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Natural Disasters and Governmental Aid: Is There a Charity Hazard?

#738

Imprint

Ruhr Economic Papers

Published by

RWI – Leibniz-Institut für Wirtschaftsforschung
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Ruhr Economic Papers #738

Responsible Editor: Manuel Frondel

ISSN 1864-4872 (online) – ISBN 978-3-86788-858-5

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RWI

Bibliografische Informationen der Deutschen Nationalbibliothek

The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available on the Internet at http://dnb.dnb.de

RWI is funded by the Federal Government and the federal state of North Rhine-Westphalia.

http://dx.doi.org/10.4419/86788858
ISSN 1864-4872 (online)
ISBN 978-3-86788-858-5

Mark Andor, Daniel Osberghaus, and Michael Simora[1]

Natural Disasters and Governmental Aid: Is There a Charity Hazard?

Abstract

In the aftermath of natural disasters, governments frequently provide financial aid for affected households. This policy can have adverse effects if individuals anticipate it and forgo private precaution measures. While theoretical literature unequivocally suggests this so called "charity hazard", empirical studies yield ambiguous results. Drawing on rich survey data from German homeowners, we analyze charity hazard for different flood precaution strategies and different flood risk areas. Our results indicate a substantial charity hazard in the insurance market for individuals residing in flood-prone areas. In contrast, we find a positive correlation between governmental aid and non-financial protection measures. Moreover, our results suggest that insurance and non-financial protection measures are rather complements than substitutes. Finally, we provide suggestive evidence that status-quo bias might play an important role for insurance uptake.

JEL Classification: Q54, C35, R22

Keywords: Adaptation; flood protection; flood insurance; objective flood risk; charity hazard

December 2017

1 Mark Andor, RWI; Daniel Osberghaus, Centre for European Economic Research; Michael Simora, RGS Econ and RWI. *– We gratefully acknowledge financial support by the German Federal Ministry of Education and Research (BMBF) within the framework program "Economics of Climate Change" under grant 01LA1113A and by the Collaborative Research Center "Statistical Modeling of Nonlinear Dynamic Processes" (SFB 823) of the German Research Foundation (DFG), within Project A3, "Dynamic Technology Modeling". We are grateful for valuable comments and suggestions by Wouter Botzen, Manuel Frondel, Peter Robinson, and Colin Vance.* *– All correspondence to: Mark Andor, RWI, Hohenzollernstr. 1-3, 45128 Essen, Germany, e-mail: mark.andor@rwi-essen.de*

1 Introduction

Natural disasters such as earthquakes, storms, and floods cause tremendous personal and economic damages each year worldwide. For the year 2016 alone, the economic damage is estimated at 175 billion US$, of which the largest part was caused by floods (Munich RE, 2017). In the wake of natural disasters, governments repeatedly decide to provide financial aid for affected households to cover at least parts of the costs.[1] Although this policy intervention might be well-intentioned, it can have adverse effects in the long-run if such governmental relief triggers the so called "charity hazard", i.e. the tendency of individuals at risk not to procure insurance or other precautionary measures as a result of a reliance on expected charity from others (Browne & Hoyt, 2000).

This paper empirically investigates the determinants of private flood insurance uptake and of the implementation of non-financial protection measures, focusing on the existence of charity hazard. We draw on survey data from German homeowners and differentiate by an objective measure of flood risk. Germany is a prime example to analyze the existence of charity hazard, since catastrophic flood events and ex-post governmental relief regularly occur, for instance, after the floods of 2002 and 2013, which caused approximately 9.7 and 8.7 billion US$ damage, respectively (Schwarze & Wagner, 2004; Thieken et al., 2016). Moreover, in contrast to many other countries, private flood insurance is generally available, but not mandatory in Germany.

Theoretical literature unequivocally suggests charity hazard in the market for natural disaster insurance and other precautionary measures (see Section 2), whereas empirical studies are not only limited, but also yield ambiguous results. While some studies find evidence for charity hazard (e.g. Botzen & van den Bergh, 2012a, 2012b), others cannot confirm the theoretical results (e.g. Browne & Hoyt, 2000; Petrolia et al., 2013, 2015).

We contribute to the literature by analyzing unique data (6,100 observations) that

[1] Examples include the U.S. Federal Emergency Management Agency (Kousky, 2017), German flood relief funds (Thieken et al., 2016), and similar assistance programs in Australia (Lo, 2013).

enables us to shed light on the received ambiguous results by being the first who have information on an objective measure of flood risk, and on both the uptake of flood insurance as well as (behavioral and technical) non-financial flood protection measures, such as the installation of back-flow flaps.

We are thus able to conduct a differentiated analysis of charity hazard that can reveal heterogeneous effects of governmental aid on households in different flood risk areas and for different flood precaution strategies. In many countries, such as Germany, governments often provide financial aid exclusively for those households that are not insured. As a consequence, households might forgo to take up a flood insurance, if they trust in financial aid from the government in case of a catastrophic flood. By contrast, they can conduct non-financial protection measures without loosing the chance to benefit from the aid. Therefore, we hypothesize that the effect of trusting in governmental aid is different for the uptake of insurances and the implementation of non-financial protection measures. Specifically, we anticipate that governmental aid and private flood insurance act as substitutes and thus cause charity hazard, while governmental aid and non-financial protection measures might be regarded as complements. Furthermore, we expect that charity hazard is more pronounced in regions that are at risk from flooding.

In addition, we shed some light on the question as to whether there exists a moral hazard problem of insured households that do not implement further non-financial protection measures (e.g. Hudson et al., 2017) and whether there is a status-quo bias for insurance uptake, i.e. the tendency to remain in the insurance status even though legal compulsion ceased to apply. Evidence for status-quo bias was previously found in the market for health insurance (Frank & Lamiraud, 2009; Krieger & Felder, 2013; Salkeld et al., 2000) and automobile liability insurance (Johnson et al., 1993), but is scarce for natural disaster insurance.

