

Discussion Paper No. 17-065

**Natural Disasters and Governmental Aid:  
Is there a Charity Hazard?**

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and Michael Simora

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## **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, namely insurance uptake and non-financial protection measures, 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.

# Natural Disasters and Governmental Aid: Is there a Charity Hazard?

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# 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.<sup>1</sup> 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, particularly focusing on the existence of charity hazard. We draw on survey data from German homeowners (6,100 observations) 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; Thielen 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).

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<sup>1</sup>Examples include the U.S. Federal Emergency Management Agency (Kousky, 2017), German flood relief funds (Thielen et al., 2016), and similar assistance programs in Australia (Lo, 2013).

We contribute to the literature by analyzing unique data that enables us to investigate the topic comprehensively, and thus to shed light on the existing ambiguous results. Specifically, we are the first that 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. Accordingly, even if households trust in financial aid from the government in case of a catastrophic flood, they can additionally conduct non-financial protection measures without losing 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 effect heterogeneity of governmental aid on households in different flood risk areas and for different flood pre-

caution strategies. While we find a positive correlation between trust in governmental 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. Altogether, 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 outlines our empirical strategy. Results are depicted in Section 4. Finally, Section 5 summarizes and concludes.

## **2 Literature Review**

Although the term “charity hazard” was first mentioned by Browne & Hoyt (2000), the underlying processes and implications were already analyzed in the seminal works of Buchanan (1975) and Coate (1995). The former work describes the “Samaritan’s dilemma” in which assistance to a person in need decreases the recipient’s incentives to improve its situation in the long term. Coate (1995) presents a setting in which the rich, represented by the government, provide assistance to the poor, who face a possible 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. Importantly, they also mention that as a consequence of the diminishing 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) have the finding in common 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.<sup>2</sup>

The review yields several main insights: First, the data base is relatively small. The three 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 result straightforward as an in-

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<sup>2</sup>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.*

dication of charity hazard,<sup>3</sup> 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 risk, we analyze the relationship between charity hazard and flood risk. Finally, by

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<sup>3</sup>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).

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 and Empirical Strategy

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). 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.<sup>4</sup> 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 after the occurrence of a natural disaster and their privately conducted precautionary measures. The first dependent variable under scrutiny is whether a household possesses a flood insurance (*insured*). In Germany, homeowners can include flood

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

coverage in their conventional home insurance for storm and fire hazard, for 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 relatively high number compared to data reported by the insurance industry. According to GDV (2016), around 35% of German households were flood insured in 2014. Hence, it is possible that a considerable share of respondents expects insurance coverage without actually being insured in case of a flood. This imprecision in the self-reported insurance status, however, is unproblematic 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 face a certain probability of actually being affected by a flood, 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.<sup>5</sup>

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 by a flood and could mark, amongst others, public institutions as well as charity orga-

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

nizations. 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 anecdotally 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; Thielen 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. These policies were taken over by a private insurance company after reunification in

Table 3: Explanatory and control variables

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

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.

First empirical insights on the connection between the two dependent variables and the key explanatory variables described above can be derived from Table 4, which depicts pairwise correlations. First, the two 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, which suggests that charity hazard is difficult to detect for the full sample. The

Table 4: Pairwise correlations of dependent and key explanatory variables

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

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

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 precautionary strategy (either insurance uptake or non-financial protection measures) 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 respective alternative precautionary strategy:

$$y_i^* = \beta_1 trust_i + \beta_2 floodprone_i + \beta_3 trust_i \times floodprone_i + \beta_4 y_i^c + \gamma^T \mathbf{x}_i + \delta t_i + \epsilon_i \quad (1)$$

where  $y_i^*$  designates the precautionary strategy under scrutiny (in Case A insurance uptake, *insured*, and in Case B the implementation of non-financial protection measures, *protection*) 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  $y^c$  denotes the alternative precautionary strategy (the implementation of non-financial protection measures, *protection*, in Case A, and the insurance uptake, *insured*, in Case B).  $x$  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,  $\beta$ ,  $\gamma$  and  $\delta$  are the parameters to be estimated and  $\epsilon$  denotes the error term. 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 omittance 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.

## 4 Results

First, we present results for all three specifications regarding flood insurance uptake (Case A), focusing on the existence of charity hazard (Table 5).<sup>6</sup> In Specification 1, without controlling for objective flood risk and non-financial protection measures,

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<sup>6</sup>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.

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

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

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

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.<sup>7</sup> This main result is confirmed by Specification 3, where we additionally control for the implementation of non-financial protection measures.

