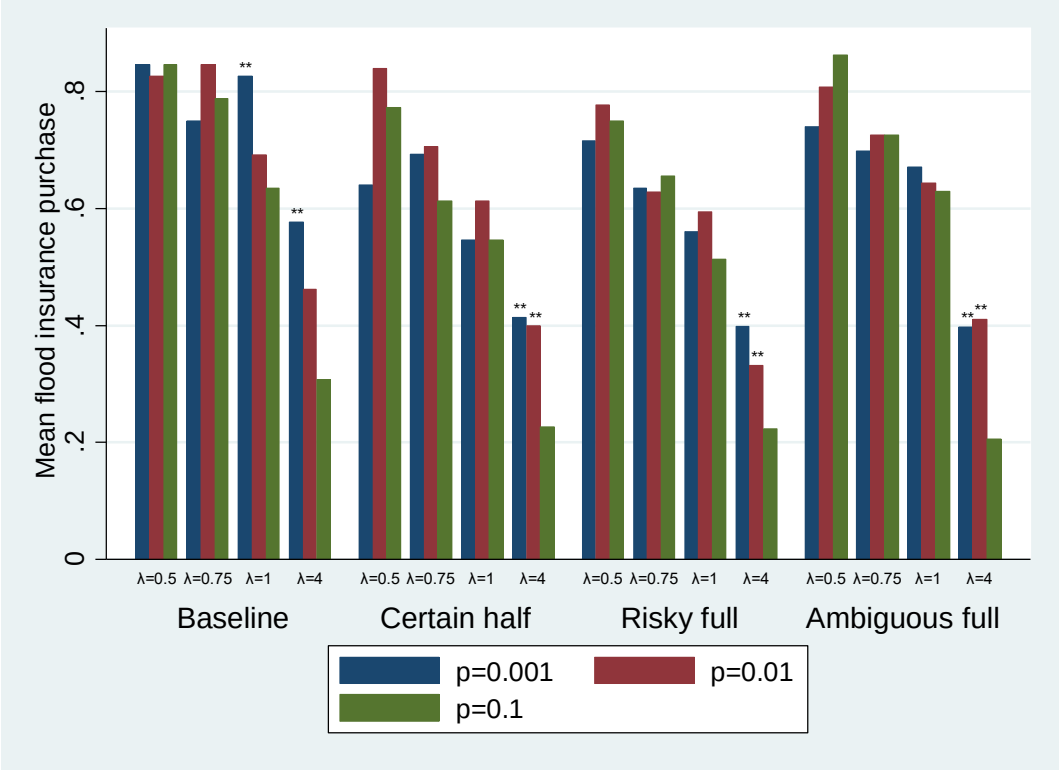


Figure 1: Mean insurance purchases under flooding probabilities (p) 0.001, 0.01 and 0.1, per government compensation version and loading factor (λ) 0.5, 0.75, 1 and 4

Notes: ** indicates a significant difference at the 5% level with respect to flooding probability = 0.1 according to McNemar's test.

[27] This finding is comparable to ours because in our experiment there is one expected loss, which may remove subjects' entire endowment when flooding probability = 0.001.

In Table 5 we investigate the difference in the percentage of subjects insuring in the versions of government compensation (certain half, risky full and ambiguous full), relative to the baseline no government compensation condition. Chi-square tests are conducted to examine whether significant differences exist, because the comparisons are between-subjects.

The table shows that subjects were less likely to purchase insurance under the versions of government compensation relative to the no government compensation condition in nearly all cases, which is consistent with the charity hazard. This effect appears to be strongest and most significant when comparing the no government compensation condition to the certain half and risky full versions of compensation. Only in one case (under flood probability 0.001 and loading factor 4), there is a significantly negative effect of the ambiguous full government compensation version relative to no government compensation (p-value < 0.05). The results imply that flood insurance demand is highest when no government compensation is present, and that certain half as well as risky full compensation have a significantly negative impact on demand. Ambiguous full compensation reduces demand marginally compared to no government compensation, but this effect has little significance. This may suggest that subjects were on average ambiguity averse when facing ambiguous government compensation, and insured more often because of this.

There is no clear evidence to suggest that differences in charity hazard are responsive to the loading factor. Regarding the flood probability, in many cases differences are larger for probability 0.001 except for when the loading factor is 0.75.

Table 5: Percentage difference in insurance purchase under the different conditions of government compensation relative to the baseline (no government compensation condition)

Loading factor	Flooding probability	Certain half	Risky full	Ambiguous full
0.5	0.001	-20.6% (0.011)	-13% (0.063)	-10.6% (0.154)
	0.01	1.3% (0.845)	-5% (0.447)	-1.9% (0.790)
	0.1	-7.3% (0.310)	-9.6% (0.153)	1.7% (0.791)
0.75	0.001	-5.7% (0.486)	-11.5% (0.131)	-5.1% (0.528)
	0.01	-13.9% (0.069)	-21.8% (0.004)	-12% (0.112)
	0.1	-17.5% (0.037)	-13.3% (0.074)	-6.8% (0.426)
1	0.001	-28% (0.001)	-26.6% (0.001)	-15.6% (0.052)
	0.01	-7.9% (0.360)	-9.8% (0.212)	-4.8% (0.572)
	0.1	-8.8% (0.323)	-12.1% (0.131)	0% (0.959)
4	0.001	-16.4% (0.070)	-17.8% (0.026)	-18% (0.047)
	0.01	-6.2% (0.490)	-13% (0.093)	-5.1% (0.574)
	0.1	-8.1% (0.306)	-8.5% (0.222)	-10.2% (0.192)

Notes: Percentage differences are: % insuring in government compensation versions - % insuring in baseline. The values in parentheses are p-values of Chi-square tests.

4.2 Parametric analysis

Table 6 displays results of a random effects Probit regression analysis, to examine the influence of our variables of interest on flood insurance purchase. The random effects model is used because we have panel data with

multiple responses from individual subjects, and we estimate coefficients of time-invariant regressors.[28] We cluster standard errors by subject to account for potential non-independence within subject responses, although our qualitative results do not depend on clustering standard errors.

We will first investigate pooled regression results in models 1, 2, 3 and 4. Model 1 examines the influence of the flood probability (flooding probability = 0.1 is the reference category), loading factor (loading factor = 4 is the reference category), government compensation versions (no government compensation is the reference category), risk aversion and ambiguity aversion (elicited in the gain domain with the MPL measures) on insurance purchase for the entire sample. This model can be used to test **H1**, **H2** and **H4**. Model 2 takes into account the potential interaction between the flood probability and risk aversion to test **H3**. An order variable is also included in models 1 and 2 to control for the effect of being presented with either the risky full, certain half or ambiguous full version of government compensation first. Models 3 and 4 carry out the same analysis as models 1 and 2 respectively, except the stated measure of risk aversion is used instead of the MPL measure.

The models show that there is a negative relation between the loading factor and flood insurance demand. That is, subjects were less likely to purchase flood insurance as the insurance premium increased. Moreover, relative to no government compensation, compensation in the form of risky full or certain half reduces the probability of insurance purchase, although this is not the case for ambiguous full compensation. Regarding ambiguity and risk preferences, more ambiguity averse subjects are more likely to purchase flood insurance, whereas there is no impact of risk aversion measured according to the MPL task on insurance purchase. However, we do find a positive impact of risk aversion on insurance purchase with the stated measure. Lastly, models 1 and 3 show that a decrease in the flood probability from 0.1 to 0.01 increases the probability of flood insurance purchase, consistent with the findings of Laury et al. (2009). However, lowering the flood probability to 0.001 does not significantly influence the likelihood of insurance purchase relative to probability 0.1. This may be due to a sub-group of subjects perceiving probability 0.001 to be below their threshold level of concern. There are also no interaction effects between the flood probability and risk aversion according to the MPL measure. Whereas, there is an interaction effect between flood probability 0.01 and stated risk aversion.

Now consider the results from models 5, 6, 7 and 8. Model 5 examines observations from subjects who faced both risky full government compensation and certain half, and the effect of the former relative to the latter on insurance purchase. Model 6 accounts for the potential interactions included in model 2, as well as the possible interaction between the riskiness of government compensation and risk aversion measured according to the MPL task to test **H5**. An order variable is also included in models 5 and 6 to control for the effect of being presented with either the risky full or certain half version of government compensation first. Models 7 and 8 perform the same respective analysis as models 5 and 6, except the stated measure of risk aversion is used instead of the MPL measure.

[28] It can also be assumed that unobserved subject-specific effects are uncorrelated with government compensation versions, because the versions were randomly assigned across subjects. Our qualitative results are robust to pooled Probit and pooled OLS estimates with clustered standard errors by subject.

Consistent with models 1, 2, 3 and 4, the loading factor is negatively related to flood insurance demand. In addition, relative to certain half government compensation, compensation in the form of risky full does not impact the probability of insurance purchase, and there is no interaction between the riskiness of government compensation and risk aversion either measured with the MPL task or stated. There is also no unique effect of risk aversion measured with the MPL task or ambiguity aversion on the likelihood of insurance purchase, but there is a unique effect of stated risk aversion. The non-significance of ambiguity aversion is unsurprising, because there is no ambiguity in the risky full and certain half government compensation versions. Despite the positive effect of a lower flood probability (from 0.1 to 0.01) on the probability of insurance purchase in models 5 and 7, including interactions between the flood probability and risk aversion results in insignificant coefficient estimates, using both the MPL measure and stated. Lastly, there are no order effects between the risky full and certain half government compensation versions of the experiment.

Moving on to the results of regression models 9, 10, 11 and 12, model 9 considers observations from subjects who faced both risky full government compensation and ambiguous full, and the effect of the risky version relative to the ambiguous version on insurance purchase. Model 10 accounts for the potential interactions included in model 2, as well as the interaction between the degree of ambiguity in government compensation and ambiguity aversion. In model 10, the coefficient estimate on the ambiguity aversion gain domain variable can be used to test **H6**. The interaction between the risky full government compensation and ambiguity aversion gain domain variables can be used to test **H7**. An order variable is also included in models 9 and 10 to control for the effect of being presented with either the risky full or ambiguous full version of government compensation first. Models 11 and 12 provide the same analysis as models 9 and 10, except the stated measure of risk aversion is used instead of the MPL measure (which is utilized in models 9 and 10).

The loading factor negatively affects the probability of insurance purchase, consistent with the other regression results. Moreover, relative to ambiguous full government compensation, compensation in the form of risky full has a negative impact on the probability of insurance purchase in models 9 and 11. Interpreting models 10 and 12, there is a negative interaction between risky full government compensation and ambiguity aversion, as well as a positive coefficient estimate on the ambiguity aversion variable. This implies that ambiguity aversion positively affects insurance demand under ambiguous full government compensation. In addition, more ambiguity averse subjects demanded less insurance in the risky full relative to the ambiguous full version of the experiment. In other words, ambiguity averse subjects have lower insurance demand when government compensation is less ambiguous. Consistent with the prior results, we also find no effect of risk aversion measured with the MPL task on the likelihood of insurance purchase. Furthermore, although there are positive coefficient estimates on the 0.01 flood probability variable in models 9 and 11, we find no significant probability effect in models 9 and 11, nor in model 10 which considers potential interactions between the flood probability and risk aversion according to the MPL measure. Nevertheless, there is an interaction between flood probability 0.01 and stated risk aversion in model 12. Finally, we do find order effects between the risky full and ambiguous full government compensation versions. Importantly, the effect we find, regarding the impact of risky vs. ambiguous government compensation on flood insurance demand, is not due to order of government compensation, because order has been controlled for in our regression results.

Table D1 in Appendix D displays results of a random effects Probit regression analysis, with risk and ambiguity preferences elicited in the loss domain. The qualitative conclusions remain the same, except we find no unique effect of ambiguity aversion elicited in the loss domain on insurance demand. Nevertheless, there is still a negative interaction between risky government compensation and ambiguity aversion elicited in the loss domain in Table D1. Ambiguity preferences elicited in the gain domain may better predict the unique effect on insurance demand under ambiguous government compensation if the compensation and the endowment were often integrated by subjects into potential losses, so the insurance decisions were viewed in the gain domain.

