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Climate risk perceptions of businesses: the role of experience and objective risk factors

Markus Rieger-Fels[1]

September 04, 2024

Abstract

The changing climate requires businesses to take adaptive action. A key prerequisite for optimal adaptive action is that businesses are aware of the climate risks that they face. This, in turn, necessitates that businesses do not base their risk perception solely on prior experience, or a lack thereof, but take objective risk factors into account. I use data from a large-scale survey of German businesses to investigate how they assess the acute physical climate risk presented by the increased frequency of natural hazards: droughts, storms, extreme heat, heavy precipitation, and floods. I find experience to have a large effect on the perceived probability of hazard events, but no effect on their perceived consequences. Objective risk criteria such as firm size, industry, and location characteristics inform expectations independent of experience and, depending on the hazard, even to a larger extent than experience. The results suggest that it might not be a lack of risk awareness that underlies any adaptation gap.

JEL Classification: D22, D83, Q54

Keywords: Risk perception, risk management, climate risks, natural hazards

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1. Introduction

The changing climate influences the risk environment that businesses operate in. They face both physical risks, such as extreme weather events, and transitional risks, such as growing pressures to decarbonize their production from both customers and regulators. (Sussman and Freed 2008, Agrawala et al. 2011, Cochu et al. 2019, EPA 2022) Given that climate change will, at best, be slowed in the foreseeable future, societies are confronted with the challenge to adapt to the consequences of climate change.

The importance of businesses for society's adaptation to climate change is often stressed (Surminski 2013, Schaer and Kuruppu 2018, Cochu et al. 2019). A key antecedent of any corporate adaptation is that businesses perceive climate risks as relevant for their success and survival (Grothmann and Patt 2005, Agrawala et al. 2011, Berkhout 2012, Linnenluecke et al. 2012, Pinske and Gasbarro 2019). Climate risks compete with other topics for managerial attention. If climate risks are deemed unimportant or only important in the future, other challenges are prioritized. After all, managers will not allocate scarce financial or personal resources to adaptation efforts if they deem climate risks negligible. Given this importance of climate risk perception as a precondition for adaptive action, it is remarkable that we still know rather little about businesses' perceptions of specific climate risks, how these perceptions are formed, how well they are informed, and how they evolve over time.

Understanding how businesses form expectations about future climate risks is important to shape policy. A common concern is that particularly small and medium-sized enterprises (SMEs) underestimate or ignore the climate risks they face (AXA and UNEP 2015, Linnenluecke and Smith 2018, Mathews et al. 2021) and, because of this, fail to adapt. While a lack of risk awareness can be an important impediment to adaptive action, other hurdles exist (Grothmann and Patt 2005, Linnenluecke et al. 2012, Leitold et al. 2021, Schlepphorst et al. 2023). Firms may fail to take appropriate action for a variety of other reasons including the lack of financial, personal, or time resources. As a result, the perception of climate risks is a necessary, but not a sufficient condition for adaptation. Given that the correct policy response depends heavily on the reasons underlying inaction, determining to which extent risk perceptions are informed, i.e., determining whether firms are indeed unaware of or ill-informed about the climate risks that they face, is crucial.

As Table 1 indicates, existing research heavily focuses on the climate risk perceptions of households and individuals (Siegrist and Gutscher 2006, Botzen et al. 2009, Frondel et al. 2017) and often finds prior experience with natural hazards to play an important role. It is well-known that heuristics, i.e., cognitive short-cuts for complex judgment or decision tasks, shape individual risk assessments (Tversky and Kahneman 1974). One such heuristic - availability – might explain the large role experience plays in shaping expectations (Tversky and Kahneman 1973). But it remains unclear to what extent business perceptions of risks are prone to such heuristics. On the one side, many firms invest heavily in a professional risk management that might mitigate individual biases. On the other side, even more firms – particularly smaller ones - simply lack the resources for a professional analysis of their risk environment. In addition, as Bleta et al. (2023) point out, climate change and its associated challenges present such a complex development that organizations need to rely on heuristics for sense- and decision-making irrespective of their size.

Understanding the extent to which businesses rely on past experience to form their expectations is important. After all, a changing climate means that prior experience of natural hazards, or a lack of such experience, may only be an inadequate signal of future risks. It is thus crucial that businesses also consider objective risk factors, such a firm size, industry, or location in their risk assessment. If they fail to do so and, instead, largely rely on the past experience of climate events to assess their susceptibility, they may end up missing the increase in climate risks that climate change entails and fail to adapt appropriately (Bleda et al. 2023).

Prior research on businesses' risk perceptions with respect to natural hazards either focuses on specific hazards such as floods, or on industries such as agriculture and locations that are deemed particularly vulnerable (Kreibich et al. 2008; van Duinen et al. 2015; Mase et al. 2017; Linnenluecke and Smith 2018). Yet, this leaves us with a rather incomplete picture of businesses' risk perceptions as it remains unclear whether the findings generalize to other hazards or industries. Moreover, it prevents us from understanding to what extent objective risk factors, of which firm size, location, and industry are an integral part, inform these subjective risk perceptions.

Table 1: Related literature

Author(s), year	Method	Location	Observation unit	Hazard/climate risk	Outcome	Risk factors considered	Findings
Botzen et al. (2009)	survey	Netherlands	approx. 1,000 households	flood	probability, expected damage	Location	Prior Experience positively related to probability, but negativley to expected flood damage; geographical characteristics (distance to river, elevation) are negatively related to both.
Frondel et al. (2017)	survey	Germany	approx. 8,500 households	heat, storm, flood	probability	Location	Prior experience has a positive effect on the probability, objective risk measures have a positive effect for heat and floods, but not for storms.
Kreibich et al. (2008)	survey	Germany	438 firms	flood	preparedness	N/A	Preparedness increased after flood event.
Peacock et al. (2005)	survey	USA	1260 households	hurricane	risk score	Location	Experience of a hurricane has no significant effect.
Sakhel (2017)	analysis of secondary data, database on voluntary disclosures	Europe	126 listed firms	Physical versus regulatory and market risk	risk score	High-emission industry	Firms from high-emission industries do not rate physical risks higher than firm from low-emission industries.
Siegrist & Gutscher (2006)	survey	Germany, Switzerland	approx. 1,300 households		probability	Location	Both experience and objective risk are significiantly related to the probability assessement.
van Duinen et al. (2015)	survey	Netherlands	142 farmers	drought	risk score	Location characteristics, crop, firm size	Both experience and objective risk factors drive risk perception.
Weinhofer & Busch (2013)	case study	Austria, Switzerland	11 electric-utility companies	climate risks	N/A	N/A	Firms base their risk assessment on experience, and, where this is not possible, on scientific information and analyses.

Finally, existing research often does not distinguish between the different components of climate risk, i.e., the probability of a hazard and its possible consequences (Grothman and Pratt 2005). Except for Botzen et al. (2009), the studies either consider only one component, probability (Siegrist and Gutscher 2006, Frondel et al. 2017), or they consider risk scores (Peackcock et al. 2005, van Duinen et al. 2015, Sakhel 2017) that mix probability and consequence expectations thereby precluding any analysis of whether experience affects the two components of risk perception differently.

In this study, I investigate the perception of acute physical risks, specifically the increased frequency of natural hazards, such as storms, floods, extreme heat, precipitation, and droughts, that follows from climate change. I use data from a large-scale survey among German businesses conducted by the Institut für Mittelstandsforschung (IfM) Bonn during July and August 2022 (Schlepphorst et al. 2023).[2] Responses by almost 800 companies allow to analyze the perception of these physical climate risks. I investigate how likely they expect to be impacted by the different natural hazards and how vulnerable they deem themselves to these hazards. Information on firm size, industry, dependence on partners in the value chain, and location characteristics allow to investigate the extent to which objective risk criteria, in addition to experience, inform the subjective risk assessments. In addition, I conduct dominance analyses (Azen and Budescu 2003) to determine the relative importance of experience versus objective risk factors and the relative importance of different objective risk factors, such as location, industry, or firm size, in explaining the variation in expectations.

The paper adds to the literature on the perception of climate risks.[3] I find that, consistent with much of the literature (Siegrist and Gutscher 2006; Botzen et al. 2009, Weinhofer and Busch 2013, van Duinen et al. 2015, Frondel et al. 2017), experience plays a large role in the expectation of future risk. However, adding to that literature, I only find a strong influence of experience on the probability with which businesses expect to be affected by a natural hazard. I do not find a significant influence of experience on the expected consequences of a hazard event. Instead, objective risk factors, in particular firm size, industry, and location inform the consequence expectations.

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2 Although, from a global perspective, Germany is among those countries less affected by the physical consequences of climate change, it will nevertheless experience a strong increase in natural hazards including an increased frequency of extreme weather events, droughts, and floods (Kahlenborn et al. 2021, Thow et al. 2022). And even if German firms are less affected directly, Germany's strong export orientation and a dependence on foreign inputs mean that the success of its businesses might be impaired by natural hazards in other, more heavily affected countries.

3 See, e.g., Wachinger & Renn (2010) for an overview.

Finally, I find that the relative importance of experience compared to objective risk factors and the relative importance of the different risk factors depend on the hazard.

These results are significant both from a theoretical and practical perspective. From a theoretical perspective, they show that a distinction of the different components of risk is necessary when investigating the role of experience on risk perceptions. From a practical perspective, they indicate that objective risk factors shape business expectations of climate risks, suggesting that an adaption gap might not be primarily due to a lack of risk awareness. Policymakers may then want to focus their attention on other hurdles to adaptation. Still, probability assessments of natural hazards are still highly dependent on prior experience. Given that climate change means that prior experience with natural hazards or a lack thereof may only be partially informative about future risks, managers may want to consider to a larger degree objective risk factors in their risk assessments.

2. Theoretical considerations and hypotheses

To investigate the relationship between experience, objective risk factors, and risk perception, it is important to keep in mind that expectations about an event can be disentangled into a probability judgment (sometimes also referred to as likelihood) and a consequence judgment (Hirshleifer and Riley 1992). That is, firms need to form a belief about the probability of being affected by a hazard, and a belief about the expected consequences of such an event. The subjective beliefs about hazard probability and hazard consequences may or may not coincide with the objective risk that a firm faces. This objective risk is a function of objective risk factors, such as location, industry, or a firm's value chain. If risk perception is informed by the objective risk, then these objective risk factors should also influence the subjective beliefs about hazard probability and consequence of a firm.

