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Short contribution on adaptive behaviour of flood-prone companies: A pilot study of Dresden-Laubegast, Germany

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Abstract

Integrated flood management strategies consider property-level precautionary measures as a vital part. Whereas this is a well-researched topic for residents, little is known about the adaptive behaviour of flood-prone companies although they often settle on the ground floor of buildings and are thus among the first affected by flooding. This pilot study analyses flood responses of 64 businesses in a district of the city of Dresden, Germany that experienced major flooding in 2002 and 2013. Using standardised survey data and accompanying qualitative interviews, the analyses revealed that the largest driver of adaptive behaviour is experiencing flood events. Intangible factors such as tradition and a sense of community play a role for the decision to stay in the area, while lacking ownership might hamper property-level adaptation. Further research is also needed to understand the role of insurance and governmental aid for recovery and adaptation of businesses.

KEYWORDS

adaptation, disaster risk reduction, integrated flood risk management, risk perception

1 | INTRODUCTION

Although rivers have attracted settlement for centuries (Smith & Tobin, 1979), the exponential growth of flood damage since the 1950s (EEA, 2016) could alter the flood response patterns of residents and businesses in flood-prone areas (Kousky, 2017).

Individual adaptation to flood risk is a well-researched topic for residents (e.g., Birkholz, Muro, Jeffrey, & Smith, 2014; Bubeck, Botzen, & Aerts, 2012; Grothmann & Reusswig, 2006) revealing flood experience, observational learning, social networks, and personal capacities as overall drivers (Bubeck, Botzen, Laudan, Aerts, & Thieken, 2018; Poussin, Botzen, & Aerts, 2014). In contrast, behavioural patterns of businesses are under-researched and hence less understood (Kreibich, Müller, Thieken, & Merz, 2007), although several studies, particularly from Asian countries, have been published recently. Chinh, Bubeck, Dung, and Kreibich (2016) revealed that small companies in Vietnam behave similarly to private households with regard to preparedness, warning and emergency response. Taking the cites of Jakarta and Semarang as examples from Indonesia, Neise and Revilla Diez (2019) found that company size and associated financial resources and competiveness influenced the uptake of long-term adaptive measures or relocation. It was striking that small companies kept relying on emergency responses (e.g., pumps) or surrendered ("wait-and-see"-strategy; Neise & Revilla Diez, 2019). Lack of insurance and business continuity planning were found to hinder recovery of flooded small firms in Thailand (Pathak & Ahmad, 2016). Multiple

flood impacts, including indirect and long-lasting financial burden, were also found in the UK, where small businesses faced increasing insurance premiums and excesses after having been flooded (Wedawatta, Ingirige, & Proverbs, 2014). Besides company size, the business sector might influence adaptation needs and strategies (Kreibich et al., 2007; Sieg, Vogel, Merz, & Kreibich, 2017). Although experienced flooding increased the uptake of adaptive measures, businesses tend to be less prepared for floods than private households when being flooded again (Kreibich et al., 2011). This is significant because businesses are fundamental components of communities by contributing to the wealth and pull-factors of a district (Van Hear, Bakewell, & Long, 2018). As commercial spaces are often situated on the ground floor, businesses tend to be among the most affected by flooding (Penning-Rowsell et al., 2013, p. 164). As such, their behaviour and its drivers need to be investigated in more detail.

This study presents a preliminary analysis of a mixed qualitative and quantitative dataset capturing responses of businesses to flooding in the area of Dresden-Laubegast, a district of the city of Dresden, Germany. This site was chosen, as two major floods, that is, in 2002 and 2013, and several minor events affected it in-between. The dataset is focused on the business owners' perceived flood probability (risk perception), as well as general potential drivers for different adaptive responses. Two research questions are focused on, namely (a) what is the perceived risk of companies in the study area and (b) what are possible drivers behind flood-adaptive behaviour? By doing so, the study intends to identify factors for later studies on what could prompt increased anticipatory adaptation to floods by businesses.