Table 6: Random effects Probit regression of variables of influence on flood insurance purchases with risk and ambiguity preferences elicited in the gain domain												
	Pooled				Risky full vs. certain half				Risky full vs. ambiguous full			
	MPL		Stated		MPL		Stated		MPL		Stated	
Variable	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**	**M12**
Flooding probability=0.001	0.17	0.26	0.17	-0.17	0.13	0.58	0.13	0.42	0.14	0.20	0.14	-0.76
	(0.12)	(0.35)	(0.12)	(0.33)	(0.16)	(0.43)	(0.16)	(0.41)	(0.20)	(0.69)	(0.20)	(0.65)
Flooding probability=0.01	0.24***	0.10	0.24***	-0.28	0.29**	0.29	0.29**	0.09	0.17	0.18	0.17	-0.71
	(0.09)	(0.27)	(0.09)	(0.25)	(0.13)	(0.35)	(0.13)	(0.31)	(0.15)	(0.51)	(0.15)	(0.47)
Loading factor=0.5	1.52***	1.52***	1.52***	1.53***	1.40***	1.41***	1.40***	1.41***	1.67***	1.68***	1.67***	1.70***
	(0.09)	(0.09)	(0.09)	(0.09)	(0.15)	(0.15)	(0.15)	(0.15)	(0.14)	(0.14)	(0.14)	(0.15)
Loading factor=0.75	1.18***	1.18***	1.18***	1.19***	1.09***	1.10***	1.09***	1.10***	1.27***	1.27***	1.27***	1.29***
	(0.08)	(0.08)	(0.08)	(0.08)	(0.11)	(0.11)	(0.11)	(0.11)	(0.12)	(0.12)	(0.12)	(0.13)
Loading factor=1	0.88***	0.88***	0.88***	0.88***	0.68***	0.69***	0.68***	0.68***	1.08***	1.09***	1.08***	1.10***
	(0.07)	(0.07)	(0.07)	(0.07)	(0.10)	(0.10)	(0.10)	(0.10)	(0.11)	(0.11)	(0.11)	(0.11)
Certain half	-0.39**	-0.39**	-0.32**	-0.32**								
	(0.16)	(0.16)	(0.16)	(0.16)								
Risky full	-0.39**	-0.39**	-0.32**	-0.32**	0.01	-0.13	0.01	-0.11	-0.29***	0.46	-0.29***	0.47
	(0.16)	(0.16)	(0.16)	(0.16)	(0.09)	(0.27)	(0.09)	(0.22)	(0.09)	(0.36)	(0.09)	(0.36)
Ambiguous full	-0.11	-0.11	-0.05	-0.05								
	(0.17)	(0.17)	(0.16)	(0.16)								
Risk aversion gain domain	0.01	0.01			0.03	0.04			-0.04	-0.04		
	(0.03)	(0.03)			(0.04)	(0.05)			(0.04)	(0.05)		
Stated risk aversion			0.14***	0.09*			0.15**	0.15*			0.12*	0.02
			(0.04)	(0.05)			(0.07)	(0.08)			(0.06)	(0.07)
Ambiguity aversion gain domain	0.08**	0.08**	0.06*	0.06	0.10	0.10	0.07	0.07	0.09	0.16**	0.07	0.14*
	(0.04)	(0.04)	(0.04)	(0.04)	(0.06)	(0.07)	(0.06)	(0.06)	(0.08)	(0.08)	(0.08)	(0.08)
Flooding probability=0.001 X risk aversion gain domain		-0.01				-0.06				-0.01		
		(0.05)				(0.06)				(0.09)		
Flooding probability=0.01 X risk aversion gain domain		0.02				0.00				-0.00		
		(0.04)				(0.05)				(0.07)		
Flooding probability=0.001 X stated risk aversion				0.06				-0.06				0.16
				(0.06)				(0.07)				(0.11)
Flooding probability=0.01 X stated risk aversion				0.10**				0.04				0.16**
				(0.04)				(0.06)				(0.08)
Risky full X risk aversion gain domain						0.02						
						(0.04)						
Risky full X stated risk aversion								0.02				
								(0.05)				

Risky full X ambiguity aversion gain domain										-0.13** (0.06)		-0.13** (0.06)
Order	0.11* (0.06)	0.11* (0.07)	0.11* (0.06)	0.11* (0.07)	0.01 (0.09)	-0.00 (0.10)	0.01 (0.09)	0.00 (0.09)	0.22** (0.09)	0.25*** (0.09)	0.22** (0.09)	0.25*** (0.09)
Constant	-1.40** (0.64)	-1.38** (0.63)	-2.12*** (0.61)	-1.85*** (0.61)	-3.19** (1.27)	-3.28** (1.32)	-3.77*** (1.28)	-3.76*** (1.29)	-0.84 (0.97)	-1.30 (0.95)	-1.55* (0.87)	-1.42 (0.93)
Observations	4,176	4,176	4,176	4,176	1,800	1,800	1,800	1,800	1,752	1,752	1,752	1,752
Subjects	200	200	200	200	75	75	75	75	73	73	73	73

Notes: Dependent variable: insurance purchase. Model coefficients are shown and standard errors are reported in parentheses clustered by subject. ***Significant at 1%; **Significant at 5%; *Significant at 10%. Regressions control for gender, age, being Dutch, flood risk perceptions and perceptions about government compensation.

5. Discussion

5.1 Hypotheses

Table 7 describes how the hypotheses fared. Experimentally revealed risk preferences according to the MPL measure were not a significant predictor of flood insurance decisions. This result is consistent with some other experimental studies finding that risk preferences elicited experimentally do not explain insurance demand (e.g., Aseervatham et al., 2015; Harrison and Ng, 2016; Sauter et al., 2016). We cannot rule out that risk preferences may be different in insurance decisions compared to those elicited in standard gamble tasks due to a framing effect (Hershey and Schoemaker, 1980). We find that risk aversion according to a stated measure of risk preference in Dohmen et al. (2011) is positively related to insurance demand. Dohmen et al. (2011) showed that the stated measure is a good all-round predictor of risk taking behaviour in practice, and may better capture risk aversion in relation to flood insurance demand in our experiment. Overall, we find partial support for **H1**.

Our results also suggest that a decrease in the flood probability from 0.1 to 0.01 increases flood insurance demand, consistent with Laury et al. (2009). Interestingly, the regression results find that a further reduction in the flood probability to 0.001, has no significant impact on flood insurance demand relative to 0.1. It may be that a sub-group of subjects find that flood probability 0.001 falls below their threshold level of concern. This sub-group may treat this very low-probability of flooding as negligible. This type of behaviour is typical of individuals facing low-probability risks in practice (Camerer and Kunreuther, 1989), and has been observed in another experiment of flood insurance demand among Dutch homeowners by Robinson and Botzen (2018).

We find a positive interaction effect between flood probability 0.01 (relative to flood probability 0.1) and stated risk aversion on insurance demand. But we do not find the expected interaction effect with flood probability 0.001, which may fall below subjects' threshold level of concern, nor with the MPL measure of risk aversion. Therefore, we find partial support for **H3**.

Concerning the loading factor, our results show that there is an inverse relationship between flood insurance demand and the price of insurance, in support of **H2**.

In addition, certain half and risky full government compensation negatively impacts flood insurance demand relative to the baseline, in support of **H4** and the charity hazard hypothesis. However, the ambiguous full government compensation does not significantly influence flood insurance demand. This result is consistent with the field survey results of Raschky et al. (2013), who find that partial certain government compensation drives a stronger crowding out of flood insurance demand, than ambiguous full government relief which is subject to political influences.

We reject **H5** given that flood insurance demand is approximately the same under risky full vs. certain half government compensation, and more risk averse subjects demand no more or less insurance under either version. Overall, insurance demand is highest under no government compensation and ambiguous full government compensation and lowest under certain half and risky full government compensation.

Based on the Klibanoff et al. (2005) smooth model of decision making under ambiguity, we expand upon the analysis in Kelly and Kleffner (2003) and Raschky and Weck-Hannemann (2007), to examine insurance demand under

ambiguous government compensation.[29] We find that there is a significant positive unique effect of ambiguity aversion on the likelihood of flood insurance purchase under ambiguous full government compensation, according to ambiguity preferences elicited in the gain domain, supporting **H6**. Whereas, this is not the case with ambiguity preferences elicited in the loss domain. Perhaps gain domain ambiguity preferences were a better predictor of this unique effect because compensation and the endowment were often integrated into potential losses by subjects, so the insurance decisions were viewed as a gain. That is, subjects may have kept the endowment in mind when making insurance choices. Klibanoff et al. (2015) also assume EU under risk, and therefore that individuals process outcomes in terms of final wealth.

For our final hypothesis **H7** we find that insurance demand is significantly higher under ambiguous full government compensation vs. risky full government compensation for more ambiguity averse individuals, which is consistent with **H7.** This is regardless of whether preferences are elicited in the gain or loss domain.

Table 7: Summary of hypotheses results

Hypothesis	Explanation	Result
H1	There is a positive unique effect of stated risk aversion on insurance demand, but not with the MPL measure of risk aversion.	Partial support
H2	There is a negative effect of the loading factor on insurance demand.	Support
H3	There is a positive interaction effect between flood probability 0.01 and stated risk aversion on insurance demand, but not with flood probability 0.001, nor with the MPL measure of risk aversion.	Partial support
H4	There is a negative effect of certain half and risky full government compensation on insurance demand, but not with ambiguous full government compensation.	Partial support
H5	There is not an interaction effect between risky full government compensation and risk aversion on insurance demand.	Not supported
H6	There is a positive unique effect of ambiguity aversion in the gain domain on insurance demand, but not with ambiguity aversion in the loss domain.	Partial support
H7	There is a negative interaction effect between risky full government compensation and ambiguity aversion on insurance demand.	Support

5.2 Policy recommendations

Our between-subjects analysis of the charity hazard shows that certain half and risky full government compensation crowd out flood insurance demand. Findings also suggest that ambiguous government compensation does not significantly reduce flood insurance demand after taking into account the impact of loading factor, flood probability, as well as risk and ambiguity preferences. Therefore, if eliminating government compensation completely is infeasible, perhaps it should be made ambiguous because crowding out of insurance demand appears to be less persistent. However, this is practically difficult given the high political incentives to offer compensation for uninsured losses after a disaster (Dari-Mattiacci and Faure, 2015). Broad media coverage which often accompanies disaster assistance can lead households to expect that uninsured flood losses will be compensated in the future (Seifert et al.,

[29] The smooth model is commonly used in theoretical examinations of insurance demand under ambiguity or uncertainty of the loss probability (e.g., Snow, 2011; Alary et al., 2013; Brunette et al., 2013; Bajtelsmit et al., 2015; Berger, 2016). Ambiguity aversion increases insurance demand when the probability of loss is more ambiguous according to these studies.

2013). Finding solutions to lessen reliance on government support schemes is a necessity, given that flood risks are likely to increase with socio-economic developments and climate change (IPCC, 2012). We propose that increasing flood insurance demand, so that uninsured losses are hardly present is the best way forward.

Raschky and Weck-Hannemann (2007) suggest that redirecting the funds used for government relief to insurance subsidies, may be an economically attractive solution to overcoming the charity hazard. This would also reduce homeowners' ambiguity about whether their flood losses will be covered, assuming that flood insurance demand increases and there is no risk of insurer default. Our results show that the price of flood insurance is a strong determinant of demand, therefore subsidies may work well. An exception is if an individual perceives the subjective likelihood of flood risk to fall below their threshold level of concern. Empirical evidence from the U.S. suggests that demand for subsidized flood insurance is quite low (Dixon et al., 2006), perhaps due to individuals dismissing flood risks. A disadvantage of subsidizing flood insurance is that it reduces the price signal of flood risk, thereby encouraging individuals to settle into high-risk areas at the potential expense of the tax-payer (Young, 2008). Moreover, subsidies may reduce incentives for risk mitigation (Kousky, 2018), i.e., premium discounts for risk mitigation are less effective if flood insurance premiums are subsidized rather than risk-based.