Similarly, both the judgment of a hazard probability and hazard consequences might be based on prior experience. The literature underlines the importance of the experience of prior events in forming expectations of climate risks (Wachinger and Renn 2010). This may be quite rational given that objective risk is tied to factors that do not quickly change such as the characteristics of the business location. Experience should then have predictive value. However, in a changing climate, experience (or a lack thereof) is far from a perfect predictor of future susceptibility. The relative importance of experience and objective risk factors is still a subject of discussion in the literature (Peacock et al. 2004, Siegrist and Gutscher 2006, Botzen et al. 2009, Frondel et al. 2017). Specifically, the literature differs on whether experience has predictive value beyond its correlation with objective risk factors and whether objective risk factors have predictive value beyond shaping experience. In addition, the importance of experience and of various risk factors may differ across the two judgments. Despite that, as Table 1 shows, most of the literature either considers only one component of the risk assessment, probability (Siegrist and Gutscher 2006, Frondel et al. 2017), or it uses a risk score that mixes the two components (Peackcock et al. 2005, van Duinen et al. 2015, Sakhel 2017). In both cases, it is not possible to see whether the relative importance of experience and objective risk factors in explaining risk perceptions differs across the two components of risk.

2.1. Probability assessment

Let us first consider the probability assessments of firms. On the one side, a stream of literature argues that individuals form their probability judgments based on heuristics, such as availability (Tversky and Kahneman 1973, 1974). Individuals deem an event more likely to occur the easier they can recall similar events from the past. Such heuristic judgments may result in biases and may explain a disparity between expert and layperson judgments. If laypersons' risk assessment is largely based on a heuristic such as availability, objective risk information is only relevant for risk perceptions as it shapes experiences. Beyond this indirect effect, it should have limited influence. In the most extreme case, if the judgment is solely based on experience, objective risk factors should have no effect once experience is controlled for. On the other hand, if individuals are perfectly rational, subjective risk assessments should largely be determined by objective risk factors. After all, experience is simply a past realization of the objective risk that the firm faces. In that case, experience merely serves as a proxy for objective risk, which means that the effect of experience should be minor after controlling for sufficiently many objective risk factors.

Hypothesis 1a: Objective risk factors, such as location, industry, and firm size influence the perceived probability of a hazard event after controlling for experience.

Hypothesis 1b: Experience of a hazard event increases the perceived probability of a hazard event after controlling for objective risk factors.

Siegrist and Gutscher (2006), Botzen et al. (2009), and Frondel et al. (2017) find experience to play a role in probability assessments even after controlling for location as an objective risk factor. Peacock et al. (2004) find experience to have little to no effect after controlling for location. When controlling for objective risk, most studies use geographical information. In line with that, firms that are located close to the coast or a river should assign larger probabilities to flooding events. Firms in the city should assign a larger probability to being impacted by heat events (Oke 1982, Heaviside et al. 2017) and, due to more surface sealing, by precipitation events (Kaspersen et al 2015). However, the risk posed by various natural hazards to a business is not just a function of location. Other factors may influence the probability of a firm being affected by a natural hazard. A remaining explanatory value of experience may then not point to the importance of the availability heuristic, but simply be the result of experience serving as a proxy for objective risk factors not controlled for. The survey results may add to the prior literature by offering a wider variety of control variables, such as industry or firm size, that should be associated with the objective probability of being affected by a hazard. For example, due to their business model, firms in construction are more likely affected by heat or heavy precipitation than businesses offering, for example, IT services. Similarly, one would expect businesses from agriculture or tourism to be more likely affected by weather events.

Beyond location and industry, firm size might be a factor in the objective risk that a business faces. For example, given that smaller firms tend to have a lower number of production sites, a lower number of employees, customers, and suppliers, one would expect the objective probability for a small firm to be impacted by a natural hazard to be lower compared to larger firms. In addition to the objective risk, one might expect the size of a firm to influence risk perception. Larger firms can dedicate specialized personal and resources to their risk management. In contrast, the risk management at micro and small firms is more likely in the hands of the management that needs to rely more heavily on intuitive judgments. Accordingly, the literature often argues that smaller firms may underestimate climate risks as they have less resources available to make a comprehensive risk analysis (AXA and UNEP 2015, Linnenluecke and Smith 2018, Mathews et al. 2021). However, it is unclear why this necessarily implies an underestimation, not just a noisier estimate of the risk. After all, an insufficient risk analysis may equally lead small firms to overestimate risks.

2.2. Consequence assessment

In contrast to its effect on the subjective probability of a hazard, the effect of experience on the belief about possible consequences of a hazard event is less straightforward. Wachinger et al. (2013) suggest that beliefs about hazard severity might adapt to experience. As people experience hazard events with severe or mild consequences, they adjust their beliefs about a natural hazard's consequences accordingly up- or downward. If one only observes whether a firm has experienced a hazard event without observing the event's severity, a restriction that applies to this study, one may find an insignificant effect because the updating in opposite directions cancel out each other. Such a cancelling out cannot be distinguished from experience not having an effect at all. However, this averaging-out requires that the prior belief about hazard consequences is correct on average. While this may be true, Ockam's razor suggests that the simpler explanation of experience not having an effect should be favored over the more complicated explanation of the exact cancelling of experiences of different severity. However, as Linnenluecke et al. (2012) point out, there are ways how experience can impact expected hazard consequences beyond changing beliefs about hazard severity. On the one side, experience of a hazard event might heighten awareness of the risk leading to experienced firms being better prepared and thus less vulnerable. On the other side, recovery after a hazard event depletes financial reserves leaving experienced firms more vulnerable to future events. Again, we have two countervailing effects and no a priori indication whether one dominates the other. Given that, I expect no correlation between experience and expected consequences.

In contrast to experience, objective risk criteria should influence beliefs about hazard consequences. For example, smaller firms should be more vulnerable to natural hazards (Craioveanu and Terrell 2016, Collier et al. 2019). First, the very same reasons that lower the probability of an impact – a lower number of production sites, employees, and suppliers - imply a lack of diversification advantages. Hence, the impact of a hazard on a smaller firm can be expected to be more severe. In addition, smaller firms have less resources to recover and rebuild. In sum, it appears reasonable that smaller firms face a different risk structure than larger firms by facing a lower probability of being affected by a hazard, but a higher impact in case they are affected. In addition to firm size, one would expect industry affiliation to influence hazard consequences. For example, it seems more conceivable that firm in agriculture closes because of a severe drought than an IT firm. In contrast to the impact on hazard probability, one may expect location to play less of a role for the consequence assessments of firms in this study as I only observe whether a firm is close to a river but not how close. Finally, an important vulnerability factor for a business is the dependence on a particular market partner such as a specific supplier or a specific customer. Barrot and Sauvagnat (2016), Boehm et al. (2019), and Carvalho et al. (2021) find firms to suffer significant output losses when important suppliers are affected by natural disasters. If beliefs are formed rationally, these factors should influence consequence belief independent of prior hazard experience.

Hypothesis 2a: Objective risk factors, such as firm size, industry, and dependence on market partners influence the expected consequences of hazard events after controlling for experience.

Hypothesis 2b: Experience of a hazard event does not influence the expected consequences of hazard events after controlling for objective risk factors.

3. Method

3.1. Sample and data

I use data from a business survey conducted by the Institut für Mittelstandsforschung (IfM) Bonn (Schlepphorst et al. 2023). The survey was conducted online starting in July and ending in August 2022.[4] A stratified sample of 55,369 companies from a large business database were contacted via e-mail.[5] 1,335 respondents completed the survey leading to a response rate of 2.4 per cent. After dropping all observations with missing values for the probability assessments that serve as dependent variables (see section 3.2) and for the control variables detailed below, I arrive at a final sample size of 796. As Table 2 shows, larger firms are overrepresented in the sample compared to their population shares.[6] Industry affiliation was categorized according to the German Classification of Economic Activities, Edition 2008.[7] To attain further information on objective risk factors, firms were asked whether they are heavily dependent on specific market partners, such as specific suppliers, customers, employees, etc.[8] Roughly six out of ten confirmed such a dependence on some market partner (item "dependence"). About half of the respondents confirmed that their firm's business had been affected by a natural hazard, such as an extreme weather event, in the previous five years (item "experience"). Respondents were asked to report whether the location of the firm showed certain characteristics, such as proximity to the coast or a river, that are indicative of the objective risks that the firm faces. The survey also asked about respondent information such as gender, age, management position, ownership of a stake in the company, and whether the respondent feels well-informed about climate risks.[9] Except

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4 The time of the survey is important for interpreting the results as Germany suffered a major heat wave in the summer of 2022. Accordingly, the hazard of extreme heat events was likely much more salient to the respondents compared to other natural hazards. On the other hand, the willingness to participate in a survey on climate risks might have been positively affected.

5 The sample was stratified according to four size categories (see footnote 6) and five industry/sector categories (industry, trade, business-related services, other services, other).

6 Firm-size categories were built based on the number of employees, with a micro enterprise having no more than 9, a small enterprise having between 10 and 49, a medium-sized enterprise having between 50 and 249, and a large enterprise having at least 250 employees.

7 Website: https://www.destatis.de/DE/Methoden/Klassifikationen/Gueter-Wirtschaftsklassifikationen/Downloads/klassifikation-wz-2008-englisch.html

8 A firm is classified as “dependent” if the respondent declared the business highly dependent on at least one of the following: specific domestic supplier, specific foreign supplier, specific domestic customer, specific foreign customer, business network, specific employee(s), other actor(s).

9 Respondents were classified as feeling well-informed if they chose to give themselves a score of four or five on a five-point Likert scale.

for prior experience of a hazard, all this information was asked at the end of the questionnaire to reduce the chance that they may bias the answers on risk perception.[10]

3.2. Probability assessment

I use information on the subjective probability assessments with respect to five natural hazards (drought, storm, heat, extreme precipitation, flooding) from the survey. The questions read "How large do you deem the probability that your firm will be affected by the following climate events [drought, storm, heat, extreme precipitation, flooding] in the coming five years?". For each hazard, respondents could use a slider to set a number between 0 and 100 or enter a number manually. The number 0 was labeled as "impossible", and the number 100 was labeled as "certain". I normalize the entries to numbers between 0 and 1. I only use observations where a probability assessment was made for all five hazards to increase comparability of estimates across hazards.

As the dependent variables are percentages, I estimate and report average marginal effects of fractional logit regressions with robust standard errors. Finally, I conduct dominance analyses in order to assess the relative contribution of experience and objective risk factors to the variation in probability perceptions. The method has been employed to assess the relative importance of different predictors for various questions in management research (Kluemper et al. 2011, Scott et al. 2014, Judge and Zapata 2015, Terbeck et al. 2022). To my knowledge, it has not yet been employed to address the question of how informed climate-risk perceptions are.

Table 2: Sample composition

	Share in sample	Population share*
<u>**Firm characteristics**</u>		
Size		
Micro	21.1 %	85.2 %
Small	30.9 %	11.8 %
Medium	26.1 %	2.6 %
Large	21.9 %	0.4 %
Industry		
Agriculture, forestry & fishing	4.8 %	
Mining & Quarrying	1.3 %	0.1 %
Manufacturing	14.8 %	6.2 %

[10] A possible bias cannot be completely ruled out as respondents were free to move back and forth between questions at their own discretion.