Our results provide evidence that there is substantial heterogeneity in the effects of governmental aid on households in different flood risk areas and for different flood precaution strategies. While we find a positive correlation between trust in govern-

mental relief and the implementation of non-financial protection measures, the results for insurance uptake differ depending on flood exposure. Individuals living in flood-prone areas and trusting in financial aid from the government are less likely to purchase flood insurance. On the contrary, for individuals who face a low objective flood risk, we do not find a robust relation between trust in governmental aid and insurance uptake. Our results therefore suggest that a charity hazard exists for the uptake of insurance if the household faces an objective flood risk. Furthermore, our results indicate that governmental aid and non-financial protection measures are complements, and in line with previous empirical literature, we find a positive correlation between insurance uptake and non-financial protection measures, which relaxes concerns over moral hazard in the flood insurance market (e.g. Hudson et al., 2017). Finally, we provide first suggestive evidence that status-quo bias might play an important role for the uptake of flood insurance. As is typical for empirical studies of charity hazard (e.g. Browne & Hoyt, 2000; Petrolia et al., 2013, 2015), our results should be interpreted as correlations and we recognize that the relationships are not necessarily causal. Nevertheless, our findings contribute to an improved understanding of the existing mixed empirical results regarding charity hazard.

The paper is organized as follows. In Section 2 we give a short overview of the existing theoretical and empirical literature on charity hazard. Subsequently, Section 3 introduces our data set and Section 4 outlines our empirical strategy. Results are depicted in Section 5. Finally, Section 6 summarizes and concludes.

2 Literature Review

While Browne & Hoyt (2000) introduced the term "charity hazard", Buchanan (1975) and Coate (1995) already analyzed the underlying processes and implications in their seminal works. Buchanan (1975) describes the "Samaritan's dilemma" in which assistance to a person in need decreases the recipient's incentives to improve her situation in the long-term. Coate (1995) presents a setting in which the rich, represented

by the government, provide assistance to the poor, in the event of a loss. The model shows that in case of unconditional assistance, the poor will forgo costly insurance.

Further studies have analyzed charity hazard in the specific context of natural hazard protection measures. Raschky & Weck-Hannemann (2007) postulate that the more institutionalized the relief is, the more pronounced charity hazard is. They also mention that as a consequence of reduced demand due to charity hazard, insurance companies may be forced to either exit the market or to increase premiums, which leads to more consumers forgoing insurance and a further weakened market (cf. "disaster syndrome": Kunreuther, 1996; Schwarze & Wagner, 2004). Importantly, these and other theoretical works (Lewis & Nickerson, 1989; Kelly & Kleffner, 2003; Arvan & Nickerson, 2006) find that unconditional post-disaster relief undermines incentives to insure or to implement further precautionary measures.

In contrast to the unequivocal conclusions of the theoretical literature, empirical studies show a mixed picture regarding the existence and strength of charity hazard. Table 1 presents an overview of the main findings of empirical studies in the context of flood and wind insurance, as well as non-financial protection measures at the household level.[2]

The review yields several main insights: First, the data base that is used in the literature is relatively small. The studies of Botzen et al. (2009) and Botzen & van den Bergh (2012a, 2012b) use the same data set, as do both publications of Petrolia et al. (2013, 2015). Second, it seems difficult to confirm the – theoretically well-reasoned – charity hazard in empirical data. Although slightly more works suggest a negative effect of government relief on insurance uptake or protection measures, the evidence is far from clear. While most authors who find a negative relationship interpret this

[2]In addition to the studies presented in Table 1, some works are loosely connected to this strand of literature. Brunette et al. (2013) analyze charity hazard in a non-incentivized laboratory experiment and find a significant negative effect of governmental aid on the willingness to insure. Berlemann et al. (2015) analyze household savings after a major flood in Germany. They find a negative effect of flood experience on savings and interpret this as the reaction to government relief payments, referring to the Samaritan's dilemma. Furthermore, a small body of literature analyzes the charity hazard in the agricultural sector (e.g. van Asseldonk et al., 2002; Liesivaara & Myyrä, 2014; Deryugina & Kirwan 2016).

Table 1: Overview of empirical studies on charity hazard

Study	Sample and location	Dependent variable	Effect of governmental aid
Browne & Hoyt (2000)	50 states in the USA over a period of 10 years	Flood insurance penetration on state level	+ (***)
Botzen et al. (2009)	494 homeowners in the Dutch river delta	Stated willingness to buy sandbags	- (**)
Botzen & van den Bergh (2012a, 2012b)	982 homeowners in the Dutch river delta	Purchase of (2012a) and WTP for (2012b) flood insurance in a hypothetical choice experiment	- (***)
Raschky et al. (2013)	220 flood affected homeowners in Austria and Germany	Stated WTP for and uptake of flood insurance	- (***)
Seifert et al. (2013)	144 flood affected households in Germany	Stated WTP for flood insurance	No effect
Petrolia et al. (2013)	805 homeowners at Gulf coast, USA	Uptake of flood insurance	+ (**)
Petrolia et al. (2015)	238 (insurance) and 829 (mitigation) homeowners at Gulf coast, USA	Uptake of wind insurance and protection measures	No effect
Osberghaus (2015)	4,272 households in Germany	Uptake of flood protection measures	+ (*)
Kousky et al. (2017)	8,315 zip-code areas in Florida, USA over a period of 10 years	Average flood insurance coverage and uptake	- (*) for average coverage; No effect for uptake

*This table lists studies that quantify the effect of governmental aid on household's insurance and protection behavior in response to natural hazards. Note: ***,**,* denote statistical significance at the 1%, 5%, and 10% level, respectively.*

result straightforward as an indication of charity hazard,[3] opposite findings are partly explained as correlations and not as causal relationships (Browne & Hoyt, 2000; Osberghaus, 2015). If an unobserved variable, such as flood exposure, increases both the engagement in flood precaution as well as governmental relief, a positive correlation may be estimated. Petrolia et al. (2013) provide a further explanation for their counterintuitive finding: They measure government relief as the stated assessment of the respondent to be eligible for governmental aid, which might be confounded as respondents, who are really dependent on governmental aid, are ashamed to admit this.