Another solution to the charity hazard is strengthening/introducing flood insurance purchase requirements in high-risk areas, so that individuals who are incognizant of their flood risk or those who have a tendency to dismiss it, would be automatically covered. However, other types of regulatory intervention which overcome insurance demand choice anomalies while preserving an individual's freedom of choice may provide a better solution (Schwarcz, 2010). An example of such a choice anomaly in our experiment is that despite predictions of EU Theory, there is no significant difference in the rate of flood insurance purchase when the probability attached to flood risk is 0.001, compared to when the probability is 0.1 with the same expected value. We conjecture that this may be due to a sub-group of subjects finding that flood probability 0.001 falls below their threshold level of concern. Overcoming systematic biases in judgment may require re-framing information about flood risks. Schwarcz (2010) discusses how the latter could be used to overcome threshold probabilities, by framing flood risks over periods in excess of a single year. Empirical findings suggest that flood risk perceptions are higher when the probability of one flood is described as 1 in 3 over 40 years, relative to 1 in 100 every year (Keller et al., 2006). Alternatively, bundling flood risk with other low-probability risks into a single insurance policy may raise perceived loss probabilities above individual threshold levels (Kunreuther and Pauly, 2004). The empirical evidence on bundling so far is mixed (Slovic et al., 1977; Schoemaker and Kunreuther, 1979), and more research may be needed to confirm whether it is a feasible solution.

6. Conclusion

In this paper we examine the charity hazard hypothesis in relation to various degrees of ambiguity in government compensation, as well as the influence of risk preferences, ambiguity preferences and insurance pricing on flood insurance demand. We compare several theoretical predictions to our results, according to EU Theory and the Klibanoff et al. (2005) smooth model of decision making under ambiguity.

Our results are based on an incentivized economic experiment, conducted with 200 subjects. We conclude that flood insurance demand is negatively related to certain and risky government compensation, although ambiguous

compensation does not significantly crowd out demand. We also find that ambiguity averse subjects have higher demand for insurance when government compensation is ambiguous relative to risky, according to experimentally elicited ambiguity preferences. Ambiguity preferences elicited in the gain domain also better predicted the unique effect on insurance demand under ambiguous government compensation, relative to those elicited in the loss domain.

Stated risk aversion better predicts flood insurance demand and aversion to mean-preserving spreads than risk preferences elicited in MPL tasks. Moreover, premium loading is inversely related to flood insurance demand regardless of the type of government compensation granted.

In addition to whether or not compensation is provided, the extent of relief is influenced by political factors in practice. Future research may consider examining whether ambiguity in the extent of government compensation affects flood insurance decision making. Another useful next step may be to investigate ambiguity in the probability of flooding as well as ambiguity in government compensation simultaneously, since in some countries the flood probability may be not well studied and unknown.

We suggest several recommendations for policy to improve flood risk preparedness, including mandatory insurance, re-framing probability information and bundling. The effectiveness of these policies can also be useful topics for future research.

Appendix A: Welfare evaluation of the insurance decision

Consumer surplus (CS) of the insurance decision is the difference between the certainty equivalent of EU with full insurance and the certainty equivalent of EU with zero insurance (Harrison and Ng, 2016). Under EU, risk aversion ($U'(\cdot) > 0$ and $U''(\cdot) < 0$), as well as actuarially fair or subsidized insurance, CS is positive:

$$U^{-1}\{U[W - P(1)]\} - U^{-1}\{pU[W - (1-\theta)L] + (1-p)U[W]\} > 0 \quad \text{(A1)}$$

That is, the certainty equivalent of EU with full insurance is greater than the certainty equivalent of EU with zero insurance. Consider constant relative risk averse (CRRA) utility, $U[x] = x^r$, where $r = 1$ for risk neutrality, $0 \leq r < 1$ for risk aversion, $r > 1$ for risk seeking and x denotes final wealth states. Figure A1 shows the CS of full insurance across loading factors and risk preference parameters, assuming $\theta = 0$ (no government compensation), and $W = L = 60{,}000$ currency units (CU) with $p = 0.001$.

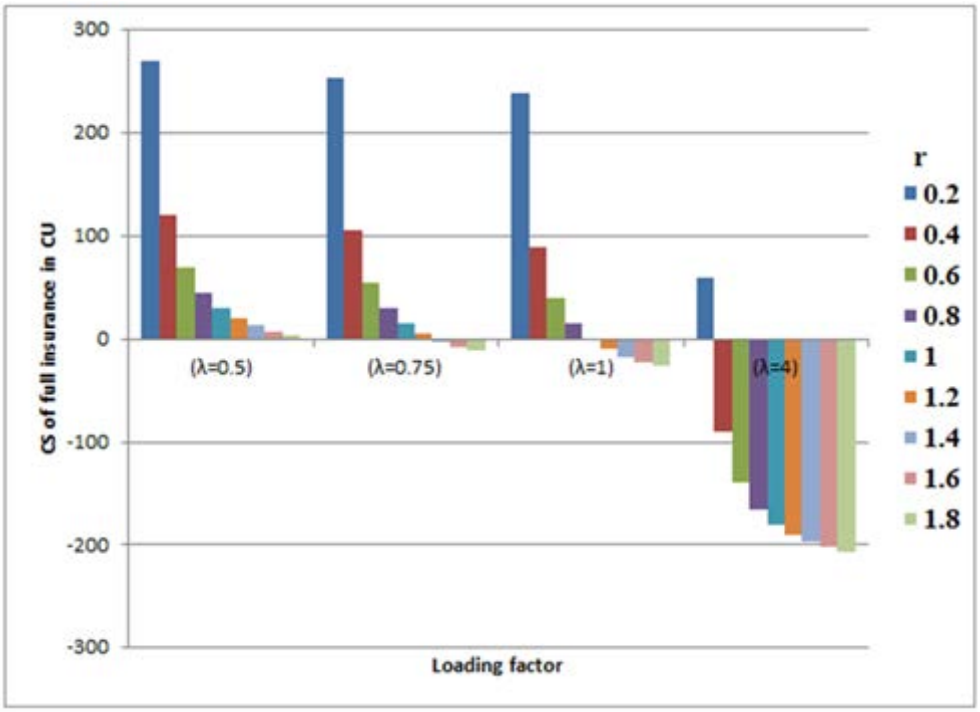


Figure A1: Welfare gain of full insurance in currency units (CU) across constant relative risk aversion coefficients (r) and loading factors (λ) under no government compensation and low probability of loss

Figure A1 shows that CS is positively related to levels of risk aversion (related to **H1**) and negatively related to the loading factor (related to **H2**). For actuarially fair insurance, only risk averse individuals are willing to pay for insurance. We now consider a new risk level, where the risk in Figure A1 is a mean-preserving spread of this new risk level. Figure A2 shows the CS of full insurance across loading factors and risk preference parameters, assuming $\theta = 0$ (no government compensation), $W = 60{,}000$ CU, $L = 6{,}000$ CU and $p = 0.01$.

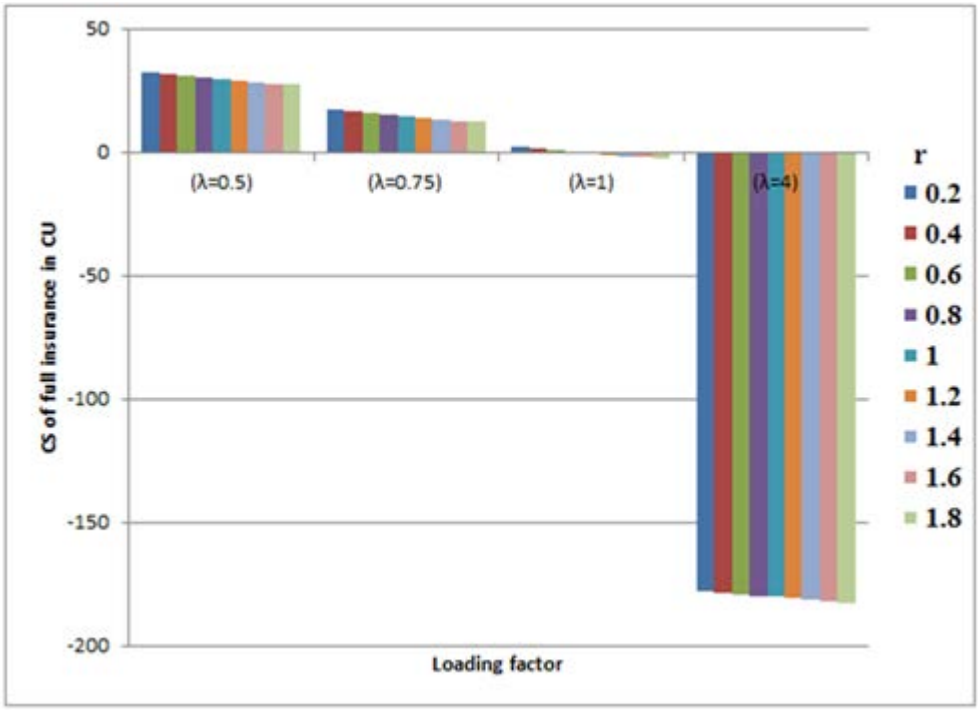


Figure A2: Welfare gain of full insurance in currency units (CU) across constant relative risk aversion coefficients (r) and loading factors (λ) under no government compensation and high probability of loss

Given that risk averse individuals dislike mean-preserving spreads, increasing the probability of loss while keeping the expected value of loss and loading factor constant, will result in less demand for insurance because the welfare gain of insuring will be lower (related to **H3**) (see also Laury et al. (2009), Browne et al. (2015) and Slovic et al. (1977)).

When there is an objective probability of receiving government compensation equal to π CS can be modified to:

$$U^{-1}\{U[W-P(1)]\}-U^{-1}\{\pi\big[pU[W-(1-\theta)L]+(1-p)U[W]\big]+(1-\pi)\big[pU[W-L]+(1-p)U[W]\big]\} \quad \text{(A2)}$$

Figure A3 shows the CS of full insurance with certain half government compensation across loading factors and risk preference parameters, assuming $W = L = 60{,}000$ CU with $p = 0.001$.

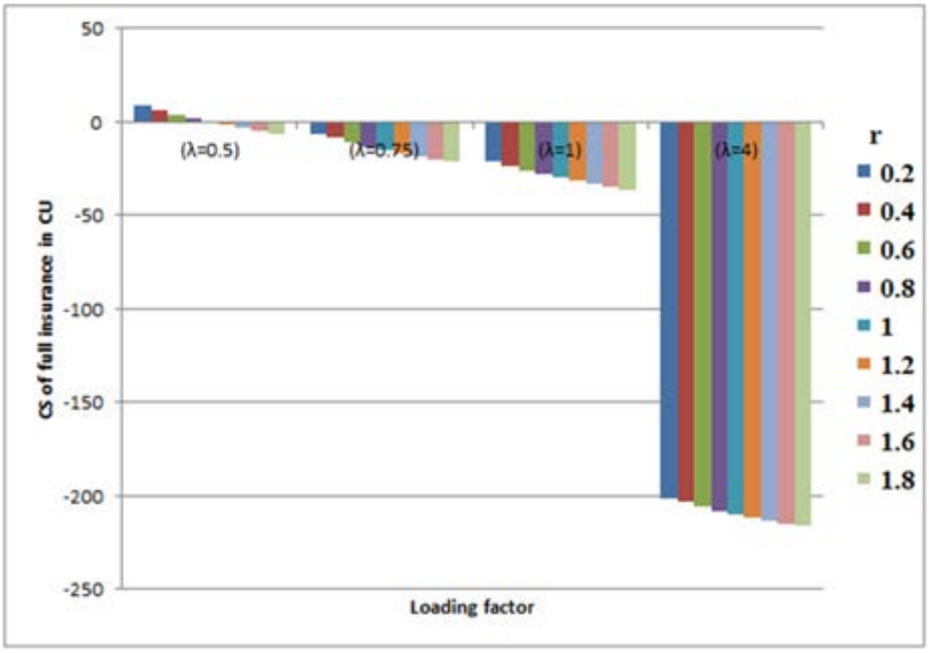


Figure A3: Welfare gain of full insurance in currency units (CU) across constant relative risk aversion coefficients (r) and loading factors (λ) under certain half government compensation and low probability of loss

Figure A4 displays the same analysis as Figure A3 under risky full government compensation, with otherwise identical parameters.