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

<sup>7</sup>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.

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 Thielen 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.

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

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

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

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

protection measures and trust in governmental relief (Table 6).<sup>8</sup> 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 et 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 with a higher income have a higher probability to conduct these measures.

<sup>8</sup>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.

## 5 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 surprisingly ambiguous.

Regarding charity hazard for insurance uptake, we contribute results that are differentiated by 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, protection measures 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 for the first time in a multivariate setting (controlling

i.a. for flood risk) 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 ambiguous 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
<i>trust</i>	0.055 (0.042)	0.088* (0.044)	0.077 (0.045)
<i>floodprone</i>	—	0.134 (0.094)	0.143 (0.096)
<i>trust</i> × <i>floodprone</i>	—	-0.328* (0.143)	-0.355* (0.147)
<i>protection</i>	—	—	0.230** (0.041)
<i>ex-mandatory</i>	0.545** (0.048)	0.534** (0.048)	0.546** (0.050)
<i>experience</i>	0.085* (0.041)	0.088* (0.041)	0.073 (0.042)
<i>damage</i>	0.169** (0.059)	0.168** (0.059)	0.103 (0.062)
<i>female</i>	-0.023 (0.047)	-0.020 (0.048)	-0.008 (0.050)
<i>age</i>	-0.005** (0.002)	-0.005** (0.002)	-0.007** (0.002)
<i>college</i>	-0.126** (0.044)	-0.122** (0.045)	-0.125** (0.046)
<i>middleincome</i>	0.113 (0.059)	0.116 (0.059)	0.071 (0.061)
<i>highincome</i>	0.214** (0.064)	0.215** (0.064)	0.156* (0.066)
<i>t</i>	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
<i>trust</i>	0.016	0.025	0.017
<i>floodprone</i>	0.014	0.048	0.008
<i>trust</i> × <i>floodprone</i>	-0.122*	-0.121*	-0.110*
<i>protection</i>	0.078**	0.078**	0.068**
<i>ex-mandatory</i>	0.172**	0.175**	0.170**
<i>experience</i>	0.024	0.025	0.026*
<i>damage</i>	0.035	0.035	0.030
<i>female</i>	-0.003	-0.002	-0.006
<i>age</i>	-0.002**	-0.002**	-0.002**
<i>college</i>	-0.043**	-0.042**	-0.045**
<i>middleincome</i>	0.025	0.024	0.031
<i>highincome</i>	0.054*	0.054*	0.059**
<i>t</i>	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 inferred 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
<i>trust</i>	0.122** (0.039)	0.120** (0.041)	0.121** (0.044)
<i>floodprone</i>	—	0.174* (0.087)	0.182* (0.092)
<i>trust</i> × <i>floodprone</i>	—	0.034 (0.139)	0.036 (0.149)
<i>insured</i>	—	—	0.236* (0.042)
<i>ex-mandatory</i>	-0.057 (0.044)	-0.053 (0.044)	-0.101* (0.046)
<i>experience</i>	0.176** (0.038)	0.174** (0.038)	0.161** (0.040)
<i>damage</i>	0.770** (0.056)	0.773** (0.056)	0.765** (0.058)
<i>female</i>	0.066 (0.045)	0.060 (0.045)	0.065 (0.048)
<i>age</i>	0.008** (0.002)	0.009** (0.002)	0.009** (0.002)
<i>college</i>	-0.015 (0.042)	-0.012 (0.042)	0.007 (0.044)
<i>middleincome</i>	0.205** (0.057)	0.207** (0.057)	0.172** (0.061)
<i>highincome</i>	0.288** (0.061)	0.287** (0.061)	0.276** (0.065)
<i>t</i>	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
<i>trust</i>	0.047**	0.046**	0.042**
<i>floodprone</i>	0.073*	0.069*	0.073*
<i>trust</i> × <i>floodprone</i>	0.014	0.011	0.005
<i>insured</i>	0.090**	0.090**	0.077**
<i>ex-mandatory</i>	-0.039*	-0.039*	-0.042*
<i>experience</i>	0.063**	0.063**	0.064**
<i>damage</i>	0.288**	0.287**	0.268**
<i>female</i>	0.025	0.025	0.026
<i>age</i>	0.004**	0.004**	0.004**
<i>college</i>	0.003	0.002	0.001
<i>middleincome</i>	0.065**	0.065**	0.048*
<i>highincome</i>	0.104**	0.104**	0.092**
<i>t</i>	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 inferred from estimation coefficients (not depicted) (cf. Greene, 2007:E18-E23, 2010:292)

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