Finally, some studies mention heterogeneities regarding charity hazard: Raschky et al. (2013) emphasize that a higher degree of institutionalization of government relief increases the charity hazard significantly. Kousky et al. (2017) find that type and magnitude of governmental relief matter. While they find no effect of the disbursement of low-interest disaster loans, non-refundable grants do affect insurance demand. The direction, however, depends on the amount of the grant: Low payments seem to increase the purchase of insurance coverage, while larger grants crowd out private demand. Petrolia et al. (2013) report a significant positive relationship between governmental relief and private precaution only for homeowners near the coastline, which the authors take as a proxy for flood exposure. In a relatively large cross-sectional survey of a nationally representative sample of German households, Osberghaus (2015) finds differing results for subsamples of the population, depending i.a. on homeownership and education.

We contribute to the empirical research on charity hazard in the following dimensions: First, we examine heterogeneities in the different forms of precautionary measures, namely flood insurance uptake and non-financial flood protection measures. We are not aware of any study that analyzes the different role of governmental aid for these two strategies. Moreover, we differentiate the analysis of charity hazard by objective flood risk. While other studies (e.g. Petrolia et al., 2013) controlled for flood

[3] Another possible rationale could be reverse causality, since more insurance penetration leads to less financing by the state and in turn to less expectancy of governmental aid (Kousky et al., 2017).

risk, we analyze the relationship between charity hazard and flood risk. Finally, by focusing on Germany, we analyze flood insurance uptake in one of the few countries where a flood insurance market exists and flood coverage is not bundled to other major hazards, such as fire or storm (Lamond & Penning-Rowsell, 2014).

3 Data

We draw on two nation-wide household surveys conducted in 2012 and 2014 that were part of a project funded by the German Federal Ministry of Education and Research (BMBF). For conducting the surveys, we developed questionnaires and commissioned the professional survey institute *forsa* to carry out data collection. *forsa* maintains a panel of more than 10,000 households that is representative of the German-speaking population and collects the data using a state-of-the-art tool that allows panelists to fill out the questionnaire using either a television or the internet.[4] From October 4 to November 4, 2012, 6,404 household heads completed the first survey. The second survey was completed by 6,602 household heads between June 13 and July 30, 2014, yielding a total sample size of 13,006 completed questionnaires.

For our analysis, we restrict the sample to homeowners, as tenants usually do not have the choice to take up flood insurance or to install further protection measures. Furthermore, we reduce the sample to households who either live on the ground floor or have a basement, as these are potentially exposed to floods. This leaves us with a sample size of 6,100 observations. Of those homeowners participating in the first survey, 2,506 also participated in the second period, a survey feature that is accounted for by clustering standard errors at the household level.

We are interested in the relationship between the household's beliefs in governmental aid to compensate for natural disasters and their private precautionary measures. The first dependent variable under scrutiny is whether a household possesses

[4]Information on the underlying questionnaires and a summary of the descriptive results are available at the project homepage: www.rwi-essen.de/eval-map. Further information on *forsa* and its household panel is available at: www.forsa.com.

a flood insurance (*insured*). In Germany, homeowners can include flood coverage in their conventional home insurance for storm and fire hazard, at the price of paying an extra premium. In our survey, almost 70% of the participants indicated to be insured against flood damages (Table 2). This is a large share compared to information reported by the insurance industry. According to GDV (2016), around 35% of German households were flood-insured in 2014. A possible explanation for this discrepancy is that a considerable share of respondents expects insurance coverage without actually being insured with respect to floods. This imprecision in the self-reported insurance status is unproblematic, however, as long as there is no systematic correlation of trust in governmental aid and flawed insurance reporting. Moreover, we find a negative correlation between trusting in governmental aid and indicating to be insured only for households living in flood-prone areas. As these respondents actually face flood risks, we argue that they are better informed about their actual level of insurance. Consequently, the overestimation of insurance coverage might be less of a problem in this subsample.

In addition to the uptake of flood insurance, we investigate the implementation of (technical and behavioral) non-financial flood protection measures. Therefore, the second dependent variable of our analysis (*protection*) captures the self-reported implementation of such measures and is a dummy variable indicating whether a household has implemented at least one of six flood protection measures. Table 2 depicts these six measures (*M1-M6*) and the shares of respondents having realized them. The portfolio of measures is inspired by the literature on flood protection measures in Germany (Bubeck et al., 2013) and covers three categories, namely adapted use (*M1*), flood barriers (*M2-M3*) and structural measures (*M4-M6*). The last row of Table 2 indicates that around 49% of the households have implemented at least one protection measure.[5]

Our two key explanatory variables are the trust in governmental aid and the objective flood risk of the household. The former is directly asked in the questionnaire: Participants indicated from whom they expect financial aid in case of being affected

[5]As a robustness check, we also conducted the analysis with the specific measures and measure categories. This does not lead to further or contradictory conclusions.

Table 2: Dependent variables: shares of homeowners reporting flood insurance and non-financial protection measures

Variable	Explanation	Shares	N
insured	Dummy: Owns flood insurance	68.8%	5,606
M1	Dummy: No valuables stored in basement	6.8%	5,444
M2	Dummy: Water barriers at basement openings	4.6%	5,378
M3	Dummy: Installation of back flow flaps	32.9%	5,840
M4	Dummy: Water-repellent exterior paint	14.4%	5,795
M5	Dummy: Water-repellent interior paint	3.6%	5,858
M6	Dummy: Water-repellent basement floor	15.7%	5,935
protection	Dummy: Any of the six non-financial protection measures	48.6%	5,789

by a flood and could mark, amongst others, public institutions, as well as charity organizations. If respondents indicated one of those, we coded them as trusting in charity (*trust*). Table 3 reveals that this is true for 28.7% of homeowners in our sample. Note that trust is elicited on the individual household level, and not on an aggregated (country or regional) level. As the decision for precautionary measures is also met on the household level, we see this as a strength of our analysis.