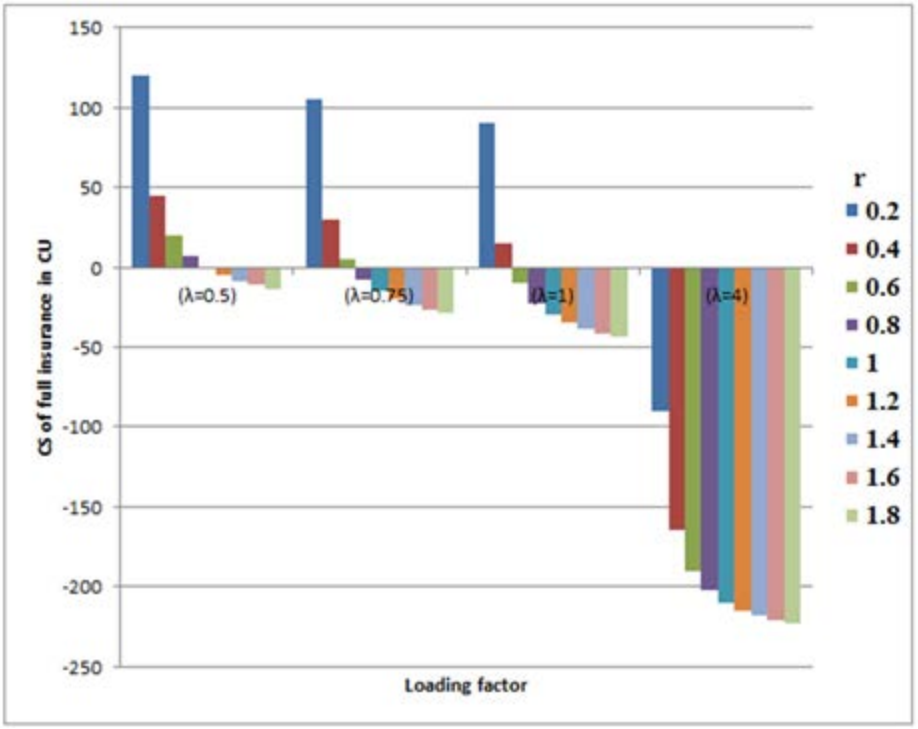


Figure A4: Welfare gain of full insurance in currency units (CU) across constant relative risk aversion coefficients (r) and loading factors (λ) under risky full government compensation and low probability of loss

Comparing Figures A3 and A4 with Figure A1, the availability of (potential) government compensation reduces the CS of purchasing full insurance (related to **H4**). Moreover, comparing Figure A3 with Figure A4, risk aversion increases the CS of purchasing full insurance under risky full government compensation relative to certain half government compensation (related to **H5**).

Under ambiguous full government compensation, CS is evaluated by:

$$\varphi^{-1}\{\varphi[U[W-P(1)]]\}-\varphi^{-1}\{\sigma_1\varphi\{U[W]\}+\sigma_0\varphi\{pU[W-L]+(1-p)U[W]\}\} \quad \text{(A3)}$$

Assume constant relative ambiguity aversion (CRAA), $\varphi(z)=z^a$, where $a=1$ for ambiguity neutrality, $0\leq a<1$ for ambiguity aversion, $a>1$ for ambiguity seeking and z denotes expected utilities. Figure A5 displays the CS of full insurance with ambiguous full government compensation across CRAA coefficients assuming $r=1$, $\lambda=0.5$, and $W=L=60{,}000$ CU with $p=0.001$.[30]

[30] For other risk preference parameters, the impact of risk aversion/seeking overcomes the influence of ambiguity preferences in deciding whether or not to insure, although conclusions regarding relative differences in CS remain the same.

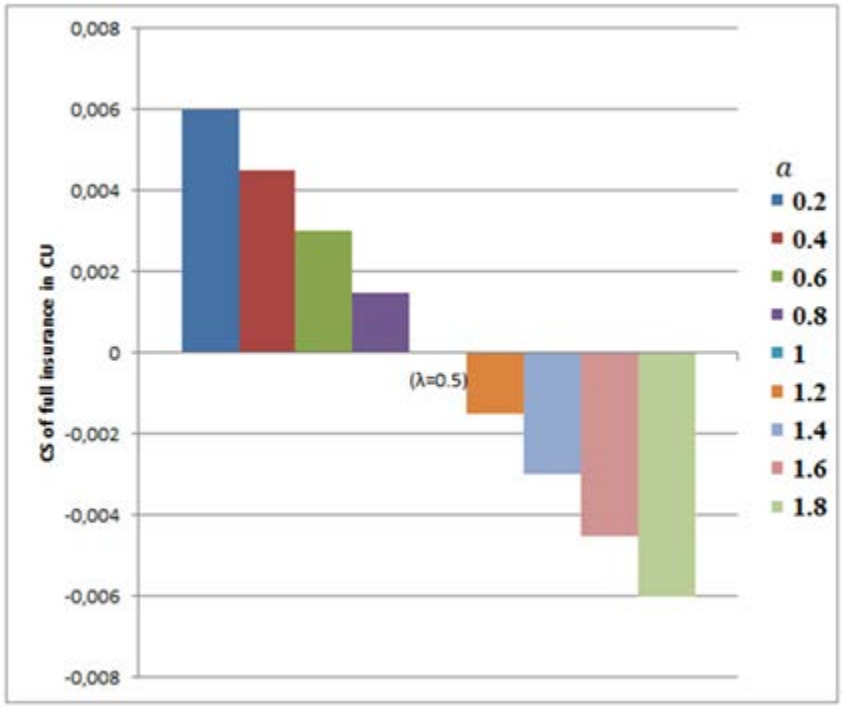


Figure A5: Welfare gain of full insurance in currency units (CU) across constant relative ambiguity aversion coefficients (a) under ambiguous full government compensation, low probability of loss, loading factor 0.5 and risk neutral preferences

Ambiguity aversion ($\varphi'(\cdot) > 0$ and $\varphi''(\cdot) < 0$) increases the CS of insuring under ambiguous full government compensation (related to **H6**). Comparing figures A4 and A5, ambiguity aversion also increases the expected welfare gain of insuring under ambiguous full government compensation relative to risky full government compensation for the levels of ambiguity preference elicited in our study, assuming $\sigma = (0.5,0.5)$ (related to **H7**).

Appendix B: Experiment instructions (screen shots)

B1: First page instructions of phase one

Welcome to the first of a two phase economic experiment.

You will be paid **€15** for participating in the experiment. You will not be asked to risk this money, it is yours to keep. In addition, some of you will earn between **€0 and €60**, depending on your choices. You also have the chance to earn up to **€600** based on your decisions.

So it is in your best interest to read the instructions carefully.

Please provide your personal information below so we can process your payments. The payments will be communicated directly after the experiment via email. Your personal information will be kept confidential.

Initials :

Last name (including prefixes) :

Email :

Participant label :

Next

B2: Description of payment mechanism

We will randomly distribute sealed envelopes (one per participant) after the experiment which will contain either a green, an orange or a red card.

If your envelope contains a red card, you will not earn anything from the experiment, however, you will still receive your €15 participation payment because this payment is not at risk in the experiment.

If you receive a green or an orange card, you will be paid based on one of your decisions from either the first or the second phase of the experiment. In this case, we will flip a coin to decide whether you will be paid based on your decisions in the first or the second phase. The first phase will decide payment if the coin lands on heads/kop and the second phase will decide payment if the coin lands on tails/munt. Therefore, the probability of either one of the phases being selected for payment is 1 in 2 (50%).

- If your envelope contains a green card, your earnings from one decision will be exchanged at 1% (10'000 CU = €100), so you can earn up to €600.

- If your envelope contains an orange card, your earnings from one decision will be exchanged at .1% (10'000 CU = €10), so you can earn up to €60.

CU denotes currency units in the experiment, similar to a euro.

Next

B3: Description of payment mechanism if phase one is selected for payment

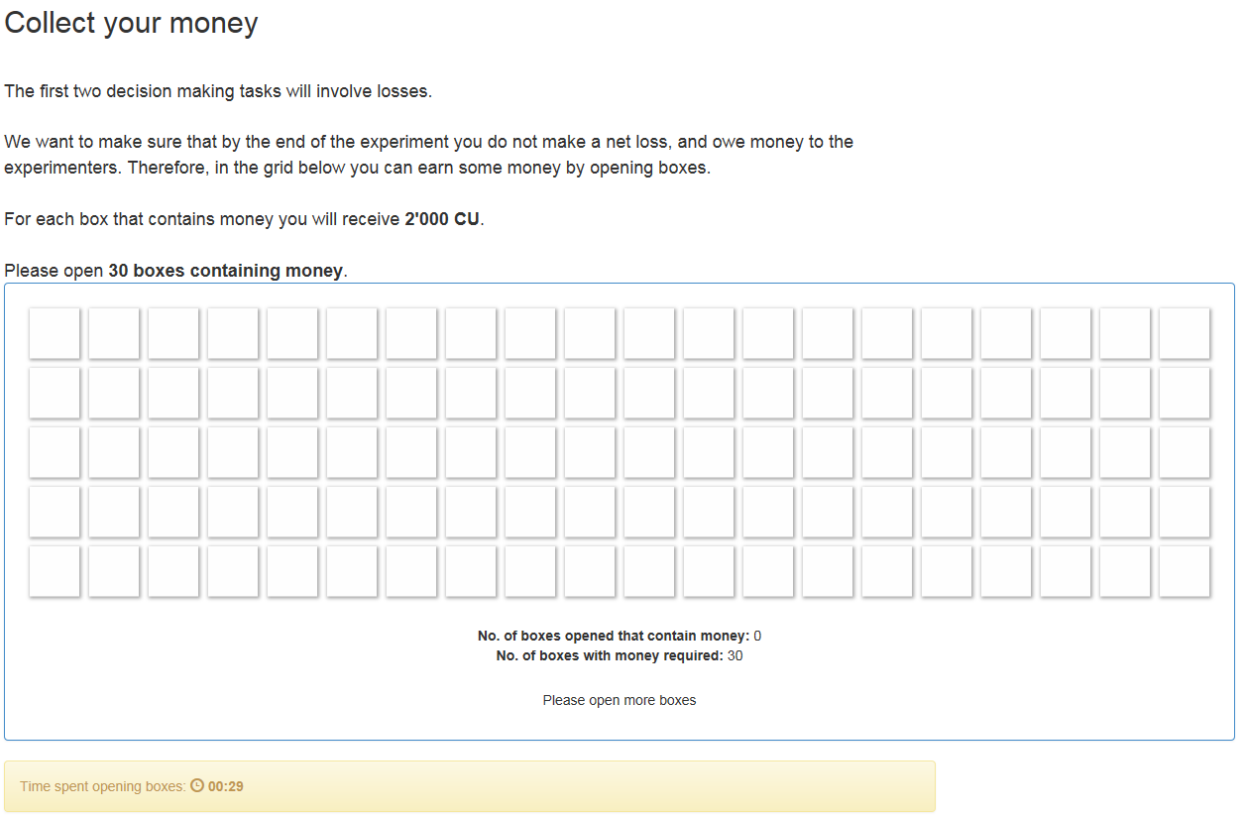
There are **four decision making tasks** in the first phase.

The four decision making tasks are independent of each other. Therefore, the choices you make in one task do not affect any of the other decision making tasks. Moreover, the gains and losses of different tasks do not offset each other.