Continued Table 3: Sample composition

	Share in sample	Population share*
Energy and water supply, sewage, waste management	2.4 %	2.4 %
Construction	8.5 %	10.7 %
Wholesale & retail trade, repair of motorvehicles/motorcylces	12.3 %	18.3 %
Transportation & storage	5.9 %	3.3 %
Accomodation & food service	3.5 %	6.6 %
Information & communication	5.8 %	3.9 %
Financial & insurance activities	4.2 %	2.5 %
Real estate activities	3.6 %	5.9 %
Professional, scientific & technical activities	5.4 %	14.3 %
Administrative & support service activities	4.0 %	6.6 %
Education	3.1 %	2.6 %
Human Health & Social Work activities	12.7 %	7.8 %
Arts, Entertainment and Recreation	1.9 %	2.8 %
Other service activities	5.8 %	6.2 %
Dependence on market partner	62.9 %	
Prior experience of natural hazard	53.1 %	
Location		
Region		
North	17.3 %	15.7 %
West	34.9 %	34.1 %
East	17.1 %	18.8 %
South	30.7 %	31.4 %
Site characteristics		
Near cost	6.9 %	
Near river/stream	29.8 %	
Low groundwater	11.3 %	
Trough/valley	7.7 %	
Near forrest	20.1 %	
In city	59.8 %	
Hill/elevation	14.1 %	
Respondent characteristics		
female	21.6 %	
age (mean)	51.2	
well-informed about climate risks	51.9 %	
manager	76.4 %	
ownership/stake	51.1 %	

*Shares according to the Business Register 2021 of the Federal Statistical Office of Germany (https://www.destatis.de/EN/Home/_node.html). The Registry does not contain companies from agriculture, forestry & fishing.

3.3. Consequence assessment

I use answers to the questions “How large do you deem the probability that your firm will be impacted by the following climate events [drought, storm, heat, extreme precipitation, flooding] in the coming five years so severely that the firm’s survival is in peril?” Respondents could use a slider to set a number between 0 and 100 or enter a number manually. If subjective probabilities follow the rules of objective probabilities, it is possible to calculate the probability of a firm’s demise conditional on it being affected by a hazard by dividing the probability of experiencing a fatal event by the probability of experiencing any event. In a frequentist interpretation, this gives us the share of natural-hazard events that the respondents expect to endanger the firm's survival, allowing us to get an impression of how severe respondents judge the consequences of the five hazards.

To my knowledge, this is the first time a consequence assessment is measured in this way. Previous approaches either use an estimate (Botzen et al. 2009, van Duinen et al. 2015) or a qualitative assessment (Sakhel 2017) of the damage in the event of a flood or drought. Both approaches yield reasonable measures of hazard consequences but suffer from one shortcoming. They disregard the highly skewed distribution of damages that many natural hazards typically entail.[11] Asking for the expected damage may miss what we are typically most interested in: a judgement concerning the tail event that a hazard leaves severe damages. The conditional probability of firm closure seeks to address this shortcoming. Unfortunately, it comes with its own drawbacks.

People are often not well-versed in dealing with probabilities (Tversky and Kahneman 1974, 1982). Specifically, subjective probability assessments sometimes fail to conform to basic probability rules. One known instance is the occurrence of what is called a conjunction fallacy (Tversky and Kahneman 1982). It refers to the phenomenon that an individual may judge the conjunction of two events as more likely than one of the constituent events. This includes the possibility that a more specific event, such as the occurrence of a flood that results in a firm having to shut down, is deemed more likely than a more general event, such as the occurrence of a flood that impairs the firm, that comprises the more specific event. If a respondent in the survey commits the fallacy, a

[11] In addition, a damage estimate may result in larger firms providing larger numbers even if they feel less vulnerable to a hazard than smaller firms. Given that I am more interested to measure an assessment of vulnerability, the conditional probability of firm closure seems more appropriate than a damage estimate. Finally, measuring both the probability and the consequence assessment with a stated probability comes with the advantage that both outcome variables are measured in a similar way. Possible differences in the effects of objective risk factors and experience on the two outcome variables can then not be attributed to differences in measurement.

subjective conditional probability cannot be calculated from the two subjective probability assessments.

As a result, to test Hypotheses 2a and 2b, I drop observations in which the joint probability of a fatal hazard event exceeds the probability of a hazard event. For the remaining observations, I assume that subjective probabilities follow probability rules and interpret their ratio as a subjective conditional probability. This conditional probability is continuous between 0 and 1. As with the probability assessments, I estimate and report average marginal effects of fractional logit regressions with robust standard errors and I conduct dominance analyses in order to assess the relative contribution of experience and objective risk factors to the variation in consequence perceptions.

The measure of hazard consequences is restricted to those respondents who do not commit a conjunction fallacy. On the downside, this further restricts the sample in addition to the loss of observations that results because a respondent may not have made both a probability and a joint-probability assessment, or because a respondent considered the hazard probability to be zero. The remaining sample size is between 542 and 612, depending on the hazard (see Table A-2, Appendix A). On the upside, the occurrence of a conjunction fallacy may be interpreted either as a sign of the use of heuristics in risk assessments, as suggested by Tversky and Kahneman (1982), or as a sign that probability assessments are made with error, as suggested by Costello (2008).[12] Hence, it can be used to test for a more frequent use of heuristics or more erroneous judgments, for example, among smaller firms. To simplify the exposition, I defer this analysis to Appendix B where I report average marginal effects of a logit regression with robust standard errors.

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[12] Costello (2008) shows that the conjunction fallacy may be consistent with probability theory if the probability judgment is made with error. Apart from this novel explanation for the conjunction fallacy, the article offers a very nice overview of competing explanations for the conjunction fallacy in the literature.

4. Results

4.1. Probability assessment

Respondents were asked to assess the probability that their firm will be impacted by different hazards in the coming five years, specifically droughts, storm/heavy winds, heat, heavy precipitation (rain, hail, snow), and floods. The median probabilities range from 26.5 per cent for flood to 53.0 per cent for heat, with 37.5 per cent for drought, 42.0 per cent for storm, and 50.0 per cent for precipitation lying between them. A closer look at the distributions in Figure 1 reveals that salient probabilities, such as 0, 50, and 100 per cent, were chosen frequently. Apart from these salient probabilities, the distribution of estimates appears more right-skewed for floods, droughts, and storms, and more evenly distributed for heat events. The reader is asked to keep in mind that the survey was conducted during a major heat wave in Germany. As a result, comparing the probabilities of the different hazards, or ranking them, might have only very limited value. What is possible, however, is to investigate how probability assessments vary with experience, with firm characteristics, and with respondent characteristics.

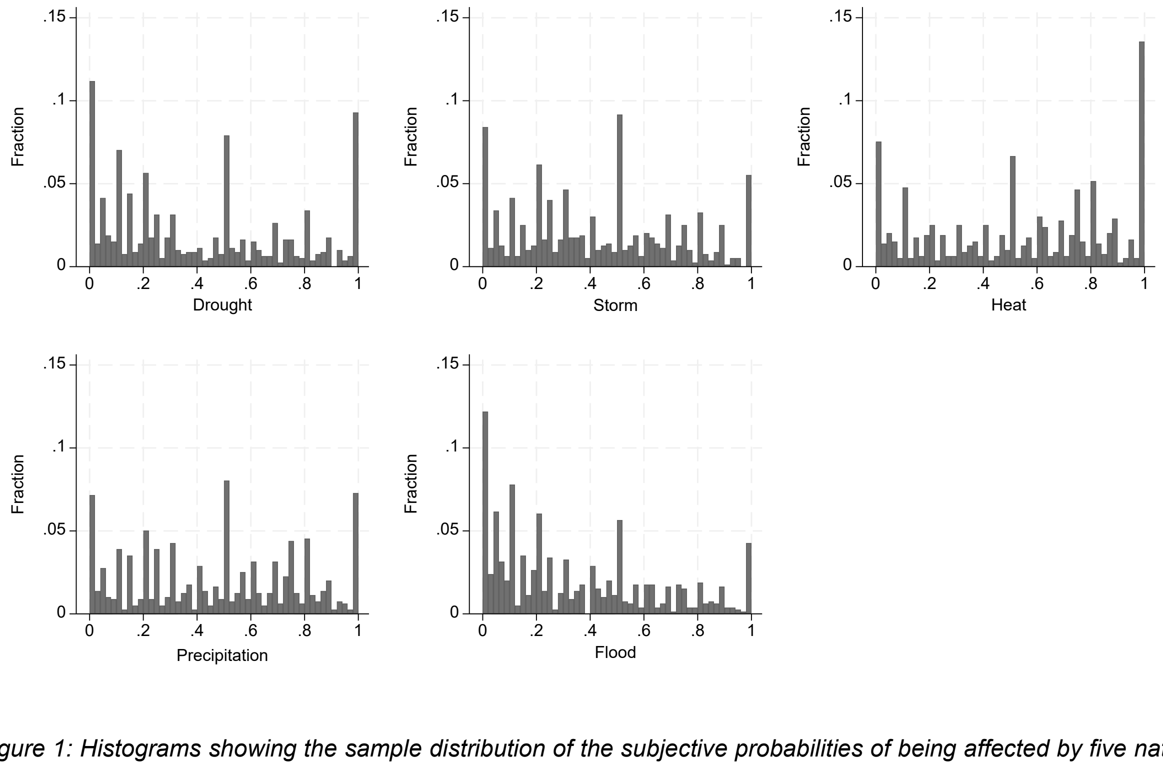

Figure 1: Histograms showing the sample distribution of the subjective probabilities of being affected by five natural hazards.

Overall, and consistent with most of the prior literature (Siegrist and Gutscher 2006, Botzen et al. 2009, Frondel et al. 2017), prior experience of an extreme event is a strong predictor of the subjective probability of a natural hazard in accordance with

Hypothesis 1a (compare Table A-1 in the Appendix). The effect is large and significant for all five hazards even after controlling for various factors associated with objective risk such as industry, size, and location characteristics. For example, businesses that experienced a natural hazard in the past five years assess the probability of being affected by a drought on average 20.5 percentage points higher and the probability of being affected by a flood on average 13.9 percentage points higher compared to those without such an experience.

Turning to the effect of objective risk factors, regression analysis reveals that there are no significant effects of firm size on the subjective probability of an event. The evidence on industry effects is mixed. Firms in agriculture, fishery, and forestry state probabilities with respect to drought and heat that are on average by 27.6 and 11.6 percentage points larger compared to businesses in manufacturing. Firms in construction report significantly larger probabilities of being affected by storms and precipitation events (11.3 and 7.9 percentage points respectively). However, not all results are in accordance with theoretical considerations. Firms in agriculture do not state a larger probability to be impacted by storm or extreme precipitation, construction firms assign a lower probability (10.0 percentage points) than manufacturing firms to be adversely affected by heat events.