To control for the objective risk of being affected by a flood, we collected data from the environmental offices of the federal states and the German Federal Institute for Hydrology (BfG, 2015). These institutions measure riverine flood risks on a four-point scale, distinguishing areas with either no flood risk or a flood return period of either 200, 100, or 20 years. For our purpose, we combined the different risk areas and created a dummy variable indicating a positive flood risk. In fact, 7.5% of the respondents face at least a flood return period of 200 years at their place of residence (Table 3).

In Germany, the share of flood-insured households varies considerably among federal states. This is often anecdotically traced back to the fact that in some federal states flood insurances were mandatory in the past or per default included in the coverage of home insurances (e.g. GDV, 2016; Thieken et al., 2006). We therefore include the dummy variable *ex-mandatory* that indicates whether the household is located in a federal state where flood insurance was mandatory or by law included in the standard home insurance in the past. This is true for East German states, as in the former German Democratic Republic the home insurance always covered flood-related damages.

Table 3: Explanatory and control variables

Variable	Explanation	Mean	N
trust	Dummy: 1 if respondent trusts in charity	0.287	6,077
floodprone	Dummy: 1 if respondent lives in flood-prone area	0.075	6,060
ex-mandatory	Dummy: 1 if respondent lives in a federal state with former mandatory flood insurance	0.277	6,100
experience	Dummy: 1 if respondent experienced a flood without personal damage	0.384	6,100
damage	Dummy: 1 if respondent suffered from flood damage	0.143	6,100
female	Dummy: 1 if respondent is female	0.262	6,100
age	Age of respondent	55.51	6,100
college	Dummy: 1 if respondent has college preparatory degree	0.319	6,100
lowincome	Dummy: 1 if household income per month $<$ 2000 EUR	0.134	6,100
middleincome	Dummy: 1 if household income per month 2000 $-$ 4000 EUR	0.487	6,100
highincome	Dummy: 1 if household income per month $>$ 4000 EUR	0.379	6,100
t	Dummy: 1 if observation in second wave of survey	0.535	6,100

Note: Including income as continuous variable or using different income categories does not change our findings.

These policies were taken over by a private insurance company after reunification in 1990. Furthermore, the state of Baden-Württemberg imposed a mandatory flood insurance until 1994 (Arendt, 2013).

We further control for past experience with floods, as this is found to be a major driver of flood insurance purchase and protection behavior (e.g. Atreya et al. 2015; Osberghaus, 2017). In contrast to previous studies, we distinguish between the mere flood experience without personal damage and households that suffered financial or health-related flood damage. While 38% of the respondents have experienced a flood without suffering damage, 14% have experience with flood-related personal damage.

Finally, we control for socio-economic variables, including gender, age, education and household's income (Table 3). The low share of females in our sample of 26% is due to the design of the underlying survey, where household heads were asked to fill in the questionnaire, as they usually decide upon financial and technical matters, such as insurance uptake and flood protection measures.

4 Empirical Strategy

First empirical insights on the connection between the two dependent variables and the key explanatory variables can be derived from Table 4, which depicts pairwise

Table 4: Pairwise correlations of dependent and key explanatory variables

	insured	*protection*	*trust*	*floodprone*
protection	0.084**	—	—	—
trust	0.029*	0.034*	—	—
floodprone	0.009	0.053**	0.031*	—
experience	0.019	-0.005	0.006	0.027
damage	0.037**	0.190**	0.011	0.051**
N	5240			

*Note: **,* denote statistical significance at the 1 % and 5 % level, respectively.*

correlations. The precautionary strategies *insured* and *protection* are positively correlated, indicating a complementary rather than substitutional relation. Trust in governmental aid is positively correlated with both precaution strategies. As a negative correlation would indicate a charity hazard, the positive correlation suggests that charity hazard is difficult to detect for the full sample. The mere experience with floods is not correlated with precautionary behavior, but the experience of flood-related damage is positively related to both dependent variables. Furthermore, living in flood-prone areas is significantly correlated with damage experience, trust in governmental aid and the implementation of non-financial protection measures. Hence, objective flood risk is an important control variable, as it may affect both trust and precautionary behavior.

For a more rigorous empirical analysis, we estimate probit models due to the binary nature of the dependent variables, and, as robustness checks, logit and linear (OLS) models, as well as a random-effects probit exploiting the panel nature of the data. Specifically, we analyze the uptake of private flood insurance (Case A) and the implementation of non-financial protection measures (Case B) and report for each dependent variable three different model specifications. First, we regress the respective precautionary strategy on the dummy variable capturing the individual's trust in governmental relief, and control variables. In the second specification, we additionally control for flood risk and include an interaction term to derive heterogeneous effects of trust in governmental relief depending on flood risk. Finally, to consider possible correlations between the two precautionary strategies, insurance uptake and non-financial protection measures, we estimate Specification 3 including the respec-

tive alternative precautionary strategy. In Case A, we estimate:

$$\begin{aligned} insured_i &= \beta_1 trust_i + \beta_2 floodprone_i + \beta_3 trust_i \times floodprone_i + \\ &\quad \beta_4 protection_i + \gamma^T \mathbf{x}_i + \delta t_i + \epsilon_i \end{aligned} \tag{1}$$

where $insured_i$ designates the precautionary strategy insurance uptake, of respondent i, *trust* indicates whether a household expects governmental relief, $floodprone$ is a dummy variable capturing whether the household lives in an area with a flood return period of less than 200 years, and *protection* denotes the alternative precautionary strategy, the implementation of non-financial protection measures. $\boldsymbol{x}$ is a vector of all further control variables depicted in Table 3, superscript T denotes the transposition of a vector, t is a dummy indicating the second survey wave, $\boldsymbol{\beta}$, γ, and $\boldsymbol{\delta}$ are the parameters to be estimated and ϵ denotes the error term. In Case B, we investigate the implementation of non-financial protection measures and thus estimate:

$$\begin{aligned} protection_i = \beta_1 trust_i + \beta_2 floodprone_i + \beta_3 trust_i \times floodprone_i + \\ \beta_4 insured_i + \gamma^T \mathbf{x}_i + \delta t_i + \epsilon_i. \end{aligned} \tag{2}$$

We estimate and report marginal effects averaged over observations, while the reported significance levels are based on the estimated coefficients of the probit models, as suggested by Greene (2007: E18-23, 2010: 292).