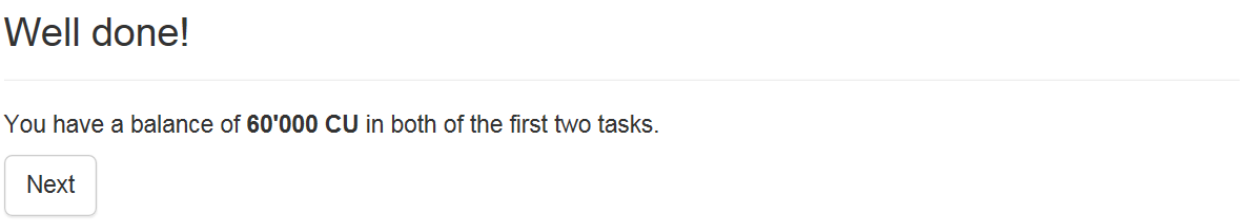
Should you be selected for payment based on your decisions in the first phase, one of the four tasks will be chosen for payment by rolling a four-sided die (dobbelsteen). Rolling a 1 means the first task is selected for payment, and rolling a 2 means the second task is selected etc. Therefore, the probability of either one of the tasks being selected for payment is 1 in 4 (25%).

Next

B4: Phase one earnings task



B5: Outcome of phase one earnings task



B6: First task of phase one

Lottery task

You have a balance of **60'000 CU** for the first task based on the number of boxes that you opened before.

Consider the following ten decisions between Option A and Option B. Each decision is a paired choice between Option A and Option B.

In the first line, Option A is a 50% chance of -560 CU (losing 560 CU) and a 50% chance of -720 CU (losing 720 CU), whereas Option B is a 50% chance of -60'000 CU (losing 60'000 CU) and a 50% chance of 0 CU (losing nothing).

If this task is selected for payment, we will select one line to pay as follows: one ball will be drawn from a bingo cage containing 10 balls numbered 1 to 10. If the 1 ball is drawn, the first line is selected for payment. If the 2 ball is drawn, the second line is selected, etc.

Another draw will then be made from a bingo cage containing 10 balls numbered 1 to 10 to determine your earnings.

In the second line, a choice for Option A pays -540 CU (a loss of 540 CU) if the drawn ball is between (and including) 1 and 5, and it pays -720 CU (a loss of 720 CU) if the drawn ball is 6 to 10. A choice for Option B pays -5'600 CU (a loss of -5'600 CU) if the drawn ball is 1 to 5, and it pays 0 CU (a loss of nothing) if the drawn ball is 6 to 10. The payment for other decision lines in this task is similar.

First task: Indicate for each line whether you prefer Option A or Option B.

Option A					Option B				
50% chance:	**-560 CU**	50% chance:	**-720 CU**	○	○	50% chance:	**-60'000 CU**	50% chance:	**0 CU**
50% chance:	**-540 CU**	50% chance:	**-720 CU**	○	○	50% chance:	**-5'600 CU**	50% chance:	**0 CU**
50% chance:	**-520 CU**	50% chance:	**-720 CU**	○	○	50% chance:	**-2'400 CU**	50% chance:	**0 CU**
50% chance:	**-500 CU**	50% chance:	**-720 CU**	○	○	50% chance:	**-1'560 CU**	50% chance:	**0 CU**
50% chance:	**-480 CU**	50% chance:	**-720 CU**	○	○	50% chance:	**-1'200 CU**	50% chance:	**0 CU**
50% chance:	**-460 CU**	50% chance:	**-720 CU**	○	○	50% chance:	**-1'000 CU**	50% chance:	**0 CU**
50% chance:	**-440 CU**	50% chance:	**-720 CU**	○	○	50% chance:	**-876 CU**	50% chance:	**0 CU**
50% chance:	**-420 CU**	50% chance:	**-720 CU**	○	○	50% chance:	**-795 CU**	50% chance:	**0 CU**
50% chance:	**-400 CU**	50% chance:	**-720 CU**	○	○	50% chance:	**-744 CU**	50% chance:	**0 CU**
50% chance:	**-380 CU**	50% chance:	**-720 CU**	○	○	50% chance:	**-720 CU**	50% chance:	**0 CU**

Next

B7: Indifference question if subject switched on decision line 5 or 6 in the first task of phase one

Lottery task

Line 5 of the previous task asked whether you prefer Option A (50% chance: -480 CU, 50% chance: -720 CU) or Option B (50% chance: -1'200 CU, 50% chance: 0 CU).

We would like to ask whether you are indifferent between these options. In this case, you consider each option as equally attractive.

If line 5 in the previous task is selected for payment, an indifference between the two options will be paid by flipping a coin. Option A will decide payment if the coin lands on heads/kop and Option B will decide payment if the coin lands on tails/munt.

View previous decisions

Are you indifferent between Option A (50% chance: -480 CU, 50% chance: -720 CU) and Option B (50% chance: -1'200 CU, 50% chance: 0 CU)?

Next

B8: Second task of phase one

Lottery task

You have a balance of **60'000 CU** for the second task based on the number of boxes that you opened before.

There are two bingo cages, cage X and cage Y.

- **Cage X** contains **5 BLACK balls and 5 WHITE balls**.
- **Cage Y** contains **10 balls which are either ALL BLACK or ALL WHITE. The probability that the balls are either ALL BLACK or ALL WHITE is unknown.**

You will first be asked to bet on one colour (BLACK or WHITE). Imagine that a ball will then be drawn from either bingo cage X if you choose Option X, or bingo cage Y if you choose Option Y.

Consider the following ten decisions between Option X (bingo cage X to execute a bet) and Option Y (bingo cage Y to execute a bet).

In the first line, a choice for Option X gives 0 CU (no loss) if the betting colour is matched with the colour of the ball drawn from bingo cage X, and -800 CU (a loss of 800 CU) if the betting colour is not matched. A choice for Option Y gives 0 CU (no loss) if the betting colour is matched with the colour of the ball drawn from bingo cage Y, and -28'000 CU (a loss of 28'000 CU) if the betting colour is not matched.

If this task is selected for payment, we will select one line to pay as follows: one ball will be drawn from a bingo cage containing 10 balls numbered 1 to 10. If the 1 ball is drawn, the first line is selected for payment. If the 2 ball is drawn, the second line is selected, etc.

Another draw will then be made from either bingo cage X or bingo cage Y (based on your decisions) to determine your earnings.

Betting colour :

Second task: Indicate for each line whether you prefer Option X or Option Y.

Option X (Cage X: 5 BLACK, 5 WHITE)					Option Y (Cage Y: either all BLACK or all WHITE)				
Colour match:	**0 CU**	No colour match:	**-800 CU**	○	○	Colour match:	**0 CU**	No colour match:	**-28'000 CU**
Colour match:	**0 CU**	No colour match:	**-3'700 CU**	○	○	Colour match:	**0 CU**	No colour match:	**-28'000 CU**
Colour match:	**0 CU**	No colour match:	**-12'000 CU**	○	○	Colour match:	**0 CU**	No colour match:	**-28'000 CU**
Colour match:	**0 CU**	No colour match:	**-17'000 CU**	○	○	Colour match:	**0 CU**	No colour match:	**-28'000 CU**
Colour match:	**0 CU**	No colour match:	**-22'000 CU**	○	○	Colour match:	**0 CU**	No colour match:	**-28'000 CU**
Colour match:	**0 CU**	No colour match:	**-28'000 CU**	○	○	Colour match:	**0 CU**	No colour match:	**-28'000 CU**
Colour match:	**0 CU**	No colour match:	**-35'000 CU**	○	○	Colour match:	**0 CU**	No colour match:	**-28'000 CU**
Colour match:	**0 CU**	No colour match:	**-43'000 CU**	○	○	Colour match:	**0 CU**	No colour match:	**-28'000 CU**
Colour match:	**0 CU**	No colour match:	**-50'000 CU**	○	○	Colour match:	**0 CU**	No colour match:	**-28'000 CU**
Colour match:	**0 CU**	No colour match:	**-60'000 CU**	○	○	Colour match:	**0 CU**	No colour match:	**-28'000 CU**

Next

B9: Third task of phase one

Lottery task

Consider the following ten decisions between Option C and Option D. Each decision is a paired choice between Option C and Option D. **Note that each choice is now about gains in CU, not losses.**

If this task is selected for payment, we will select one line to pay with a ball draw from a bingo cage containing 10 balls numbered 1 to 10 as before.

Another draw will then be made from a bingo cage containing 10 balls numbered 1 to 10 to determine your earnings similar to the first task.

Third task: Indicate for each line whether you prefer Option C or Option D.

Option C					Option D				
50% chance:	**380 CU**	50% chance:	**720 CU**	○	○	50% chance:	**720 CU**	50% chance:	**0 CU**
50% chance:	**400 CU**	50% chance:	**720 CU**	○	○	50% chance:	**744 CU**	50% chance:	**0 CU**
50% chance:	**420 CU**	50% chance:	**720 CU**	○	○	50% chance:	**795 CU**	50% chance:	**0 CU**
50% chance:	**440 CU**	50% chance:	**720 CU**	○	○	50% chance:	**876 CU**	50% chance:	**0 CU**
50% chance:	**460 CU**	50% chance:	**720 CU**	○	○	50% chance:	**1'000 CU**	50% chance:	**0 CU**
50% chance:	**480 CU**	50% chance:	**720 CU**	○	○	50% chance:	**1'200 CU**	50% chance:	**0 CU**
50% chance:	**500 CU**	50% chance:	**720 CU**	○	○	50% chance:	**1'560 CU**	50% chance:	**0 CU**
50% chance:	**520 CU**	50% chance:	**720 CU**	○	○	50% chance:	**2'400 CU**	50% chance:	**0 CU**
50% chance:	**540 CU**	50% chance:	**720 CU**	○	○	50% chance:	**5'600 CU**	50% chance:	**0 CU**
50% chance:	**560 CU**	50% chance:	**720 CU**	○	○	50% chance:	**60'000 CU**	50% chance:	**0 CU**

Next

B10: Indifference question if subject switched on decision line 6 or 7 in the first task of phase one

Lottery task

Line 6 of the previous task asked whether you prefer Option C (50% chance: 480 CU, 50% chance: 720 CU) or Option D (50% chance: 1'200 CU, 50% chance: 0 CU).

We would like to ask whether you are indifferent between these options. In this case, you consider each option as equally attractive.

If line 6 in the previous task is selected for payment, an indifference between the two options will be paid by flipping a coin. Option C will decide payment if the coin lands on heads/kop and Option D will decide payment if the coin lands on tails/munt.

View previous decisions

Are you indifferent between Option C (50% chance: 480 CU, 50% chance: 720 CU) and Option D (50% chance: 1'200 CU, 50% chance: 0 CU)?

Next

B11: Fourth task of phase one

Lottery task

There are two bingo cages, cage V and cage W.

- **Cage V** contains **5 BLUE balls and 5 RED balls**.
- **Cage W** contains **10 balls which are either ALL BLUE or ALL RED. The probability that the balls are either ALL BLUE or ALL RED is unknown.**

Consider the following ten decisions between Option V (bingo cage V to execute a bet) and Option W (bingo cage W to execute a bet). **Note that each choice is about gains in CU, not losses.**

If this task is selected for payment, we will select one line to pay with a ball draw from a bingo cage containing 10 balls numbered 1 to 10 as before.

Another draw will then be made from either bingo cage V or bingo cage W (based on your decisions) to determine your earnings similar to the second task.

Betting colour :

Fourth task: Indicate for each line whether you prefer Option V or Option W.

Option V (Cage V: 5 BLUE, 5 RED)					Option W (Cage W: either all BLUE or all RED)				
Colour match:	**60'000 CU**	No colour match:	**0 CU**	○	○	Colour match:	**28'000 CU**	No colour match:	**0 CU**
Colour match:	**50'000 CU**	No colour match:	**0 CU**	○	○	Colour match:	**28'000 CU**	No colour match:	**0 CU**
Colour match:	**43'000 CU**	No colour match:	**0 CU**	○	○	Colour match:	**28'000 CU**	No colour match:	**0 CU**
Colour match:	**35'000 CU**	No colour match:	**0 CU**	○	○	Colour match:	**28'000 CU**	No colour match:	**0 CU**
Colour match:	**28'000 CU**	No colour match:	**0 CU**	○	○	Colour match:	**28'000 CU**	No colour match:	**0 CU**
Colour match:	**22'000 CU**	No colour match:	**0 CU**	○	○	Colour match:	**28'000 CU**	No colour match:	**0 CU**
Colour match:	**17'000 CU**	No colour match:	**0 CU**	○	○	Colour match:	**28'000 CU**	No colour match:	**0 CU**
Colour match:	**12'000 CU**	No colour match:	**0 CU**	○	○	Colour match:	**28'000 CU**	No colour match:	**0 CU**
Colour match:	**3'700 CU**	No colour match:	**0 CU**	○	○	Colour match:	**28'000 CU**	No colour match:	**0 CU**
Colour match:	**800 CU**	No colour match:	**0 CU**	○	○	Colour match:	**28'000 CU**	No colour match:	**0 CU**

Next

B12: First page instructions of phase two

Introduction

We invite you to participate in the second of the two phase economic experiment.