The results for location characteristics are more in line. The subjective probability of a drought event is positively associated with being in an area with low groundwater. Storm events are deemed more likely by firms at the coast (though not by those on a hill/an elevation), while an impact by heat events is deemed more likely by firms in the city. The probability of being affected by extreme precipitation is not associated with being situated in a valley or in the city. The probability of a flood event is higher among firms at the coast, at a river, and in a valley, but lower by firms situated on a hill/an elevation.

While not all results are fully in line with theoretical considerations, they suggest that objective risk criteria do play a role in the risk assessment in support of Hypothesis 1b.

With respect to respondent characteristics, I find little consistent evidence. Feeling well-informed about climate risks is positively associated with the subjective probabilities assigned to two of the five hazards. The causal direction underlying this association is not clear, since, on the one hand, better-informed individuals might underestimate hazards less, and, on the other hand, individuals that feel more threatened by natural hazards have stronger incentives to inform themselves about climate risks.

I use dominance analysis to determine the relative contribution of experience, objective risk factors (dependence, size, industry, region, site characteristics) and respondent characteristics. For heat and precipitation, I find experience to completely dominate objective risk factors, contributing 54.7% and 53.2% respectively to the fit statistic (Pseudo R^2) while the risk factors only contribute slightly more than 40 per cent (Table 3). For droughts, storms, and floods, the pattern is reversed with objective risk factors completely dominating experience by contributing more than a half to the fit statistic.

Table 4: Standardized Dominance Statistics, Probability of a hazard

	Drought	Storm	Heat	Precipitation	Flood
Experience	42.9%	39.2%	54.7%	53.2%	35.0%
Objective risk factors	50.7%	55.9%	42.5%	42.3%	57.5%
Respondent characteristics	6.4%	4.9%	2.8%	4.5%	7.5%
N	796	796	796	796	796
Overall Fit Statistic (Pseudo R^2)	0.0943	0.0522	0.0859	0.0578	0.0566

Standardized Dominance Statistics show the share of the fit statistic (Pseudo R^2) that is attributable to a (set of) predictor(s). The dominance analyses are based on the fractional logit regressions in Table A-1. The set "Objective risk factors" includes Dependent, Size (Micro, Small, Medium), Industry Dummies, Region, and Site characteristics. The set "Respondent characteristics" includes Female, Age, Informed about climate risk, Manager, Ownership/stake. See Table A-1.

When disentangling the contribution of the objective risk factors further into dependence, size, industry, and location (comprising region and site characteristics) effects, I find that industry and location are the most important risk factors informing subjective hazard probabilities (Table 4). Industry affiliation is more important than location for all hazards but floods.

Table 5: Standardized Dominance Statistics, Probability of a hazard, detailed

	Drought	Storm	Heat	Precipitation	Flood
Experience	42.2%	38.8%	54.0%	53.0%	34.9%
Dependence	0.7%	0.2%	2.5%	0.3%	0.4%
Size	1.0%	2.6%	1.4%	2.7%	3.2%
Industry	34.2%	35.1%	26.4%	22.8%	20.1%
Location	15.7%	18.6%	13.0%	16.9%	34.0%
Respondent Characteristics	6.2%	4.8%	2.7%	4.4%	7.4%
N	796	796	796	796	796
Overall Fit Statistic (Pseudo R^2)	0.0943	0.0522	0.0859	0.0578	0.0566

Standardized Dominance Statistics show the share of the fit statistic (Pseudo R^2) that is attributable to a (set of) predictor(s). The dominance analyses are based on the fractional logit regressions in Table A-1. The set "Location" includes Region and Site characteristics. The set "Respondent characteristics" includes Female, Age, Informed about climate risk, Manager, and Ownership/stake.

4.2. Consequence assessment

One can calculate the conditional probability of each of the five events resulting in the firm's demise by dividing the probability of a hazard event that leads to firm closure by the probability of experiencing the hazard. The histograms in Figure 2 show the distributions of these conditional probabilities.

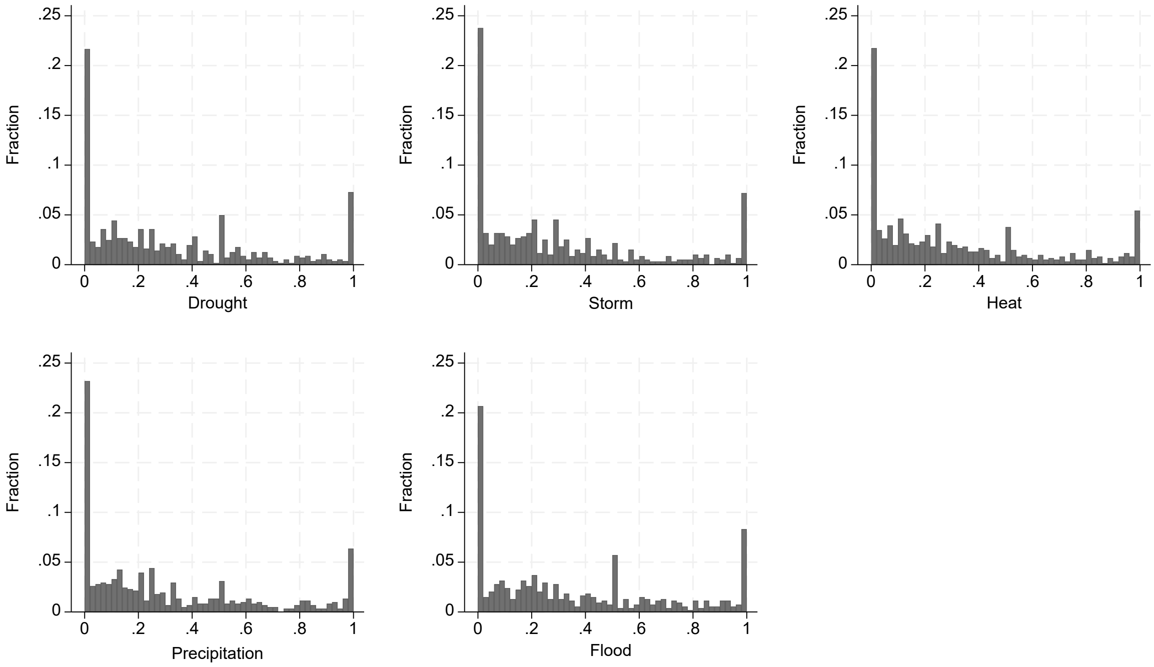

Figure 2: Histograms showing the sample distribution of the imputed (conditional) probabilities of firm closure conditional on occurrence of a hazard.

The most striking feature of the distributions are the two modi at 0 and 100 per cent respectively. The results suggest that roughly a quarter of the businesses takes an extreme view on the five risks. They expect the hazards - should they occur - to lead to the firm's demise either with certainty or under no circumstances. The remaining three quarters deem the firm's survival possible, though not a certainty. The median conditional probability is 21.6 per cent for drought, 20.0 per cent for storms, 20.8 per cent for heat, 20.0 per cent for precipitation, and 25.0 per cent for flood events, indicating that half of the sampled businesses sees their chance of surviving a natural hazard no better than four fifths. While this view seems rather pessimistic, we need to keep in mind that half the sample are micro or small enterprises that are unlikely to have sufficient reserves to recuperate from a major loss event.

The regression analyses reveal that experience has no significant effect on the conditional probability of a firm surviving a hazard in line with Hypothesis 2b. This suggests that people do not base their judgments of hazard consequences on experience.

The evidence on the role of objective risk criteria is mixed (Table A-2, Appendix). Across all five hazards, SMEs, particularly micro enterprises, report a significantly larger vulnerability than large firms. For example, micro enterprises report a conditional probability of firm closure after a flood event that is on average 14.6 percentage points higher than large companies. The conditional probability reported by medium-sized companies is 9.7 percentage points higher. This indicates that smaller firms are well-aware of their larger vulnerability. In contrast, the dependence on a market partner shows no significant effect and industry differences are either not significant or contrary to theoretical prediction. Finally, apart from droughts, I find little dependence of the impact assessment on location characteristics such as coastal or river proximity. This seems in line with the idea that location is more relevant for the probability of a hazard event than for the vulnerability to a hazard.

Again, I find only little evidence of a consistent effect of personal characteristics of the respondents. Age is positively associated and being a manager is negatively associated with conditional probabilities, but only for one of the five hazards.

Table 6: Standardized Dominance Statistics, Conditional Probability of Closure following a Hazard

	Drought	Storm	Heat	Precipitation	Flood
Experience	0.3%	2.8%	0.1%	1.8%	0.0%
Objective risk factors	92.4%	86.8%	83.9%	86.2%	89.7%
Respondent characteristics	7.3%	10.4%	16.1%	12.1%	10.3%
N	563	597	607	612	542
Overall Fit Statistic (Pseudo R^2)	0.0506	0.0396	0.0451	0.0351	0.0419

Standardized Dominance Statistics show the share of the fit statistic (Pseudo R^2) that is attributable to a (set of) predictor(s). The dominance analyses are based on the fractional logit regressions in Table A-1. The set "Objective risk factors" includes Dependent, Size (Micro, Small, Medium), Industry Dummies, Region and Site characteristics. The set "Respondent characteristics" includes Female, Age, Informed about climate risk, Manager, Ownership/stake. See Table A-2.

Using dominance analysis, it is possible to determine the relative contribution of various independent variables. When distinguishing three clusters, experience, objective risks factors, and personal characteristics, I find experience to play the least important role, being dominated even by personal characteristics (Table 5). The largest contribution is made by objective risk factors. Disentangling the contributions of the different risk factors reveals that size, industry, and location play the largest role, with the ranking differing between hazards (Table 6). For drought and precipitation, size is the most important factor. For storms and heat, industry is most important. Finally, location is the most important factor for floods.

Table 7: Standardized Dominance Statistics, Cond. Probability of Closure following a Hazard, detailed

	Drought	Storm	Heat	Precipitation	Flood
Experience	0.2%	2.8%	0.0%	1.7%	0.0%
Dependence	0.3%	2.2%	0.8%	0.1%	2.0%
Size	35.7%	29.8%	19.9%	35.0%	22.0%
Industry	28.8%	35.5%	45.5%	25.9%	31.1%
Location	28.6%	19.6%	18.7%	25.9%	35.1%
Respondent characteristics	6.4%	10.2%	15.1%	11.5%	9.8%
N	563	597	607	612	542
Overall Fit Statistic (Pseudo R^2)	0.0506	0.0396	0.0451	0.0351	0.0419

Standardized Dominance Statistics show the share of the fit statistic (Pseudo R^2) that is attributable to a (set of) predictor(s). The dominance analyses are based on the fractional logit regressions in Table A-1. The set “Location” includes Region and Site characteristics. The set “Respondent characteristics” includes Female, Age, Informed about climate risk, Manager, Ownership/stake.