Due to our rich data set, we are able to observe both precautionary strategies and their relationship with each other. In particular, we control for the (endogenous) alternative precautionary strategy in Specification 3 to test if the general conclusions in regard to charity hazard change. For instance, a finding of a charity hazard could simply be due to the ommitance of the alternative precautionary strategy. While our results should be interpreted as correlations and have no causal inference, as typical for most empirical studies of charity hazard (e.g. Browne & Hoyt, 2000; Petrolia et al., 2013, 2015), they offer interesting new insights.

Table 5: Marginal effects of probit estimation on flood insurance uptake (Case A)

	Specification 1	Specification 2	Specification 3
trust	0.019	0.021*	0.017
floodprone	—	0.014	0.014
trust × *floodprone*	—	-0.112*	-0.121*
protection	—	—	0.078**
ex-mandatory	0.176**	0.172**	0.174**
experience	0.029*	0.030*	0.025
damage	0.057**	0.057**	0.035
female	-0.008	-0.007	-0.003
age	-0.002**	-0.002**	-0.002**
college	-0.043**	-0.042**	-0.043**
middleincome	0.040	0.041	0.024
highincome	0.074**	0.074**	0.053*
t	0.007	0.007	0.007
N	5,586	5,549	5,240

*Note: **,* denote statistical significance at the 1 % and 5 % level, respectively.*

5 Results

First, we present results for all three specifications regarding flood insurance uptake (Case A), focusing on the existence of charity hazard (Table 5).[6] In Specification 1, without controlling for objective flood risk and non-financial protection measures, trust in governmental relief has no bearing on insurance uptake providing no indication of charity hazard. In Specification 2, including a flood risk dummy as well as an interaction term with trust in governmental relief, we find a significant negative relationship between trust in governmental relief and insurance uptake for households in flood-prone areas. The results suggest that governmental aid and flood insurance are substitutes for those individuals who actually face an objective flood risk. Specifically, the probability of taking up flood insurance reduces by approximately 9.1 percentage points (0.021-0.112=-0.091) , revealing a substantial charity hazard.[7] This main result is confirmed by Specification 3, where we additionally control for the implementation of non-financial protection measures.

[6]Estimation coefficients can be found in Table A1 in the Appendix. Furthermore, all main results are confirmed by the robustness checks using logit, OLS and random-effects probit regressions, see Table A2 in the Appendix.

[7]Note that the positive effect of trust in governmental relief for households outside flood-prone areas is not robust since it is only significant in Specification 2. Hence, we will not further interpret this correlation.

Specification 3 moreover reveals – in line with Hudson et al. (2017) and Petrolia et al. (2015) – a positive correlation between insurance uptake and further protection measures. This finding suggests that households tend to perceive both flood precaution measures, the uptake of an insurance and the implementation of non-financial protection measures, as complements, rather than substitutes. Accordingly, we find no indication of careless behavior of insured households and thus no evidence that the possession of an insurance causes a moral hazard.

Furthermore, the probability of being insured is substantially higher in federal states where flood insurance was the default coverage in home insurance contracts until the early 90's. This finding was previously mentioned in descriptive terms (e.g. by Thieken et al., 2006), but to our knowledge has never been analyzed in a multivariate regression model. As we control for several observable characteristics, i.a. flood risk and income, we interpret this finding as a hint on status-quo bias (see Samuelson & Zeckhauser, 1988), according to which individuals remain in their insurance status due to habit, even though other insurance options become available or – as in the case of Baden-Württemberg – legal compulsion ceased to apply. This result is the first evidence for status-quo bias in the natural disaster insurance context and adds to the literature on status-quo bias in other markets (Frank & Lamiraud, 2009; Johnson et al., 1993; Krieger & Felder, 2013; Salkeld et al., 2000).

The results in Table 5 show further determinants of insurance uptake, which are broadly in line with the literature. First, experience with flood events increases the probability of owning flood insurance. If the respondent suffered from personal damage, this effect is even more pronounced. However, including the implementation of non-financial protection measures in Specification 3 renders these effects statistically insignificant, due to a high correlation between flood experience and non-financial protection measures. Furthermore, a higher income affects insurance uptake positively. There are significant correlations of insurance uptake with age and education, indicating a lower probability of flood insurance uptake for elderly individuals as well as respondents who hold a college preparatory degree.

Table 6: Marginal effects of probit estimation on non-financial protection measures (Case B)

	Specification 1	Specification 2	Specification 3
trust	0.047**	0.047**	0.047**
floodprone	—	0.070*	0.073*
trust × *floodprone*	—	0.012	0.013
insured	—	—	0.090**
ex-mandatory	-0.022	-0.020	-0.038*
experience	0.069**	0.068**	0.063**
damage	0.293**	0.293**	0.288**
female	0.025	0.023	0.025
age	0.003**	0.003**	0.004**
college	-0.006	-0.005	0.009
middleincome	0.078**	0.079**	0.065**
highincome	0.110**	0.109**	0.105**
t	0.020	0.019	0.022*
N	5,767	5,728	5,240

*Note: **,* denote statistical significance at the 1 % and 5 % level, respectively.*

In contrast to the uptake of flood insurance, we do not find an indication of charity hazard for the implementation of non-financial protection measures (Case B). Indeed, we derive in all three specifications a positive correlation between non-financial protection measures and trust in governmental relief (Table 6).[8] Accordingly, our results suggest that the trust in governmental aid does not harm the implementation of non-financial protection measures. We do not find heterogeneous effects in regard to different flood risks.