The second phase is about your views about flood safety and flood insurance.

Next

B13: Description of phase two earnings task

You will soon make a series of flood insurance decisions that may involve losses. We want to make sure that by the end of the experiment you do not make a net loss, and owe money to the experimenters. Therefore, in the next task you will complete a quiz to earn some money. It is in your interest to complete this quiz to the best of your ability **because the more questions you answer correctly the more money you stand to make**.

Next

B14: Phase two earnings task

Earnings task

Please indicate the correct answer for each question. You will receive CU based on the number of questions you answer correctly.

If you answer 8 or more questions correctly, you will receive 60'000 CU. If you answer 7 or fewer questions correctly, you will receive 30'000 CU.

Which of the following countries has the lowest average elevation above sea level in Europe?
- ○ Denmark
- ○ Netherlands
- ○ Estonia
- ○ Belgium

What is 30% of 500?
- ○ 100
- ○ 150
- ○ 200
- ○ 300

Who painted the Mona Lisa?
- ○ Vincent van Gogh
- ○ Leonardo da Vinci
- ○ Pablo Picasso
- ○ Oscar-Claude Monet

Vatican City is a country which is located within which European city?
- ○ Dublin
- ○ Rome
- ○ Warsaw
- ○ Prague

What is the capital of Spain?
- ○ Vienna
- ○ Barcelona
- ○ Valencia
- ○ Madrid

Which of the following is the only EU member state to have voted to leave the EU?
- France
- Belgium
- United Kingdom
- Republic of Ireland

What currency does Japan use?
- Yen
- Japanese dollars
- Pesos
- Pounds

Where is the Notre Dame cathedral?
- London
- Berlin
- Paris
- Washington DC

What is the largest country in the world in terms of land area?
- China
- Canada
- Russia
- United States

Which of the following countries does not border Italy?
- Germany
- Switzerland
- France
- Austria

Which of the following is a movie about life in prison?
- Braveheart
- Top Gun
- Shawshank Redemption
- Fight Club

Which distance is the greatest?
- 800 Meters
- 1 Kilometer
- 50000 Centimeters
- 1 Mile

"The Simpsons" is an animated television series set in which fictional town?
- Springfield
- South Park
- Bedrock
- Quahog

What is 3x3x3?
- 9
- 30
- 27
- 81

Who invented the electric light bulb?
- Henry Ford
- Steve Jobs
- Nikola Tesla
- Thomas Edison

Next

B15: Information about government compensation

No government compensation

Insurance decision instructions

A current insurance policy for house and contents in the Netherlands does not cover damage caused by flooding from dike failure. The government can provide compensation for flood damage, however, this compensation may be influenced by political decision making.

Suppose that it is now possible to buy flood insurance, but that it is no longer possible to receive compensation for flood damage via the government.

You will now make a series of decisions about purchasing flood insurance in situations with different levels of flood risk.

Next

Certain half government compensation

Insurance decision instructions

A current insurance policy for house and contents in the Netherlands does not cover damage caused by flooding from dike failure. The government can provide compensation for flood damage, however, this compensation may be influenced by political decision making.

Suppose that it is now possible to buy flood insurance. There are two political commentators, who both agree that you will be compensated by the government for flood damages for certain. You will be compensated for 50% of damages in the event you are flooded and don't hold insurance.

You will now make a series of decisions about purchasing flood insurance in situations with different levels of flood risk.

Next

Risky full government compensation

Insurance decision instructions

A current insurance policy for house and contents in the Netherlands does not cover damage caused by flooding from dike failure. The government can provide compensation for flood damage, however, this compensation may be influenced by political decision making.

Suppose that it is now possible to buy flood insurance. There are two political commentators, who both agree that your chances of being compensated by the government for flood damages are 1 in 2. You will be compensated for 100% of damages in the event you are flooded, don't hold insurance and compensation is approved by the government.

You will now make a series of decisions about purchasing flood insurance in situations with different levels of flood risk.

Next

Ambiguous full government compensation

Insurance decision instructions

A current insurance policy for house and contents in the Netherlands does not cover damage caused by flooding from dike failure. The government can provide compensation for flood damage, however, this compensation may be influenced by political decision making.

Suppose that it is now possible to buy flood insurance. There are two political commentators, who disagree about whether you will be compensated by the government for flood damages. The first commentator believes that you will be compensated for 100% of damages in the event you are flooded and don't hold insurance for certain. The second commentator believes that you will not receive any compensation. It is uncertain which commentator is the most trustworthy.

You will now make a series of decisions about purchasing flood insurance in situations with different levels of flood risk.

Next

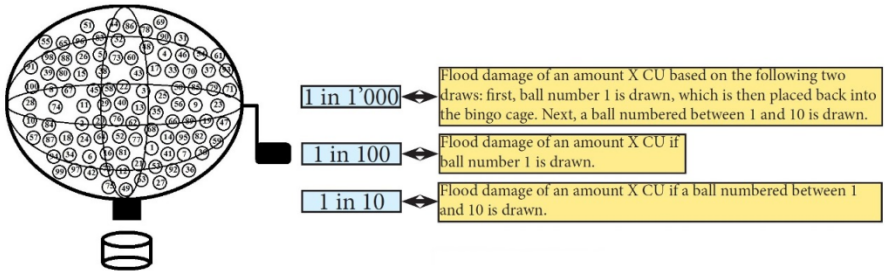
B16: Description of the probability of flooding

Calculating the probability of flooding

Each flood insurance decision has the possibility of a negative outcome (a flood occurring). In each flood insurance decision, you will be allowed to buy insurance against the flood, although you are not required to buy the insurance. Any loss you incur will be paid out of the money you earned by taking the quiz, unless you choose to purchase insurance.

The probability of flooding can be illustrated with a bingo cage containing 100 balls numbered 1 to 100.

In each flood insurance decision the probability of a flood will be either 1 in 1'000, 1 in 100 or 1 in 10 in a given period. Should a flood occur, it will cause property damages of an amount X CU (where X CU can change between decisions).



Flood damage will only occur based on the bingo cage drawings above. Otherwise, no flood will take place.

Next

B17: Description of government compensation (when available)

Certain half government compensation

Calculating the probability of government compensation

Recall that you will be compensated for 50% of the uninsured flood damages for certain in the event you are flooded and don't hold insurance.

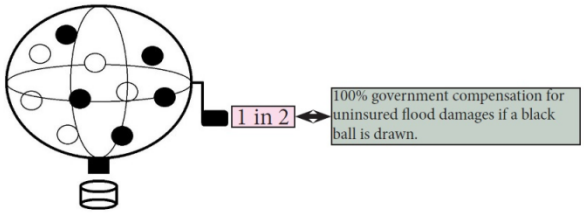
Next

Risky full government compensation

Calculating the probability of government compensation

The probability of government compensation for uninsured flood damages can be illustrated with a bingo cage containing 10 balls, 5 of which that are black and 5 that are white.

The following example illustrates how the probability of government compensation is determined should you experience an uninsured flood, which is 1 in 2 that you are compensated for 100% of the uninsured flood damages. Otherwise, you will not receive any compensation.



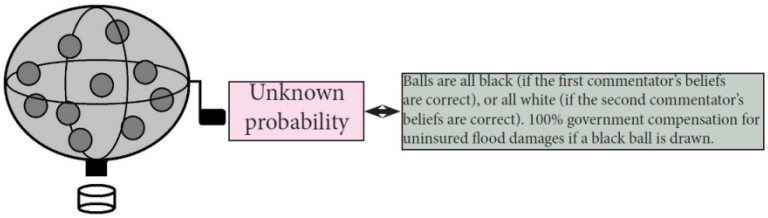
Next

Ambiguous full government compensation

Calculating the probability of government compensation

The probability of government compensation for uninsured flood damages can be illustrated with a bingo cage containing 10 balls which are either all black or all white. The probability that the balls are either all black or all white is unknown.

The following example illustrates how the government compensation is determined should you experience an uninsured flood, which is based on which political commentator's beliefs are correct. You will be compensated for 100% of the uninsured flood damages if the first commentator is correct. Otherwise, you will not receive any compensation if the second commentator is correct.



Next

B18: Description of payment mechanism if phase two is selected for payment

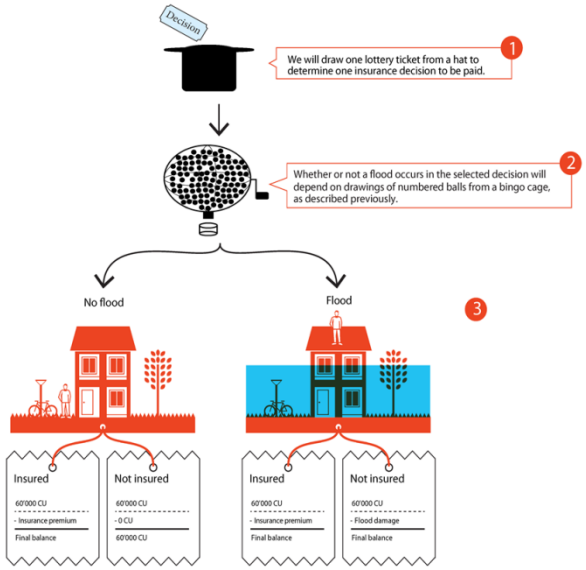
No government compensation

Payment

According to the choices you made in the quiz, you have a balance of 60'000 CU. This amount reflects the amount of money you have in your bank account. In **every** question in which you are asked to make a decision about buying flood insurance you will have this amount from which to pay for the insurance premium, or the flood damages as mentioned in the question. Additionally assume that you have just purchased a house with a mortgage which has a value of 240'000 CU in an area which may flood.

Recall that after the experiment you will receive a sealed envelope, which will contain either a green, an orange or a red card.

The figure below contains additional information about the method by which you will be paid should you receive a green or an orange card and the second phase is chosen for payment.



You should read the information provided in each flood insurance decision carefully: the probability of flood damage, the amount of damage and the cost of insurance may change from one decision to another.

The flood insurance decisions are independent of each other. Therefore, the choice you make in one decision does not affect any of the other decisions. Moreover, each decision is made from the bank balance you earned in the quiz, and you cannot save money over the insurance decisions.

Next

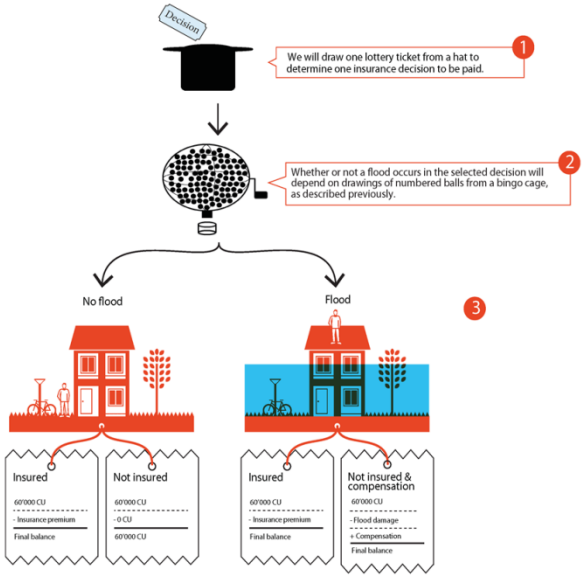
Certain half government compensation

Payment

According to the choices you made in the quiz, you have a balance of 60'000 CU. This amount reflects the amount of money you have in your bank account. In **every** question in which you are asked to make a decision about buying flood insurance you will have this amount from which to pay for the insurance premium, or the flood damages as mentioned in the question. Additionally assume that you have just purchased a house with a mortgage which has a value of 240'000 CU in an area which may flood.