5. Discussion

5.1. Implications for theory and future research

Consistent with the prior literature (Siegrist and Gutscher 2006, van Duinen et al. 2015, Botzen et al. 2009, Frondel et al. 2017), I find that prior experience of a natural hazard is a strong predictor for the expectation of five natural hazards. However, the strong relationship is only present for the probability assessments of natural hazards, not for the consequence assessment. The strength of the relationship in the former is noteworthy for two reasons. First, I control for a large variety of objective risk factors including location, firm size, industry, and dependence among others suggesting that experience is not simply a proxy for objective risk factors unaccounted for in the regressions. Second, the experience variable is a rather crude measure that only indicates whether any hazard has been experienced but does not differentiate between types of natural hazards (drought, storm, etc.). I expect an even stronger relationship with a more specific measure. It thus seems appropriate to conclude that business expectations of natural hazards are subject to heuristics such as the availability heuristic.

It seems equally appropriate to conclude that these expectations are not entirely based on heuristics as objective risk factors also play a role. Even after controlling for experience, firms in agriculture assign a larger probability and firms in IT a lower probability to being affected by droughts compared to firms in manufacturing. Firms in construction assign a larger probability to have their business disrupted by storms. For some hazards, most strongly storms and floods, the objective risk factors are – in cumulation – more important than experience for explaining differences in the probability assessment across firms.

In contrast to what theoretical considerations suggest, I did not find any effect of firm size on the probability assessment. This is difficult to reconcile both with the idea that SMEs face a lower hazard probability and with the common concern that SMEs underestimate climate risks (AXA and UNEP 2015, Linnenluecke and Smith 2018).[13] While I cannot rule out that there are small firms underestimating their individual risk, a systematic underestimation of climate risks by SMEs is difficult to reconcile with the re-

[13] In a logit regression with experience as the dependent variable, firm size is not significant. This suggests that either the theorized connection between firm size and the probability of being affected by a natural hazard is simply not there, or firms disregard indirect effects, for example, of disrupted value chains when reporting on their experience. In a general structural equation model, I can jointly estimate the five probability assessments and experience as a mediator in these assessments (Appendix C). Here, firm size is not a significant predictor of experience either (see Table A-5.

sults that I obtain here. It is possible, of course, that both small and large firms underestimate their risk, which could explain the insignificant effect of firm size. Yet, this would mean that the underestimation of climate risks is a general problem, not one specific to SMEs.

The results on expectations about hazard consequences contrast strongly with those about hazard probabilities. First and foremost, the expectations of hazard consequences do not respond to prior experience. That could be a result of the experience measure not being sufficiently precise as it does not differentiate either between the type of the experienced hazard or its severity. However, unless future research finds consequence assessments of firms to respond to the severity of previously experienced hazards, Ockham's razor suggests that the simpler explanation of experience not shaping consequence expectations should be favored over the alternative explanation that the positive effect of mild experiences exactly offset the negative effect of severe experiences.

Still, the imprecision of the experience measure needs to be acknowledged as a limitation of this study that future research may seek to address. Specifically, the effect of experience on expected consequences of a hazard may vary depending on the hazard, the severity of the experience, and the nature of the experience (harm to one's own firm, a supplier or a customer, or a business in the vicinity).

In contrast to prior experience, objective risk factors play a role in shaping consequence expectations. In addition to industry affiliation, firm size has a significant influence for all five hazards. This indicates that smaller firms are well-aware of their increased vulnerability. That firms, who are dependent on a market partner, such as a specific supplier, do not indicate a larger vulnerability suggests that firms underestimate how natural hazards can harm their businesses indirectly.

I can only calculate conditional probabilities for firms who do not commit a conjunction fallacy, i.e., those who assess the joint probability of a natural hazard that results in the firm's closure to be larger than the probability of a natural hazard impacting the firm. The occurrence of this conjunction fallacy might serve as an additional indicator of the use of heuristics in the risk assessment of firms. Results presented in Appendix B indicate that the conjunction fallacy is more prevalent in smaller, particularly micro, enterprises. That is well in line with the notion that risk management in micro enterprises is more informal.

A shortcoming of the analysis might be that I estimate separate regressions for each hazard and error terms in these subjective risk assessments might be correlated across hazards. As a robustness check, I estimate the risk assessment for the five hazards jointly in a general structural equation model (Appendix C). The GSE model, however, comes with the disadvantage that it does not allow for fractional logit regressions and that I cannot perform a dominance analysis subsequently. Comparing the two estimation approaches, I find the results from the regressions to be largely consistent.

Finally, another limitation of the study is that I only observe a probability assessment for a subset of the survey respondents. Imputing a consequence assessment is possible for an even smaller group due to the occurrence of a conjunction fallacy, the need for an additional (joint) probability assessment, and the need for the probability assessment to be non-zero. While the remaining number of observations is still non-negligible, the analysis may be biased if item non-response in the survey was not random. For example, logit regressions reveal that firms with previous hazard experience were significantly more likely to make a probability assessment in the survey. If firms who – on average – consider themselves more likely to be affected by a hazard were also more inclined to state a probability assessment in the survey, the positive effect of experience that I observe would still underestimate the true effect.

5.2. Practical implications

The strong effect of experience on perceived hazard probabilities suggests that businesses rely to a large extent on experience when forming expectations about future climate risks. A proper management of these risks needs to consider that a changing climate implies that the past is only an imperfect signal for the future. Hence, reliance on experience – or, worse, a false sense of security based on a lack of experience with natural hazards – may lead to an underestimation of the true risk. Businesses need to use to a larger extent external information sources that help them assess the current and future climate risks that they face.

Still, the common concern that businesses, particularly SMEs, are unaware of the climate risks that they face is not borne out by the evidence. Many businesses see a non-negligible chance of severe damages by natural hazards. Importantly, the risk assessments are not just a function of experience but take into account objective risk criteria. Policymakers may thus redirect their attention and public resources from raising awareness to providing businesses with relevant information and to removing other hurdles to adaptation. It is of course possible that the survey attracted a selected sample of businesses that are particularly concerned about natural hazards thereby producing an overoptimistic picture about corporate risk awareness. While such a selection effect can never be completely ruled out, two considerations may increase confidence in the generalizability of the results. First, if the selection effect was substantial, one would expect firms from industries that are particularly affected, such as agriculture, construction, or real estate, to be overrepresented in the sample. Table 2, that provides both the sample shares, and the population shares according to the German Business Registry, shows that this was not the case for construction and real estate.[14] Second, the questions on the physical risks of climate change, that I use in this article, were embedded in a survey on several effects of climate change including physical and transitory risks. Hence, even businesses that do not feel particularly concerned about the physical consequences of climate change, but care about the transitory risks associated with climate change, such as political, societal, regulatory, or market changes, should be interested in the survey's topic.

Conclusion

I investigate the risk perception of businesses with respect to acute physical climate risks, more specifically the increased frequency of natural hazards. Using data from a survey of German businesses, I find the probability assessments for different hazards to be driven by objective factors such as industry and location characteristics. In addition, prior experience of a hazard event strongly increases the expectation of future hazard events. I find no association between hazard probability and firm size although one would expect a negative relationship. This contrasts with the common concern that SMEs underestimate climate risks (AXA and UNEP 2015, Linnenluecke and Smith 2018).

When I analyze the expectations on hazard consequences, more precisely the probability not to survive a natural hazard, I find no significant effect of prior experience. This suggests that firms do not assess their own vulnerability to different hazards based on prior hazard experiences. In contrast, I find objective factors to play a stronger role. Specifically, I find evidence that suggests that smaller firms are aware of their larger vulnerability to natural hazards. In addition, industry affiliation and location are important determinants of the vulnerability assessment. I find no association between vulnerability assessments and dependence on market partners such as specific suppliers or customers. This indicates that firms insufficiently consider the possibility of being affected indirectly by natural hazards when considering their own vulnerability.

The results presented here raise several questions for future research. First, given the large role experience plays in probability assessments, it would be interesting to see

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14 The German Business Registry does not contain information on companies from agriculture. The share of firms in agriculture, forestry, and fishing in the official sales tax statistics of 2019 is about 3.2 per cent, which is lower, but not far away from the 4.8 per cent share of such firms in the final sample.

results using a more nuanced measure. How does the type of experience, its severity, and its recency affect probability assessments of firms? How do businesses assess their vulnerability of natural hazards, and what are important factors driving these assessments beyond the ones considered here? More generally, what shapes climate risk perceptions of businesses, how do they change over time, and what role do heuristics play in these questions? Given the importance of businesses in society's adaptation efforts, these questions deserve closer scrutiny.

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Appendix A: Regression tables

Table A-1: Subjective probability of hazard event impacting the firm.

	Drought	Storm	Heat	Precipitation	Flood
	AME (SE)	*AME (SE)*	*AME (SE)*	*AME (SE)*	*AME (SE)*
Prior experience	**0.205*** (0.000)**	**0.153*** (0.000)**	**0.239*** (0.000)**	**0.194*** (0.000)**	**0.139*** (0.000)**
Size (Reference: Large companies)					
Micro	0.042 (0.230)	0.031 (0.359)	-0.030 (0.401)	0.034 (0.323)	0.054 (0.101)
Small	0.026 (0.393)	-0.030 (0.292)	0.005 (0.871)	-0.028 (0.339)	-0.012 (0.675)
Medium	-0.009 (0.766)	**0.005** (0.022)**	-0.010 (0.763)	0.035 (0.226)	0.008 (0.758)
Industry (Reference: Manufacturing)					
Agriculture, forestry & fishing	**0.276*** (0.000)**	-0.052 (0.262)	**0.116** (0.014)**	0.015 (0.780)	-0.076 (0.125)
Mining & Quarrying	0.109 (0.269)	-0.025 (0.744)	-0.124 (0.232)	0.026 (0.799)	0.052 (0.628)
Energy and water supply, sewage, waste management	0.048 (0.530)	0.066 (0.242)	-0.081 (0.166)	0.033 (0.610)	**0.112* (0.060)**
Construction	**-0.099** (0.027)**	**0.113*** (0.008)**	**-0.100** (0.036)**	**0.079* (0.074)**	**0.102** (0.024)**
Wholesale & retail trade, repair of mo-torvehi-cles/motorcylces	-0.008 (0.846)	-0.014 (0.739)	**-0.095** (0.024)**	-0.008 (0.837)	-0.007 (0.841)
Transportation & storage	-0.066 (0.169)	0.059 (0.207)	**-0.105** (0.021)**	0.074 (0.119)	**0.106** (0.020)**
Accomodation & food service	0.102 (0.123)	**0.108* (0.061)**	-0.013 (0.843)	-0.007 (0.913)	-0.005 (0.931)
Information & com-munication	**-0.158*** (0.003)**	**-0.113** (0.020)**	**-0.151*** (0.006)**	-0.078 (0.163)	-0.053 (0.287)
Financial & insurance activities	-0.059 (0.305)	0.063 (0.288)	**-0.175*** (0.007)**	0.070 (0.228)	**0.112* (0.070)**
Real estate activities	-0.084 (0.146)	**0.195*** (0.001)**	-0.070 (0.284)	**0.169** (0.010)**	0.028 (0.613)
Professional, scientific & technical activities	**-0.190*** (0.000)**	**-0.109** (0.021)**	**-0.194*** (0.001)**	**-0.123** (0.012)**	-0.023 (0.626)
Administrative & sup-port service activities	-0.039 (0.497)	0.060 (0.264)	-0.017 (0.791)	0.049 (0.380)	0.025 (0.642)
Education	-0.073 (0.254)	-0.028 (0.667)	0.044 (0.455)	-0.000 (0.998)	-0.066 (0.197)

Continued Table A-1: Subjective probability of hazard event impacting the firm.