Additionally, we find a strong impact of flood experience on the implementation of non-financial protection measures (as shown by Bubeck at al., 2012 and Osberghaus, 2017). The mere experience without personal damage increases the probability of implementing non-financial protection measures by around 6-7 percentage points. If the respondent suffered from personal damage this effect increases to around 29 percentage points. An explanation for this distinct impact on precautionary behavior might be a higher risk perception of individuals with flood experience as shown by Frondel et al. (2017). As expected, respondents in flood-prone areas are more likely to conduct non-financial protection measures. Finally, older respondents as well as households

[8]Estimation coefficients can be found in Table A3 in the Appendix. Furthermore, all main results are confirmed by the robustness checks using logit, OLS and random-effects probit regressions, see Table A4 in the Appendix.

with a higher income have a higher probability to conduct these measures.

6 Summary and Conclusion

Drawing on rich survey data from German homeowners, we examine the determinants of flood insurance uptake and the implementation of technical and behavioral (i.e. non-financial) flood protection measures. We particularly focus on the effect of governmental relief expectations in case of a flood. Many theoretical works suggest charity hazard, i.e. a negative effect of governmental relief on insurance uptake and non-financial protection behavior. However, prior empirical findings are ambiguous.

Regarding charity hazard for insurance uptake, our results depend on the household's objective flood risk level: While there is no significant correlation for households in low-risk areas, homeowners in flood-prone regions tend to forgo insurance coverage if they expect governmental relief in case of a flood damage. These households seem to perceive financial payments from the government and from insurance companies as substitutes. In fact, due to eligibility criteria, governmental aid and insurance payouts are mutually exclusive.

When it comes to the implementation of non-financial protection measures, we find a positive correlation with governmental relief expectations. Hence, households perceive relief payments and the benefits of technical or behavioral flood protection as complements. Indeed, the kind of benefits of governmental aid and non-financial protection measures are quite different: While relief payments can only alleviate financial hardships, non-financial protection measures, such as back-flow flaps, can also reduce physical damages. Moreover, the implementation of non-financial protection measures has no influence on the eligibility for governmental aid.

Furthermore, we find that insurance uptake and non-financial protection measures are complements and thus can work well together in reducing household vulnerability towards flood damages. As insured households conduct additional protection measures, this might relax the concern over moral hazard in the flood insurance market.

Finally, our results indicate the existence of a status-quo bias for flood insurance uptake, as the insurance rate is still significantly higher in regions where flood coverage was historically the default for home insurance contracts.

As is typical for empirical studies of charity hazard (e.g. Browne & Hoyt, 2000; Petrolia et al., 2013, 2015), our results should be interpreted as correlations and have no causal inference. Nevertheless, our results allow us to draw some important conclusions for policy makers and future research in this area. As our findings suggest a charity hazard only for the uptake of insurance, it seems crucial to differentiate between precautionary strategies, in particular between insurance and non-financial protection measures. For a better understanding of a potential charity hazard, it is furthermore important to focus on regional effects. A distinctive feature of our study is the analysis of the heterogeneous effects regarding the different flood risks between regions: Our results indicate charity hazard only for individuals in flood-prone regions. Yet, to understand the ambigious empirical results so far, it seems important to take also the institutional settings into account (cf. Raschky et al., 2013). While our results make sense for Germany (given that governmental aid is conditioned on being not insured), the seemingly contradictory empirical results for the USA (Petrolia et al., 2013) might be explained by the fact that flood insurance is mandatory in the US for a considerable percentage of households in flood-prone areas.

For Germany, our analysis suggests that unconditional financial relief for uninsured households in the aftermath of natural disasters provides disincentives for private insurance uptake. However, due to political considerations, the government can hardly commit not to assist needy households (Coate, 1995). In order to find strategies that reduce adverse side-effects of governmental relief, future research could assess, for instance, the potential effects of mandatory flood insurance, the possibilities to make relief payments conditional on or combinable with private insurance, and the prospects of intensified information and awareness campaigns on natural disaster risk perception and adequate precautionary measures.

Appendix

Table A1: Coefficients of probit estimation on flood insurance uptake (Case A)

	Specification 1	Specification 2	Specification 3
trust	0.055 (0.042)	0.088* (0.044)	0.077 (0.045)
floodprone	—	0.134 (0.094)	0.143 (0.096)
trust × *floodprone*	—	-0.328* (0.143)	-0.355* (0.147)
protection	—	—	0.230** (0.041)
ex-mandatory	0.545** (0.048)	0.534** (0.048)	0.546** (0.050)
experience	0.085* (0.041)	0.088* (0.041)	0.073 (0.042)
damage	0.169** (0.059)	0.168** (0.059)	0.103 (0.062)
female	-0.023 (0.047)	-0.020 (0.048)	-0.008 (0.050)
age	-0.005** (0.002)	-0.005** (0.002)	-0.007** (0.002)
college	-0.126** (0.044)	-0.122** (0.045)	-0.125** (0.046)
middleincome	0.113 (0.059)	0.116 (0.059)	0.071 (0.061)
highincome	0.214** (0.064)	0.215** (0.064)	0.156* (0.066)
t	0.021 (0.031)	0.021 (0.031)	0.022 (0.032)
N	5,586	5,549	5,240

*Note: Robust standard errors in parentheses. **,* denote statistical significance at the 1 % and 5 % level, respectively.*

Table A2: Results of logit, OLS and random-effects probit estimation on flood insurance uptake (Case A)

	logit marginal effects	OLS coefficients	random-effects marginal effects
trust	0.016	0.025	0.017
floodprone	0.014	0.048	0.008
trust × *floodprone*	-0.122*	-0.121*	-0.110*
protection	0.078**	0.078**	0.068**
ex-mandatory	0.172**	0.175**	0.170**
experience	0.024	0.025	0.026*
damage	0.035	0.035	0.030
female	-0.003	-0.002	-0.006
age	-0.002**	-0.002**	-0.002**
college	-0.043**	-0.042**	-0.045**
middleincome	0.025	0.024	0.031
highincome	0.054*	0.054*	0.059**
t	0.008	0.008	0.005
N	5,240	5,240	5,240