Recall that after the experiment you will receive a sealed envelope, which will contain either a green, an orange or a red card.

The figure below contains additional information about the method by which you will be paid should you receive a green or an orange card and the second phase is chosen for payment.



You should read the information provided in each flood insurance decision carefully: the probability of flood damage, the amount of damage and the cost of insurance may change from one decision to another.

The flood insurance decisions are independent of each other. Therefore, the choice you make in one decision does not affect any of the other decisions. Moreover, each decision is made from the bank balance you earned in the quiz, and you cannot save money over the insurance decisions.

Next

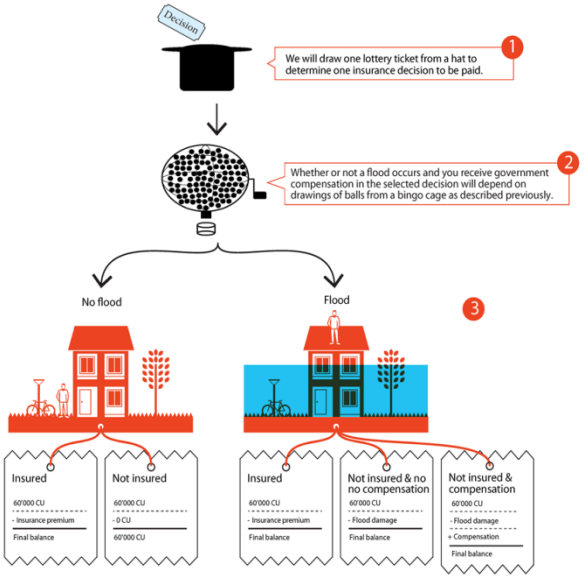
Risky full and ambiguous full government compensation

Payment

According to the choices you made in the quiz, you have a balance of 60'000 CU. This amount reflects the amount of money you have in your bank account. In **every** question in which you are asked to make a decision about buying flood insurance you will have this amount from which to pay for the insurance premium, or the flood damages as mentioned in the question. Additionally assume that you have just purchased a house with a mortgage which has a value of 240'000 CU in an area which may flood.

Recall that after the experiment you will receive a sealed envelope, which will contain either a green, an orange or a red card.

The figure below contains additional information about the method by which you will be paid should you receive a green or an orange card and the second phase is chosen for payment.



You should read the information provided in each flood insurance decision carefully: the probability of flood damage, the amount of damage and the cost of insurance may change from one decision to another.

The flood insurance decisions are independent of each other. Therefore, the choice you make in one decision does not affect any of the other decisions. Moreover, each decision is made from the bank balance you earned in the quiz, and you cannot save money over the insurance decisions.

Next

B19: Comprehension questions

We would like to ask you a few questions to make sure that you have understood the procedures. If you answer each question correctly, you will proceed to the insurance decisions task. If you answer one or more questions incorrectly, then you may need to re-read the instructions.

Based on the choices you made in the quiz, how much money do you have in your bank account from which you can pay for the insurance premium, or the flood damages in each flood insurance decision?
- ○ 30'000 CU
- ○ 100'000 CU
- ○ 240'000 CU
- ○ 60'000 CU

Should you be selected for payment based on the second phase, how many of your flood insurance decisions will be paid?
- ○ One
- ○ Three
- ○ Four
- ○ Two

Flood damage of an amount X CU with probability **z** is equivalent to the following two sequence of drawings:
- First, the drawing of a number 1 ball from a bingo cage containing exactly 100 balls numbered 1 to 100.
- Second, after placing the number 1 ball back into the bingo cage if it were to be drawn first, a drawing of a ball numbered between 1 and 10 from the 100 ball bingo cage.

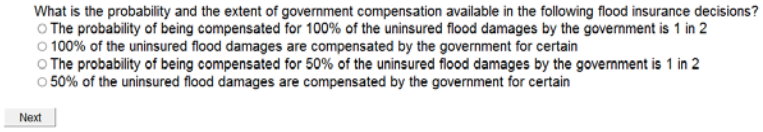
What is the value of **z**?
- ○ 1 in 100
- ○ 1 in 10
- ○ 1 in 1'000

Extra question in no government compensation condition

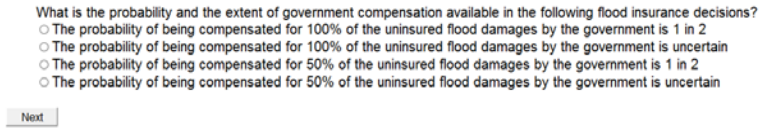
Throughout this experiment will the government compensate flood damages?
- ○ Yes
- ○ No

Next

Extra question in certain half government compensation and risky full government compensation condition

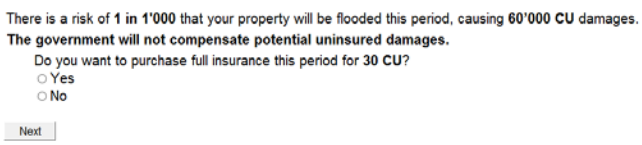


Extra question in risky full government compensation and ambiguous full government compensation condition

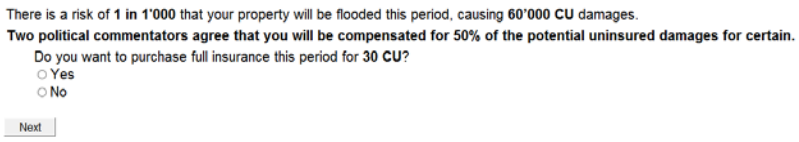


B20: Flood insurance decisions

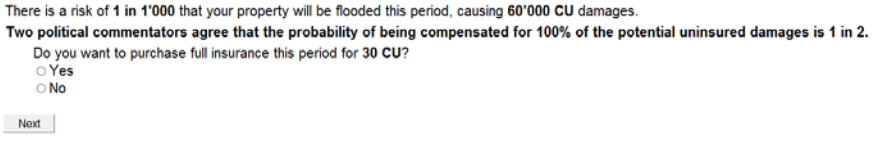
No government compensation



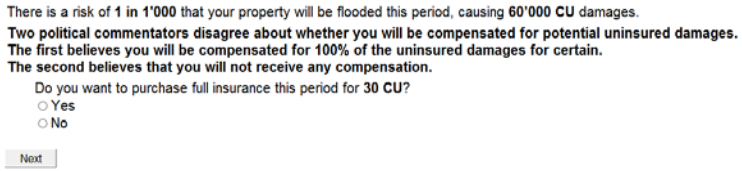
Certain half government compensation



Risky full government compensation



Ambiguous full government compensation



Subsequent questions were presented analogously

B21: Policy change

Policy change to certain half government compensation

The two political commentators now agree that you will be compensated by the government for flood damages for certain due to a change in political circumstances. In this case, you will be compensated for 50% of damages in the event you are flooded and don't hold insurance.

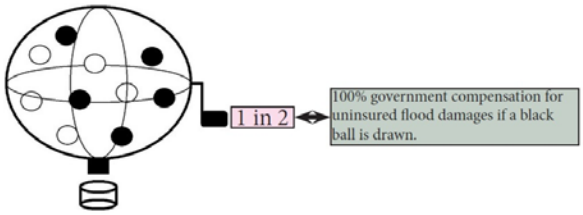
This means that if any of the following flood insurance decisions were to be chosen for payment, there would be no risk involved in whether government compensation is granted for uninsured flood damages.

Next

Policy change to risky full government compensation

The two political commentators now agree that your chances of being compensated by the government for flood damages are 1 in 2 due to a change in political circumstances. In this case, you will be compensated for 100% of damages in the event you are flooded, don't hold insurance and compensation is approved by the government. Otherwise, you will not receive any compensation

The probability of government compensation for uninsured flood damages can now be illustrated with a bingo cage containing 10 balls, 5 of which that are black and 5 that are white. This means that if any of the following flood insurance decisions were to be chosen for payment, the bingo cage below would decide whether government compensation is granted should you experience an uninsured flood.

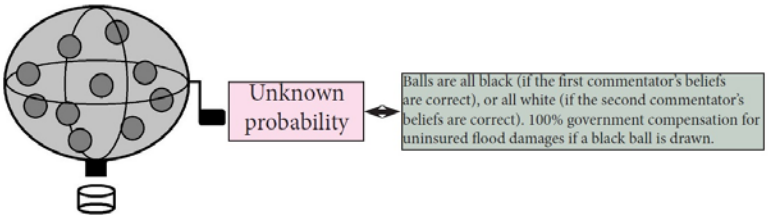


Next

Policy change to ambiguous full government compensation

The two political commentators now disagree about whether you will be compensated by the government for flood damages due to a change in political circumstances. The first commentator believes that you will be compensated for 100% of damages in the event you are flooded and don't hold insurance for certain. The second commentator believes that you will not receive any compensation. It is uncertain which commentator is the most trustworthy.

The probability of government compensation for uninsured flood damages can now be illustrated with a bingo cage containing 10 balls which are either all black or all white. The probability that the balls are either all black or all white is unknown. This means that if any of the following flood insurance decisions were to be chosen for payment, the bingo cage below would decide whether government compensation is granted should you experience an uninsured flood.



Next

B22: Comprehension question for policy change

Policy change to certain half government compensation from risky full government compensation or vice versa

We would like to ask you one question to make sure that you fully understand the policy change. If you do not answer the question correctly, we will provide this information to you again.

What is the probability and the extent of government compensation available in the following flood insurance decisions?

- ○ The probability of being compensated for 50% of the uninsured flood damages by the government is 1 in 2
- ○ 50% of the uninsured flood damages are compensated by the government for certain
- ○ 100% of the uninsured flood damages are compensated by the government for certain
- ○ The probability of being compensated for 100% of the uninsured flood damages by the government is 1 in 2

Next

Policy change to ambiguous full government compensation from risky full government compensation or vice versa

We would like to ask you one question to make sure that you fully understand the policy change. If you do not answer the question correctly, we will provide this information to you again.

What is the probability and the extent of government compensation available in the following flood insurance decisions?
- ○ The probability of being compensated for 50% of the uninsured flood damages by the government is 1 in 2
- ○ The probability of being compensated for 50% of the uninsured flood damages by the government is uncertain
- ○ The probability of being compensated for 100% of the uninsured flood damages by the government is uncertain
- ○ The probability of being compensated for 100% of the uninsured flood damages by the government is 1 in 2

Next

B23: Survey questions used to elicit other variables

How old are you (years)? [ ]

Are you male or female?
- ○ Male
- ○ Female

What is your nationality?
- ○ Dutch
- ○ Other specify: [ ]

What is your best estimate of how often a flood would occur at your home?
- ○ Once every 10 years
- ○ Once every 100 years
- ○ Once every 1'000 years
- ○ Once every 10'000 years
- ○ Once every 100'000 years
- ○ Less than once every 100'000 years

Suppose that you are the owner of a property in the Netherlands. How likely do you believe it is that the government will compensate any of your flood damage if your property is flooded?
- ○ Very likely
- ○ Likely
- ○ Neutral
- ○ Unlikely
- ○ Very unlikely

How do you see yourself: are you generally a person who is willing to take risks or do you try to avoid taking risks?