	Drought		Storm		Heat		Precipitation		Flood	
	AME (SE)		*AME (SE)*		*AME (SE)*		*AME (SE)*		*AME (SE)*	
Human Health & Social Work activities	**-0.073***	**(0.064)**	0.012	(0.744)	0.023	(0.566)	0.038	(0.308)	0.027	(0.478)
Arts, Entertainment and Recreation	-0.088	(0.299)	0.085	(0.321)	-0.063	(0.338)	**0.122***	**(0.085)**	0.041	(0.573)
Other service activities	-0.047	(0.382)	-0.041	(0.373)	**-0.130****	**(0.017)**	-0.023	(0.642)	-0.009	(0.848)
Region (Reference: West Germany)										
North	**-0.065****	**(0.039)**	-0.003	(0.916)	-0.044	(0.194)	**-0.056***	**(0.062)**	**-0.068****	**(0.022)**
East	0.024	(0.438)	0.022	(0.476)	0.009	(0.781)	**-0.086*****	**(0.005)**	**-0.124*****	**(0.000)**
South	0.006	(0.829)	-0.008	(0.741)	0.003	(0.898)	**-0.042***	**(0.094)**	**-0.048***	**(0.050)**
Site characteristics										
Near coast	0.037	(0.459)	**0.153*****	**(0.000)**	**0.083***	**(0.053)**	**0.076***	**(0.073)**	**0.085***	**(0.071)**
Near river/stream	**0.046***	**(0.061)**	0.025	(0.279)	0.031	(0.202)	0.025	(0.305)	**0.057*****	**(0.017)**
Low groundwater	**0.104*****	**(0.003)**	**0.088*****	**(0.004)**	**0.101*****	**(0.002)**	**0.062****	**(0.048)**	0.036	(0.276)
Trough/valley	0.043	(0.301)	-0.006	(0.872)	0.033	(0.411)	0.006	(0.870)	**0.088****	**(0.025)**
Near forrest	0.018	(0.544)	**0.050***	**(0.052)**	0.011	(0.706)	**0.066****	**(0.014)**	0.001	(0.956)
In city	0.025	(0.309)	0.019	(0.419)	**0.055****	**(0.025)**	0.023	(0.317)	-0.013	(0.551)
Hill/elevation	-0.026	(0.415)	0.010	(0.743)	0.001	(0.973)	-0.023	(0.451)	**-0.055****	**(0.048)**
Dependence on market partner	0.012	(0.598)	-0.005	(0.798)	**0.040***	**(0.077)**	-0.002	(0.932)	-0.002	(0.906)
Respondent characteristics										
female	0.037	(0.161)	0.022	(0.369)	0.024	(0.383)	0.021	(0.403)	**0.052****	**(0.043)**
age	0.001	(0.144)	0.000	(0.983)	0.000	(0.955)	-0.001	(0.532)	-0.001	(0.199)
well-informed about climate risks	**0.048****	**(0.020)**	**0.037****	**(0.048)**	0.018	(0.406)	0.032	(0.105)	0.030	(0.114)
manager	0.010	(0.729)	0.024	(0.338)	0.001	(0.966)	-0.008	(0.764)	0.025	(0.336)
ownership/stake	-0.040	(0.135)	-0.018	(0.463)	0.024	(0.361)	0.018	(0.466)	-0.008	(0.758)
N		796		796		796		796		796
Pseudo R^2		0.0943		0.0522		0.0859		0.0578		0.0566

Coefficients show average marginal effects of five fractional logit regressions with robust standard errors. P-values in parenthesis. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A-2: Probability of firm closure conditional on the occurrence of a hazard event.

	Drought	Storm	Heat	Precipita-tion	Flood
	AME (SE)	*AME (SE)*	*AME (SE)*	*AME (SE)*	*AME (SE)*
Prior experience	-0.006	-0.030	0.004	-0.023	-0.006
	(0.815)	(0.245)	(0.859)	(0.363)	(0.822)
Firm characteristics					
Size (Reference: Large companies)					
Micro	**0.237*** **	**0.190*** **	**0.145*** **	**0.183*** **	**0.146*** **
	(0.000)	**(0.000)**	**(0.001)**	**(0.000)**	**(0.002)**
Small	**0.134*** **	**0.111*** **	**0.107*** **	**0.151*** **	**0.163*** **
	(0.000)	**(0.003)**	**(0.003)**	**(0.000)**	**(0.000)**
Medium	**0.069***	**0.078** **	**0.065***	**0.094*** **	**0.097** **
	(0.053)	**(0.023)**	**(0.055)**	**(0.007)**	**(0.011)**
Industry (Reference: Manufacturing)					
Agriculture, forestry & fishing	0.075	**-0.140** **	0.027	**-0.095***	-0.062
	(0.232)	**(0.022)**	(0.652)	**(0.095)**	(0.380)
Mining & Quarrying	0.004	0.022	0.077	-0.039	-0.112
	(0.974)	(0.883)	(0.488)	(0.770)	(0.319)
Energy and water supply, sewage,	0.002	-0.076	0.022	-0.049	0.092
waste management	(0.982)	(0.317)	(0.833)	(0.627)	(0.314)
Construction	-0.062	**-0.112** **	**-0.083***	-0.087	-0.030
	(0.248)	**(0.026)**	**(0.092)**	(0.103)	(0.590)
Wholesale & retail trade, repair of	-0.041	-0.069	-0.018	-0.024	**0.100***
motorvehicles/motorcylces	(0.387)	(0.153)	(0.709)	(0.622)	**(0.061)**
Transportation & storage	0.034	-0.059	-0.015	-0.001	-0.010
	(0.583)	(0.296)	(0.767)	(0.980)	(0.863)
Accomodation & food service	**0.165** **	0.066	**0.140***	-0.009	0.144
	(0.030)	(0.392)	**(0.090)**	(0.905)	(0.109)
Information & communication	-0.053	**-0.142** **	-0.089	**-0.115** **	-0.040
	(0.392)	**(0.013)**	(0.102)	**(0.046)**	(0.555)
Financial & insurance activities	-0.040	-0.106	-0.031	-0.018	0.025
	(0.616)	(0.125)	(0.675)	(0.805)	(0.744)
Real estate activities	-0.097	-0.126	**-0.228*** **	-0.099	-0.018
	(0.186)	(0.109)	**(0.000)**	(0.207)	(0.834)
Professional, scientific & technical	-0.111	-0.023	-0.053	0.038	0.023
activities	(0.123)	(0.774)	(0.488)	(0.666)	(0.752)
Administrative & support service acti-	0.033	-0.004	0.045	0.039	0.093
vities	(0.624)	(0.953)	(0.514)	(0.556)	(0.215)
Education	-0.067	-0.056	-0.075	**-0.123***	0.102
	(0.309)	(0.489)	(0.283)	**(0.069)**	(0.239)
Human Health & Social Work activities	-0.011	-0.034	-0.055	-0.014	**0.108** **
	(0.819)	(0.492)	(0.213)	(0.789)	**(0.042)**
Arts, Entertainment and Recreation	-0.051	-0.027	-0.039	-0.014	-0.075
	(0.479)	(0.712)	(0.621)	(0.869)	(0.376)
Other service activities	0.060	0.047	**0.140***	0.023	0.067
	(0.445)	(0.564)	**(0.064)**	(0.746)	(0.371)

Continued Table A-2: Probability of firm closure conditional on the occurrence of a hazard event.

	Drought	Storm	Heat	Precipitation	Flood
Region (Reference: West Germany)					
North	-0.012	0.058	0.066	0.027	0.022
	(0.769)	(0.177)	(0.102)	(0.506)	(0.601)
East	-0.031	-0.042	-0.009	-0.048	-0.029
	(0.392)	(0.218)	(0.789)	(0.149)	(0.449)
South	-0.010	0.021	0.037	**0.062***	**0.092*****
	(0.752)	(0.531)	(0.228)	**(0.064)**	**(0.008)**
Site characteristics					
Near coast	0.031	-0.063	-0.040	-0.025	-0.036
	(0.567)	(0.170)	(0.414)	(0.573)	(0.457)
Near river/stream	-0.045	-0.014	-0.005	0.008	-0.001
	(0.122)	(0.635)	(0.849)	(0.782)	(0.975)
Low groundwater	-0.006	-0.049	0.009	-0.014	-0.040
	(0.871)	(0.208)	(0.795)	(0.715)	(0.343)
Trough/valley	**0.120****	0.055	0.071	-0.011	0.037
	(0.017)	(0.298)	(0.157)	(0.833)	(0.436)
Near forrest	**0.073****	0.020	**0.065***	0.056	0.021
	(0.043)	(0.600)	**(0.063)**	(0.148)	(0.575)
In city	**-0.068****	-0.034	-0.009	-0.028	**-0.083****
	(0.034)	(0.280)	(0.742)	(0.363)	**(0.010)**
Hill/elevation	**-0.061***	-0.037	-0.044	-0.051	**-0.069***
	(0.089)	(0.315)	(0.200)	(0.169)	**(0.086)**
Dependence on market partner	0.015	0.035	0.019	0.011	0.040
	(0.587)	(0.190)	(0.479)	(0.683)	(0.180)
Respondent characteristics					
female	0.033	-0.015	0.018	0.002	-0.030
	(0.286)	(0.659)	(0.562)	(0.942)	(0.394)
age	0.002	0.002	**0.003****	**0.003*****	0.002
	(0.121)	(0.103)	**(0.016)**	**(0.039)**	(0.158)
well-informed about climate risks	0.009	0.010	0.039	0.003	0.014
	(0.723)	(0.695)	(0.119)	(0.914)	(0.632)
manager	-0.008	-0.063	-0.021	-0.042	**-0.099****
	(0.839)	(0.101)	(0.568)	(0.270)	**(0.014)**
ownership/stake	-0.052	-0.008	0.006	-0.024	0.018
	(0.113)	(0.816)	(0.850)	(0.484)	(0.616)
N	563	597	607	612	542
Pseudo R^2	0.0506	0.0396	0.0451	0.0351	0.0419

Coefficients show average marginal effects of five fractional logit regressions with robust standard errors. P-values in parenthesis. * p < 0.1, ** p < 0.05, *** p < 0.01. Sample restricted to observations for which a conditional probability can be calculated for the individual hazard.