*Note: Marginal effects are averaged over observations. **,* denote statistical significance at the 1 % and 5 % level, respectively. Statistical significance for the logit and the random-effects probit estimations are infered from estimation coefficients (not depicted) (cf. Greene, 2007:E18-E23, 2010:292)*

Table A3: Coefficients of probit estimation on non-financial protection measures (Case B)

	Specification 1	Specification 2	Specification 3
trust	0.122** (0.039)	0.120** (0.041)	0.121** (0.044)
floodprone	—	0.174* (0.087)	0.182* (0.092)
trust × *floodprone*	—	0.034 (0.139)	0.036 (0.149)
insured	—	—	0.236* (0.042)
ex-mandatory	-0.057 (0.044)	-0.053 (0.044)	-0.101* (0.046)
experience	0.176** (0.038)	0.174** (0.038)	0.161** (0.040)
damage	0.770** (0.056)	0.773** (0.056)	0.765** (0.058)
female	0.066 (0.045)	0.060 (0.045)	0.065 (0.048)
age	0.008** (0.002)	0.009** (0.002)	0.009** (0.002)
college	-0.015 (0.042)	-0.012 (0.042)	0.007 (0.044)
middleincome	0.205** (0.057)	0.207** (0.057)	0.172** (0.061)
highincome	0.288** (0.061)	0.287** (0.061)	0.276** (0.065)
t	0.053 (0.028)	0.051 (0.029)	0.059* (0.030)
N	5,767	5,728	5,240

*Note: Robust standard errors in parentheses. **,* denote statistical significance at the 1 % and 5 % level, respectively.*

Table A4: Results of logit, OLS and random-effects probit estimation on non-financial protection measures (Case B)

	logit marginal effects	OLS coefficients	random-effects marginal effects
trust	0.047**	0.046**	0.042**
floodprone	0.073*	0.069*	0.073*
trust × *floodprone*	0.014	0.011	0.005
insured	0.090**	0.090**	0.077**
ex-mandatory	-0.039*	-0.039*	-0.042*
experience	0.063**	0.063**	0.064**
damage	0.288**	0.287**	0.268**
female	0.025	0.025	0.026
age	0.004**	0.004**	0.004**
college	0.003	0.002	0.001
middleincome	0.065**	0.065**	0.048*
highincome	0.104**	0.104**	0.092**
t	0.022	0.022	0.022*
N	5,240	5,240	5,240

*Note: Marginal effects are averaged over observations. **,* denote statistical significance at the 1 % and 5 % level, respectively. Statistical significance for the logit and the random-effects probit estimations are infered from estimation coefficients (not depicted) (cf. Greene, 2007:E18-E23, 2010:292)*

References

Arendt, M. (2013). Die Versicherung von Klimafolgeschäden am Beispiel der Elementarschadenversicherung: Diskussion alternativer Versicherungssysteme. *dynaklim-Publikation 41*.

Arvan, L., & Nickerson, D. (2006). Private investment, public aid and endogenous divergence in the evolution of urban neighborhoods. *Journal of Real Estate Finance and Economics, 32(1)*, 83-100.

Atreya, A., Ferreira, S., & Michel-Kerjan, E. (2015). What drives households to buy flood insurance? New evidence from Georgia. *Ecological Economics, 117*, 153-161.

Berlemann, M., Steinhardt, M., & Tutt, J. (2015). Do Natural Disasters Stimulate Individual Saving? Evidence from a Natural Experiment in a Highly Developed Country. *Institute for the Study of Labor (IZA), Discussion Paper 9026.* Bonn, Germany.

BfG – Bundesanstalt für Gewässerkunde (2015). WasserBLIcK. The German Federal Institute of Hydrology. Link: geoportal.bafg.de/mapapps/resources/apps/HWRMRL-DE/index.html.

Botzen, W. J. W., Aerts, J. C. J. H., & van den Bergh, J. C. J. M. (2009). Willingness of homeowners to mitigate climate risk through insurance. *Ecological Economics, 68(8-9)*, 2265-2277.

Botzen, W. J. W., & van den Bergh, J. C. J. M. (2012a). Monetary Valuation of Insurance Against Flood Risk Under Climate Change. *International Economic Review, 53(3)*, 1005-1026.

Botzen, W. J. W., & van den Bergh, J. C. J. M. (2012b). Risk attitudes to low-probability climate change risks: WTP for flood insurance. *Journal of Economic Behavior & Organization, 82(1)*, 151-166.

Browne, M. J., & Hoyt, R. E. (2000). The Demand for Flood Insurance: Empirical Evidence. *Journal of Risk and Uncertainty, 20(3)*, 291-306.

Brunette, M., Cabantous, L., Couture, S., & Stenger, A. (2013). The impact of governmental assistance on insurance demand under ambiguity: A theoretical model and an experimental test. *Theory and Decision, 75(2)*, 153-174.

Bubeck, P., Botzen, W. J. W., & Aerts, J. C. J. H. (2012). A review of risk perceptions and other factors that influence flood mitigation behavior. *Risk Analysis, 32(9)*, 1481-1495.

Buchanan, J. M. (1975). The Samaritan's dilemma. In: E. S. Phelps (Ed.), Altruism, Morality, and Economic Theory (pp. 71-85). New York, USA: Russel Sage Foundation.

Coate, S. (1995). Altruism, the Samaritan's Dilemma, and Government Transfer Policy. *The American Economic Review, 85(1)*, 46-57.

Deryugina, T., & Kirwan, B. (2016). Does The Samaritan's Dilemma Matter? Evidence From US Agriculture. *National Bureau of Economic Research (NBER) Working Paper*, No. 22845.