Please use a scale from 1 to 10, where a 1 means you are "completely unwilling to take risks, and a 10 means you are "very willing to take risks". You can also answer values in-between to indicate where you fall on the scale.
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7
- ○ 8
- ○ 9
- ○ 10

Next

Appendix C: Descriptive statistics and coding of variables

Table C1: Descriptive statistics and coding of the dependent and independent variables			
Variable	**Coding**	**Mean**	**Std dev**
Insurance purchase	1 = purchased insurance, 0 = insurance not purchased	0.602	
Flooding probability = 0.001	1 = flooding probability is 0.001, 0 = otherwise	0.333	
Flooding probability = 0.01	1 = flooding probability is 0.01, 0 = otherwise	0.333	
Loading factor = 0.5	1 = loading factor is 0.5, 0 = otherwise	0.250	
Loading factor = 0.75	1 = loading factor is 0.75, 0 = otherwise	0.250	
Loading factor = 1	1 = loading factor is 1, 0 = otherwise	0.250	
Certain half	1 = compensation scheme is certain half government compensation, 0 = otherwise	0.216	
Risky full	1 = compensation scheme is risky full government compensation, 0 = otherwise	0.425	
Ambiguous full	1 = compensation scheme is ambiguous full government compensation, 0 = otherwise	0.210	
Risk aversion gain domain	Switching point in the gain domain risk aversion task (higher values represent more risk aversion)	7.425	2.354
Risk aversion loss domain	Switching point in the loss domain risk aversion task (higher values represent more risk aversion)	5.825	2.446
Stated risk aversion	Stated risk preference (higher values represent more risk aversion)	5.545	1.928
Ambiguity aversion gain domain	Switching point in the gain domain ambiguity aversion task (higher values represent more ambiguity aversion)	6.190	1.806
Ambiguity aversion loss domain	Switching point in the loss domain ambiguity aversion task (higher values represent more ambiguity aversion)	6.170	1.614
Order	1 = first twelve insurance decisions, 0 = last twelve insurance decisions	0.575	
Male	1 = male, 0 = female	0.555	
Age	Age in years	22.265	3.406
Dutch	1 = Dutch national, 0 = non-Dutch national	0.620	
Flood risk perceptions	Best estimate of how often a flood would occur at subject's residence (1 = once every 10 years, 2 = once every 100 years, …, 6 = less than once every 100'000 years)	2.855	1.132
Government compensation perceptions	Perceptions about the likelihood the government would compensate any flood damage to a homeowner in the Netherlands (1 = very likely, …, 5 = very unlikely)	2.930	1.039

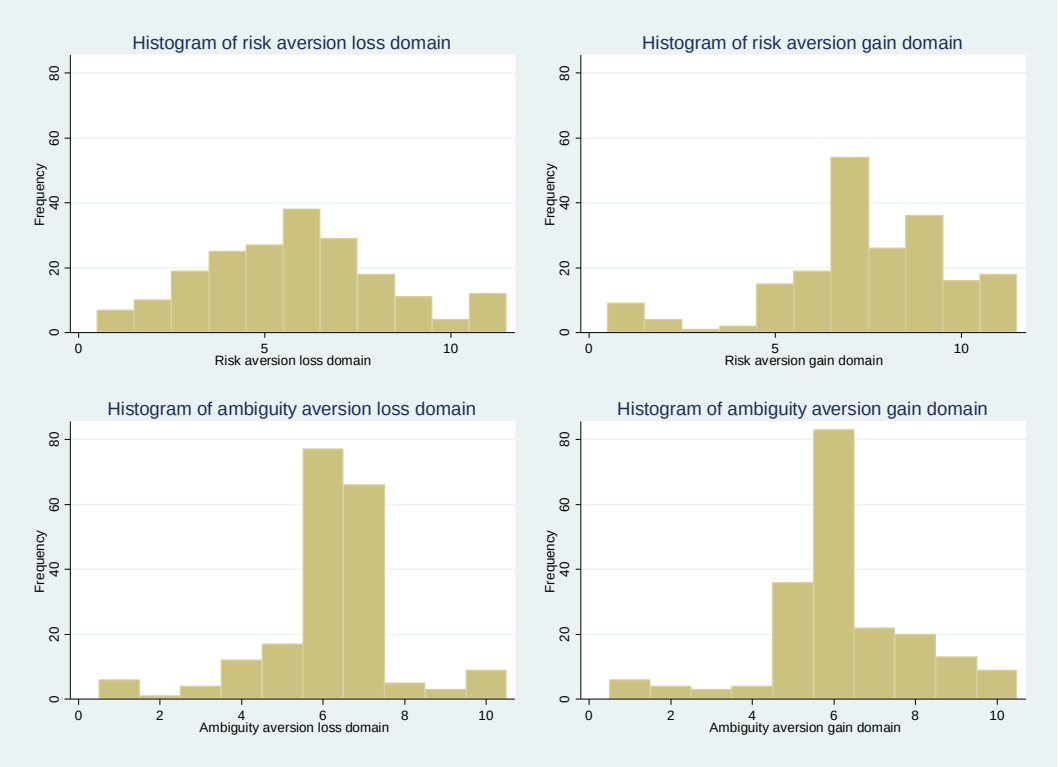


Figure C1: Distributions of risk and ambiguity preferences in the gain and loss domain with the MPL tasks

Notes: higher values represent more risk and ambiguity aversion; 1 means a switch from left to right in the first row (very risk or ambiguity seeking) and 11 or 10 means a subject never switches (very risk or ambiguity averse, respectively); risk neutral = 6 for risk aversion loss domain, and = 7 for risk aversion gain domain; the ambiguity neutral switching point is on decision line 6 in the loss domain, and decision line 5 in the gain domain.

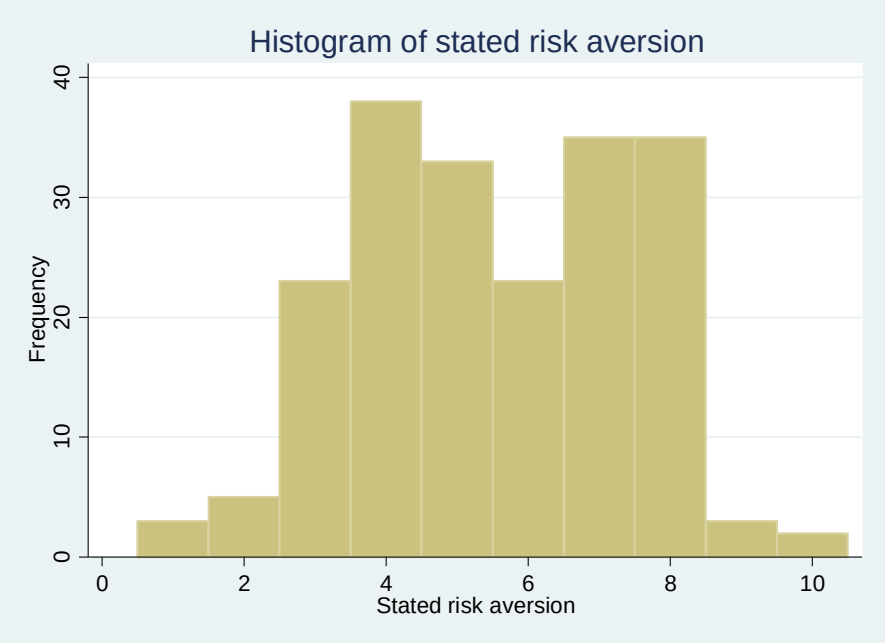


Figure C2: Distribution of stated risk preference

Notes: higher values represent more risk aversion.

Appendix D: Results from additional analyses

Table D1: Random effects Probit regression of variables of influence on flood insurance purchases with risk and ambiguity preferences elicited in the loss domain												
	Pooled				Risky full vs. certain half				Risky full vs. ambiguous full			
	MPL		Stated		MPL		Stated		MPL		Stated	
Variable	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**	**M12**
Flooding probability=0.001	0.17	0.09	0.17	-0.18	0.13	0.01	0.13	0.42	0.14	-0.25	0.14	-0.76
	(0.12)	(0.31)	(0.12)	(0.33)	(0.16)	(0.40)	(0.16)	(0.41)	(0.20)	(0.66)	(0.20)	(0.65)
Flooding probability=0.01	0.24***	0.06	0.24***	-0.28	0.29**	0.04	0.29**	0.09	0.17	-0.13	0.17	-0.71
	(0.09)	(0.23)	(0.09)	(0.25)	(0.13)	(0.29)	(0.13)	(0.31)	(0.15)	(0.52)	(0.15)	(0.48)
Loading factor=0.5	1.52***	1.52***	1.52***	1.53***	1.40***	1.40***	1.40***	1.41***	1.67***	1.68***	1.67***	1.70***
	(0.09)	(0.09)	(0.09)	(0.09)	(0.15)	(0.15)	(0.15)	(0.15)	(0.14)	(0.14)	(0.14)	(0.14)
Loading factor=0.75	1.18***	1.18***	1.18***	1.19***	1.09***	1.09***	1.09***	1.10***	1.27***	1.28***	1.27***	1.29***
	(0.08)	(0.08)	(0.08)	(0.08)	(0.11)	(0.11)	(0.11)	(0.11)	(0.12)	(0.12)	(0.12)	(0.13)
Loading factor=1	0.88***	0.88***	0.88***	0.88***	0.68***	0.68***	0.68***	0.68***	1.08***	1.09***	1.08***	1.10***
	(0.07)	(0.07)	(0.07)	(0.07)	(0.10)	(0.10)	(0.10)	(0.10)	(0.11)	(0.11)	(0.11)	(0.11)
Certain half	-0.42**	-0.42**	-0.34**	-0.34**								
	(0.17)	(0.17)	(0.16)	(0.16)								
Risky full	-0.42***	-0.42***	-0.35**	-0.35**	0.01	-0.06	0.01	-0.11	-0.29***	0.48	-0.29***	0.50
	(0.16)	(0.16)	(0.15)	(0.16)	(0.09)	(0.19)	(0.09)	(0.22)	(0.09)	(0.35)	(0.09)	(0.35)
Ambiguous full	-0.15	-0.15	-0.08	-0.08								
	(0.17)	(0.17)	(0.16)	(0.16)								
Risk aversion loss domain	0.00	-0.01			0.06	0.03			-0.04	-0.08		
	(0.03)	(0.03)			(0.04)	(0.04)			(0.05)	(0.07)		
Stated risk aversion			0.15***	0.09**			0.16**	0.15*			0.13**	0.03
			(0.04)	(0.05)			(0.07)	(0.08)			(0.06)	(0.07)
Ambiguity aversion loss domain	0.01	0.01	-0.01	-0.01	0.06	0.06	0.06	0.06	-0.09	-0.02	-0.11	-0.04
	(0.04)	(0.04)	(0.04)	(0.04)	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.08)	(0.08)	(0.08)
Flooding probability=0.001 X risk aversion loss domain		0.01				0.02				0.07		
		(0.05)				(0.07)				(0.10)		
Flooding probability=0.01 X risk aversion loss domain		0.03				0.05				0.05		
		(0.04)				(0.05)				(0.08)		
Flooding probability=0.001 X stated risk aversion				0.06				-0.06				0.16
				(0.06)				(0.08)				(0.11)
Flooding probability=0.01 X stated risk aversion				0.10**				0.04				0.16**
				(0.04)				(0.06)				(0.08)
Risky full X risk aversion loss domain						0.01						
						(0.03)						

Risky full X stated risk aversion								0.02 (0.05)				
Risky full X ambiguity aversion loss domain										-0.12** (0.05)		-0.13** (0.05)
Order	0.11* (0.06)	0.11* (0.06)	0.11* (0.06)	0.11* (0.07)	0.01 (0.09)	0.01 (0.09)	0.01 (0.09)	0.00 (0.09)	0.22** (0.09)	0.24*** (0.09)	0.22** (0.09)	0.24*** (0.09)
Constant	-0.78 (0.57)	-0.70 (0.58)	-1.66*** (0.59)	-1.39** (0.59)	-2.62** (1.22)	-2.46** (1.24)	-3.57*** (1.24)	-3.56*** (1.24)	0.13 (1.00)	-0.05 (1.02)	-0.47 (0.99)	-0.31 (1.05)
Observations	4,176	4,176	4,176	4,176	1,800	1,800	1,800	1,800	1,752	1,752	1,752	1,752
Subjects	200	200	200	200	75	75	75	75	73	73	73	73

Notes: Dependent variable: insurance purchase. Model coefficients are shown and standard errors are reported in parentheses clustered by subject. ***Significant at 1%; **Significant at 5%; *Significant at 10%. Regressions control for gender, age, being Dutch, flood risk perceptions and perceptions about government compensation.

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