Appendix B: Conjunction fallacy

For all five natural hazards, between 1 in 14 and 1 in 10 respondents showed a conjunction fallacy, i.e., they assigned a larger probability to the events that a hazard hurts its business so severely that the company's survival is at stake than to the event that a hazard impacts its business. The proportions are 7.25 per cent for droughts, 8.71 per cent for storms, 7.96 per cent for heat, 8.31 per cent for precipitation, and 10.33 per cent for floods. There is a significant correlation in the occurrence of conjunction bias across hazards (Table A-3).

Table A-3: Correlation of conjunction fallacy across hazards

	CF drought	CF storm	CF heat	CF precipitation	CF flood
CF drought	1				
CF storm	0.4647*** (0.000)	1			
CF heat	0.4610*** (0.000)	0.4841*** (0.000)	1		
CF precipitation	0.3753*** (0.000)	0.5375*** (0.000)	0.4084*** (0.000)	1	
CF flood	0.3143*** (0.000)	0.4199*** (0.000)	0.3536*** (0.000)	0.5133*** (0.000)	1

Coefficients show correlation coefficients. P-values in parenthesis. * p < 0.1, ** p < 0.05, *** p < 0.01.

The differences in occurrence across hazards seem to support the idea that people use a representative heuristic when making probability judgments (Kahneman and Tversky 1972). For example, individuals might find it easier to imagine that a flood completely wrecks a company than imagining the flood having only a negligible impact. In contrast, people might find it easier to imagine a drought or a storm that does only little harm. Proportion tests, however, reject the hypothesis that the share of respondents exhibiting conjunction fallacy is dissimilar across the different hazards with one exception: The conjunction fallacy is significantly more pronounced for flood events than for droughts (p=0.033).

I find little evidence that explains the occurrence of the conjunction fallacy (Table A-4).[15] It seems more prevalent among representatives of micro and small enterprises. That could reflect the fact that the risk assessment in smaller firms is less likely the result of professional risk analysis and more the result of intuitive judgement by the

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[15] Due to the low number of incidences of the conjunction fallacy, I need to restrict the number of control variables in the regression analysis. As the fallacy is considered a psychological phenomenon, I opt to restrict the controls on firm characteristics rather than respondent characteristics.

management. As a result, it might be more susceptible to the use of heuristic judgements. Alternatively, the risk assessment might simply be more error prone. As Costello (2008) shows, errors in the judgments on constituent probabilities may cause a conjunction fallacy, particularly if the two constituent events are causally related. Prior experience of an extreme event or site characteristics do, by and large, not play much of a role. Age is positively linked to the occurrence of the fallacy in two out of five hazards. Apart from that, there are no systematic influences detectable from the data.

Table A-4: Occurrence of conjunction fallacy for five hazards

	Drought	**Storm**	**Heat**	**Precipitation**	**Flood**
	AME (SE)	*AME (SE)*	*AME (SE)*	*AME (SE)*	*AME (SE)*
	-0.007	-0.007		-0.004	-0.038
Prior experience	(0.719)	(0.742)	0.009 (0.663)	(0.857)	(0.144)
Firm characteristics					
Size (Reference: Large companies)					
Micro	0.042	**0.101****	**0.132*****	**0.097****	**0.080***
	(0.282)	**(0.010)**	**(0.000)**	**(0.014)**	**(0.050)**
Small	0.026	**0.094*****	**0.072****	**0.056***	0.054
	(0.453)	**(0.005)**	**(0.018)**	**(0.056)**	(0.130)
Medium	-0.023	0.008	-0.021	0.015	0.010
	(0.365)	(0.710)	(0.252)	(0.487)	(0.753)
Site characteristics					
Near coast	-0.030	-0.039	-0.002	-0.000	-0.017
	(0.318)	(0.208)	(0.949)	(0.999)	(0.689)
Near river/stream	0.029	-0.020	-0.027	-0.014	-0.003
	(0.198)	(0.344)	(0.221)	(0.538)	(0.931)
Low groundwater	0.013	0.016	-0.026	0.005	-0.006
	(0.722)	(0.682)	(0.390)	(0.878)	(0.884)
Trough/valley	-0.003	0.050	0.038	0.026	-0.024
	(0.942)	(0.345)	(0.433)	(0.570)	(0.611)
Near forrest	-0.033	-0.008	0.001	0.002	0.025
	(0.165)	(0.794)	(0.974)	(0.941)	(0.416)
In city	-0.030	-0.039	-0.056*	**-0.057****	-0.023
	(0.254)	(0.160)	(0.055)	**(0.027)**	(0.407)
Hill/elevation	-0.004	**-0.056****	**-0.057*****	-0.001	-0.006
	(0.887)	**(0.010)**	**(0.003)**	(0.962)	(0.852)
Respondent characteris-tics					
female	-0.031	0.001	-0.013	-0.012	-0.011
	(0.132)	(0.976)	(0.558)	(0.600)	(0.719)
age	0.001	0.001	**0.003*****	0.001	**0.003****
	(0.263)	(0.276)	**(0.003)**	(0.234)	**(0.019)**
well-informed about cli-mate risks	0.004 (0.852)	0.030 (0.173)	-0.007* (0.728)	0.015 (0.472)	0.026 (0.292)
manager	0.006	0.025	-0.009	**0.038***	-0.072
	(0.829)	(0.368)	(0.734)	**(0.073)**	(0.182)
ownership/stake	0.002	-0.021	**-0.063****	-0.048	0.049
	(0.941)	(0.514)	**(0.022)**	(0.128)	(0.164)
N	585	585	585	585	585
Pseudo R^2	0.0498	0.0833	0.1412	0.0723	0.0709

Coefficients show average marginal effects of five logit regressions with robust standard errors. P-values in parenthesis. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. To equalize sample size across the five regressions, observations were restricted to those with information on the conjunction fallacy for all five hazards.

Appendix C: Robustness checks

Table A-5: GSE model, Probability of hazard impact with experience of hazard event as moderator

	Drought	Storm	Heat	Precipi-tation	Flood	Experi-ence
	Coef (SE)	*Coef (SE)*	*Coef (SE)*	*Coef (SE)*	*Coef (SE)*	*AME (SE)*
Experience	**0.206***** **(0.000)**	**0.153**** *** (0.000)**	**0.241***** **(0.000)**	**0.194***** **(0.000)**	**0.139***** **(0.000)**	-
Size (Reference: Large companies)						
Micro	0.043 (0.223)	0.030 (0.365)	-0.030 (0.401)	0.034 (0.324)	0.052 (0.118)	-0.017 (0.770)
Small	0.025 (0.433)	-0.032 (0.286)	0.007 (0.840)	-0.028 (0.353)	-0.011 (0.723)	0.014 (0.785)
Medium	-0.009 (0.769)	0.020 (0.496)	-0.008 (0.791)	0.035 (0.247)	0.008 (0.779)	-0.041 (0.425)
Industry (Reference: Manufacturing)						
Agriculture, forestry & fishing	**0.260***** **(0.000)**	-0.052 (0.312)	**0.098*** **(0.077)**	0.016 (0.762)	**-0.089*** **(0.086)**	**0.361***** **(0.000)**
Mining & Quarrying	0.117 (0.211)	-0.023 (0.796)	-0.121 (0.203)	0.026 (0.774)	0.054 (0.547)	**0.371***** **(0.007)**
Energy and water supply, sewage, waste management	0.050 (0.480)	0.067 (0.311)	-0.081 (0.255)	0.033 (0.632)	**0.112*** **(0.093)**	0.183 (0.133)
Construction	**-0.098**** **(0.026)**	**0.114**** *** (0.006)**	**-0.101**** **(0.025)**	**0.080*** **(0.060)**	**0.101**** **(0.016)**	**0.196***** **(0.007)**
Wholesale & retail trade, repair of motorvehicles/motorcylces	-0.009 (0.817)	-0.013 (0.724)	**-0.097**** **(0.015)**	-0.008 (0.841)	-0.007 (0.856)	0.094 (0.156)
Transportation & storage	-0.062 (0.211)	0.060 (0.201)	**-0.106**** **(0.037)**	0.075 (0.120)	**0.107**** **(0.023)**	**0.165*** **(0.052)**
Accomodation & food ser-vice	**0.107*** **(0.079)**	**0.111*** **(0.052)**	-0.013 (0.835)	-0.007 (0.908)	-0.008 (0.893)	**0.352***** **(0.000)**
Information & communica-tion	**-** **0.151***** **(0.003)**	**-0.107**** **(0.023)**	**-** **0.153***** **(0.003)**	-0.075 (0.128)	-0.050 (0.295)	-0.059 (0.481)
Financial & insurance activities	-0.060 (0.303)	0.063 (0.247)	-0.177 (0.003)	0.070 (0.210)	**0.114**** **(0.039)**	0.037 (0.704)
Real estate activities	-0.086 (0.161)	**0.197**** *** (0.001)**	-0.071 (0.258)	**0.170***** **(0.004)**	0.024 (0.686)	**0.211**** **(0.037)**
Professional, scientific & technical activities	**-** **0.184***** **(0.000)**	**-0.108**** **(0.024)**	**-** **0.195***** **(0.000)**	**-0.122**** **(0.014)**	-0.022 (0.655)	0.096 (0.270)
Administrative & support service activities	-0.035 (0.538)	0.061 (0.260)	-0.019 (0.740)	0.050 (0.375)	0.026 (0.637)	0.148 (0.132)
Education	-0.070 (0.271)	-0.025 (0.678)	0.040 (0.539)	0.001 (0.990)	-0.068 (0.258)	0.178 (0.101)
Human Health & Social Work ac-tivities	**-0.074*** **(0.065)**	0.013 (0.726)	0.023 (0.573)	0.039 (0.320)	0.025 (0.516)	**0.134**** **(0.047)**
Arts, Entertainment and Recreati-on	-0.087 (0.271)	0.088 (0.233)	-0.065 (0.422)	0.122 (0.112)	0.046 (0.543)	**0.299**** **(0.018)**
Other service activities	-0.045 (0.376)	-0.039 (0.416)	**-0.133**** **(0.010)**	-0.022 (0.653)	-0.010 (0.839)	-0.069 (0.411)

Continued Table A-5: GSE model, Probability of hazard impact with experience of hazard event as moderator