Frank, R. G., & Lamiraud, K. (2009). Choice, price competition and complexity in markets for health insurance. *Journal of Economic Behavior & Organization, 71(2)*, 550-562.

Frondel, M., Simora, M., & Sommer, S. (2017). Risk Perception of Climate Change: Empirical Evidence from Germany. *Ecological Economics, 137*, 173-183.

GDV: Gesamtverband der Deutschen Versicherungswirtschaft e. V. (2016). Verbreitung der Elementarschadenversicherung in Deutschland. German Insurance Association. Link: http://www.gdv.de/2016/09/versicherungsdichte-in-der-elementarschadenversicherung/ (accessed April 18, 2017).

Greene, W. H. (2007). Limdep version 9.0, Econometric modeling guide. New York: Econometric Software.

Greene, W. H. (2010). Testing hypotheses about interaction terms in non-linear models. *Economics Letters 107*, 291-296.

Hudson, P., Botzen, W. J. W., Czajkowski, J., & Kreibich, H. (2017). Moral Hazard in Natural Disaster Insurance Markets: Empirical Evidence from Germany and the United States. *Land Economics, 93(2)*, 179-208.

Johnson, E. J., Hershey, J., Meszaros, J., & Kunreuther, H. (1993). Framing, probability distortions, and insurance decisions. *Journal of Risk and Uncertainty, 7(1)*, 35-51.

Kelly, M., & Kleffner, A. E. (2003). Optimal Loss Mitigation and Contract Design. *Journal of Risk and Insurance, 70(1)*, 53-72.

Kousky, C. (2017). Financing Flood Losses: A Discussion of the National Flood Insurance Program. *Resources for the Future, Discussion Paper 17-03.*

Kousky, C., Michel-Kerjan, E. O., & Raschky, P. A. (2017). Does Federal Disaster Assistance Crowd Out Private Demand for Insurance? *Journal of Environmental Economics and Management*, forthcoming.

Krieger, M., & Felder, S. (2013). Can decision biases improve insurance outcomes? An experiment on status quo bias in health insurance choice. *International Journal of Environmental Research and Public Health, 10(6)*, 2560-2577.

Kunreuther, H. (1996). Mitigating disaster losses through insurance. *Journal of Risk and Uncertainty, 12(2)*, 171-187.

Lamond, J., & Penning-Rowsell, E. (2014). The robustness of flood insurance regimes given changing risk resulting from climate change. *Climate Risk Management, 2*, 1-10.

Lewis, T., & Nickerson, D. (1989). Self-insurance against natural disasters. *Journal of Environmental Economics and Management, 16(3)*, 209-223.

Liesivaara, P., & Myyrä, S. (2014): Government policies in changing climate and the demand for crop insurance. Contributed Paper prepared for presentation at the 88th Annual Conference of the Agricultural Economics Society, AgroParisTech, Paris, France.

Lo, A. Y. (2013). Household Preference and Financial Commitment to Flood Insurance in South-East Queensland. *Australian Economic Review, 46(2)*, 160-175.

Munich RE (2017): Natural Catastrophe Losses at their Highest for four Years. Munich RE Press Release, 4 January 2017. Link: https://www.munichre.com/site/corporate/get/params_E-2043428855_Dattachment/1351572/Munichre-NatCatPR-2017.pdf (accessed April 18, 2017).

Osberghaus, D. (2015). The determinants of private flood mitigation measures in Germany - Evidence from a nationwide survey. *Ecological Economics, 110*, 36-50.

Osberghaus, D. (2017). The effect of flood experience on household mitigation - Evidence from longitudinal and insurance data. *Global Environmental Change, 43*, 126-136.

Petrolia, D. R., Hwang, J., Landry, C. E., & Coble, K. H. (2015). Wind Insurance and Mitigation in the Coastal Zone. *Land Economics, 91(2)*, 272-295.

Petrolia, D. R., Landry, C. E., & Coble, K. H. (2013). Risk Preferences, Risk Perceptions, and Demand for Flood Insurance. *Land Economics, 89(2)*, 227-245.

Raschky, P. A., Schwarze, R., Schwindt, M., & Zahn, F. (2013). Uncertainty of Governmental Relief and the Crowding out of Flood Insurance. *Environmental and Resource Economics, 54(2)*, 179-200.

Raschky, P. A., & Weck-Hannemann, H. (2007). Charity hazard - A real hazard to natural disaster insurance? *Environmental Hazards, 7(4)*, 321-329.

Salkeld, G., Ryan, M., & Short, L. (2000). The veil of experience: do consumers prefer what they know best?. *Health Economics, 9(3)*, 267-270.

Samuelson, W., & Zeckhauser, R. (1988). Status quo bias in decision making. *Journal of Risk and Uncertainty, 1(1)*, 7-59.

Schwarze, R., & Wagner, G. G. (2004). In the Aftermath of Dresden: New Directions in German Flood Insurance. *The Geneva Papers on Risk and Insurance, 29(2)*, 154-168.

Seifert, I., Botzen, W. J. W., Kreibich, H., & Aerts, J. C. J. H. (2013). Influence of flood risk characteristics on flood insurance demand: A comparison between Germany and the Netherlands. *Natural Hazards and Earth System Sciences, 13(7)*, 1691-1705.

Thieken, A. H., Bessel, T., Kienzler, S., Kreibich, H., Müller, M., Pisi, S., & Schröter, K. (2016). The flood of June 2013 in Germany: How much do we know about its impacts? *Natural Hazards and Earth System Sciences, 16(6)*, 1519-1540.

Thieken, A. H., Petrow, T., Kreibich, H., & Merz, B. (2006). Insurability and Mitigation of Flood Losses in Private Households in Germany. *Risk Analysis, 26(2)*, 383-395.

van Asseldonk, M. A. P. M., Meuwissen, M. P. M., & Huirne, R. B. M. (2002). Belief in Disaster Relief and the Demand for a Public-Private Insurance Program. *Review of Agricultural Economics, 24(1)*, 196-207.