	Drought	**Storm**	**Heat**	**Precipi-tation**	**Flood**	**Experi-ence**
	Coef (SE)	*Coef (SE)*	*Coef (SE)*	*Coef (SE)*	*Coef (SE)*	*AME (SE)*
Region (Reference: West Germany)						
North	**-0.066****	-0.003	-0.046	**-0.056***	**-0.071****	**-0.254*****
	(0.045)	(0.915)	(0.173)	**(0.078)**	**(0.024)**	**(0.000)**
East	0.023	0.021	0.007	**-0.086*****	**-0.123*****	**-0.115****
	(0.458)	(0.456)	(0.823)	**(0.004)**	**(0.000)**	**(0.024)**
South	0.005	-0.007	0.004	**-0.042***	**-0.048****	**-0.080***
	(0.838)	(0.761)	(0.869)	**(0.089)**	**(0.044)**	**(0.054)**
Dependence on market partner	0.011	-0.005	**0.039***	-0.001	-0.003	0.030
	(0.617)	(0.819)	**(0.074)**	(0.955)	(0.894)	(0.411)
Site characteristics						
Near coast	0.035	**0.153*****	**0.084***	**0.076***	**0.086****	**0.177*****
	(0.443)	**(0.000)**	**(0.067)**	**(0.083)**	**(0.047)**	**(0.008)**
Near river/stream	**0.048****	0.024	0.032	0.024	**0.060****	**0.098****
	(0.045)	(0.287)	(0.192)	(0.305)	**(0.010)**	**(0.015)**
Low groundwater	**0.102*****	**0.088*****	**0.097*****	**0.061***	0.034	0.078
	(0.002)	**(0.004)**	**(0.004)**	**(0.054)**	(0.270)	(0.160)
Trough/valley	0.046	-0.007	0.029	0.006	**0.094****	0.031
	(0.249)	(0.850)	(0.480)	(0.868)	**(0.013)**	(0.650)
Near forrest	0.016	**0.050***	0.009	**0.066****	0.003	**0.100****
	(0.555)	**(0.054)**	(0.762)	**(0.014)**	(0.909)	**(0.032)**
In city	0.025	0.020	**0.054****	0.023	-0.012	0.047
	(0.306)	(0.383)	**(0.029)**	(0.324)	(0.602)	(0.241)
Hill/elevation	-0.025	0.009	-0.001	-0.024	**-0.053***	-0.005
	(0.415)	(0.745)	(0.969)	(0.427)	**(0.072)**	(0.928)
Respondent characteristics						
female	0.037	0.022	0.024	0.021	**0.052****	**0.086****
	(0.158)	(0.362)	(0.359)	(0.405)	**(0.035)**	**(0.044)**
age	0.001	-0.000	0.000	-0.001	-0.001	-0.001
	(0.162)	(0.998)	(0.949)	(0.511)	(0.198)	(0.532)
well-informed about climate risks	**0.048****	**0.037***	0.017	0.032	0.029	**0.062***
	(0.022)	**(0.055)**	(0.419)	(0.110)	(0.136)	**(0.072)**
manager	0.011	0.025	0.001	-0.008	0.025	0.031
	(0.704)	(0.363)	(0.984)	(0.776)	(0.369)	(0.515)
ownership/stake	-0.041	-0.017	0.024	0.018	-0.007	-0.068
	(0.115)	(0.494)	(0.359)	(0.474)	(0.786)	(0.115)
Const.	**0.182*****	**0.245*****	**0.363*****	**0.348*****	**0.288*****	
	(0.009)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	
N	796	796	796	796	796	808

Table shows coefficients of linear models for the hazard probabilities and average marginal effects of a logit regression for experience. P-values in parenthesis. * p < 0.1, ** p < 0.05, *** p < 0.01. The analysis only includes observations with probability assessments for all five hazards.

Table A-6: GSE model, Conditional probability of firm closure following a hazard with experience of hazard event as moderator

	Drought	Storm	Heat	Precipi-tation	Flood	Experi-ence
	Coef (SE)	*Coef (SE)*	*Coef (SE)*	*Coef (SE)*	*Coef (SE)*	*AME (SE)*
Experience	-0.006	-0.030	0.003	-0.022	-0.006	
	(0.812)	(0.255)	(0.896)	(0.396)	(0.845)	-
Size (Reference: Large companies)						
Micro	0.235***	0.193***	0.147***	0.187***	0.151***	-0.040
	(0.000)	(0.000)	(0.001)	(0.000)	(0.002)	(0.420)
Small	0.138***	0.115***	0.110***	0.155***	0.167***	0.018
	(0.000)	(0.003)	(0.003)	(0.000)	(0.000)	(0.696)
Medium	0.074*	0.083**	0.067*	0.100***	0.102**	-0.023
	(0.050)	(0.025)	(0.061)	(0.007)	(0.011)	(0.592)
Industry (Reference: Manufacturing)						
Agriculture, forestry & fishing	0.078	-0.143**	0.030	-0.097	-0.069	0.402***
	(0.223)	(0.031)	(0.625)	(0.142)	(0.368)	(0.000)
Mining & Quarrying	0.005	-0.023	0.078	-0.039	-0.116	0.342**
	(0.966)	(0.828)	(0.455)	(0.717)	(0.356)	(0.012)
Energy and water supply, sewage, waste management	0.003	-0.071	0.022	-0.041	0.094	0.261**
	(0.970)	(0.411)	(0.805)	(0.670)	(0.312)	(0.012)
Construction	-0.065	-0.114**	-0.084	-0.088	-0.030	0.192***
	(0.247)	(0.032)	(0.121)	(0.104)	(0.605)	(0.002)
Wholesale & retail trade, repair of motorvehicles/motorcylces	-0.040	-0.069	-0.016	-0.021	0.105**	0.072
	(0.409)	(0.150)	(0.726)	(0.656)	(0.046)	(0.190)
Transportation & storage	0.031	-0.058	-0.015	-0.001	-0.004	0.159**
	(0.610)	(0.325)	(0.805)	(0.985)	(0.950)	(0.022)
Accomodation & food service	0.172**	0.071	0.145*	-0.003	0.150*	0.282***
	(0.018)	(0.331)	(0.054)	(0.968)	(0.081)	(0.001)
Information & communication	-0.049	-0.142**	-0.087	-0.116*	-0.037	-0.041
	(0.430)	(0.022)	(0.149)	(0.062)	(0.582)	(0.561)
Financial & insurance activities	-0.031	-0.098	-0.024	-0.013	0.030	0.024
	(0.645)	(0.139)	(0.715)	(0.847)	(0.676)	(0.772)
Real estate activities	-0.098	-0.127*	-0.228***	-0.103	-0.015	0.130
	(0.239)	(0.090)	(0.005)	(0.180)	(0.856)	(0.139)
Professional, scientific & technical activities	-0.107	-0.019	-0.051	0.043	0.028	0.106
	(0.156)	(0.792)	(0.470)	(0.548)	(0.720)	(0.146)
Administrative & support service activities	0.037	-0.005	0.048	0.041	0.098	0.113
	(0.585)	(0.943)	(0.464)	(0.551)	(0.205)	(0.135)
Education	-0.070	-0.055	-0.077	-0.121	0.103	0.181*
	(0.383)	(0.535)	(0.301)	(0.163)	(0.258)	(0.051)
Human Health & Social Work activities	-0.011	-0.035	-0.053	-0.014	0.106**	0.106*
	(0.813)	(0.459)	(0.249)	(0.775)	(0.044)	(0.067)
Arts, Entertainment and Recreation	-0.052	-0.025	-0.038	-0.011	-0.086	0.207**
	(0.558)	(0.783)	(0.653)	(0.899)	(0.452)	(0.038)
Other service activities	0.067	0.053	0.144**	0.028	0.070	-0.010
	(0.299)	(0.421)	(0.019)	(0.670)	(0.312)	(0.885)

Continued Table A-6: GSE model, Conditional probability of firm closure following a hazard with experience of hazard event as moderator

	Drought	**Storm**	**Heat**	**Precipitati-on**	**Flood**	**Experi-ence**
	Coef (SE)	*Coef (SE)*	*Coef (SE)*	*Coef (SE)*	*Coef (SE)*	*AME (SE)*
Region (Reference: West Germany)						
North	-0.012	0.060	0.063	0.027	0.021	**-0.168*****
	(0.770)	(0.152)	(0.111)	(0.507)	(0.637)	**(0.000)**
East	-0.030	-0.044	-0.011	-0.048	-0.031	**-0.144*****
	(0.432)	(0.237)	(0.771)	(0.199)	(0.460)	**(0.001)**
South	-0.009	0.021	0.038	**0.062****	**0.091*****	**-0.096*****
	(0.766)	(0.493)	(0.213)	**(0.046)**	**(0.006)**	**(0.008)**
Dependence on mar-ket partner	0.017	0.037	0.022	0.013	0.041	**0.065****
	(0.541)	(0.167)	(0.406)	(0.628)	(0.162)	**(0.031)**
Site characteris-tics						
Near coast	-0.030	-0.068	-0.042	-0.030	-0.038	**0.138****
	(0.598)	(0.216)	(0.453)	(0.603)	(0.538)	**(0.024)**
Near river/stream	-0.044	-0.015	-0.007	0.007	-0.001	**0.121*****
	(0.135)	(0.622)	(0.807)	(0.804)	(0.978)	**(0.001)**
Low groundwater	-0.006	-0.048	0.010	-0.013	-0.039	**0.093***
	(0.889)	(0.250)	(0.804)	(0.748)	(0.402)	**(0.061)**
Trough/valley	**0.115****	0.060	0.075	-0.007	0.039	0.051
	(0.023)	(0.250)	(0.130)	(0.885)	(0.444)	(0.418)
Near forrest	**0.074****	0.021	**0.065****	0.057	0.021	**0.088****
	(0.029)	(0.546)	**(0.049)**	(0.100)	(0.569)	**(0.029)**
In city	**-0.068****	-0.033	-0.011	-0.029	**-0.085*****	0.037
	(0.025)	(0.266)	(0.698)	(0.337)	**(0.009)**	(0.284)
Hill/elevation	-0.062	-0.036	-0.047	-0.051	-0.006	0.013
	(0.105)	(0.329)	(0.209)	(0.191)	(0.845)	(0.766)
Respondent cha-racteristics						
female	0.034	-0.012	0.022	0.006	-0.028	**0.087****
	(0.288)	(0.706)	(0.479)	(0.858)	(0.427)	**(0.018)**
age	**0.002***	**0.002***	**0.003*****	**0.003****	0.002	-0.001
	(0.073)	**(0.053)**	**(0.005)**	**(0.017)**	(0.119)	(0.402)
well-informed about climate risks	0.009	0.011	0.040	0.004	0.015	**0.074****
	(0.718)	(0.670)	(0.117)	(0.890)	(0.605)	**(0.012)**
manager	-0.011	**-0.064***	-0.024	-0.043	**-0.098****	0.028
	(0.757)	**(0.074)**	(0.491)	(0.223)	**(0.013)**	(0.490)
ownership/stake	-0.051	-0.008	0.007	-0.024	0.016	**-0.079****
	(0.117)	(0.805)	(0.828)	(0.470)	(0.648)	**(0.032)**
Const	**0.171****	**0.199****	0.026	0.120	**0.181****	
	(0.044)	**(0.016)**	(0.753)	(0.157)	**(0.045)**	
N	563	597	607	612	542	1102

Table shows coefficients of linear models for the conditional probabilities and average marginal effects of a logit regression for experience. P-values in parenthesis. * p < 0.1, ** p < 0.05, *** p < 0.01.