2 | STUDY AREA AND FLOOD EVENTS

Laubegast, a district of the city of Dresden, Germany, was severely affected by floods of the river Elbe in 2002 and 2013. Additional less severe floods occurred in 2006, 2010 and 2011 (Kienzler, Pech, Kreibich, Müller, & Thieken, 2015; Kreibich et al., 2011; Kreibich & Thieken, 2009). The studied district is located along the river in the east of the city of Dresden in the state of Saxony, but it can also be flooded by the smaller river Lockwitzbach (Figure 1).

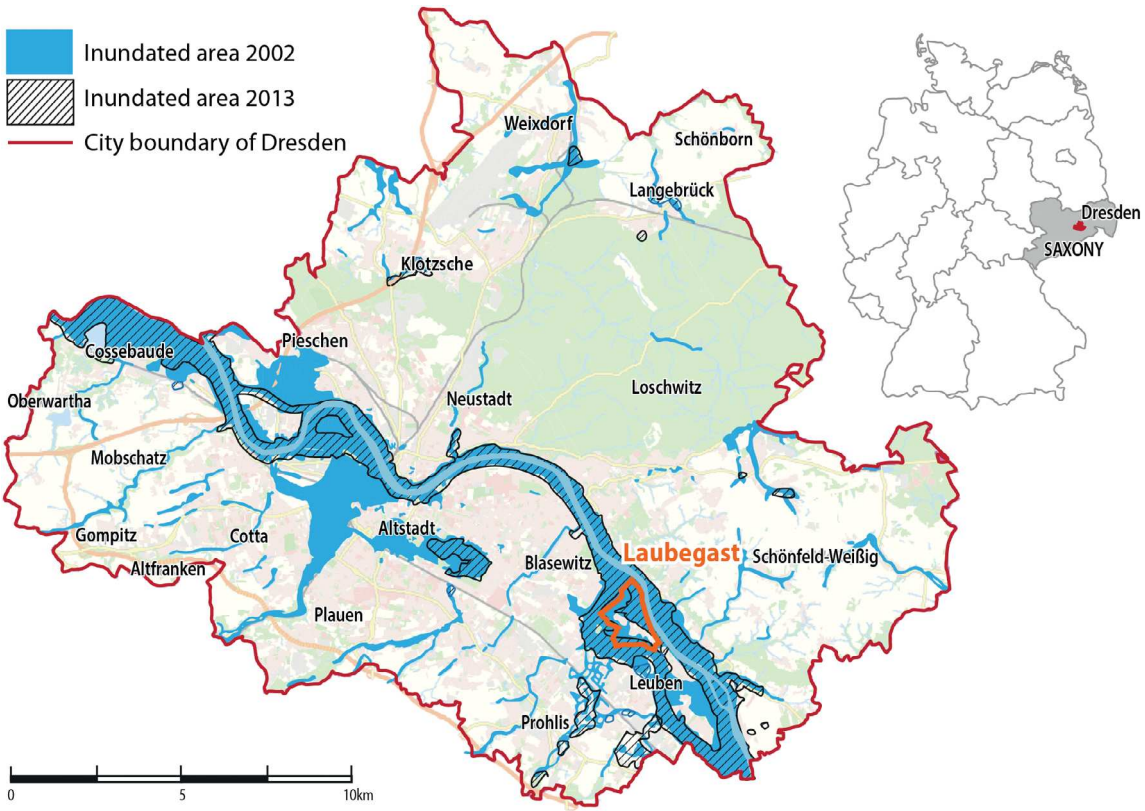

FIGURE 1 Dresden-Laubegast and flooded areas in 2002 and 2013. The map on the top right depicts the location of Dresden in Germany. The city outlines and the flood extents of 2002 and 2013 are illustrated on the map in the centre. The district of Dresden-Laubegast is highlighted in red (adapted from Landeshauptstadt Dresden; Amt für Geodaten und Kataster)

The 2002 Elbe flood can be attributed to record-breaking rainfall in the mountain ranges home to the spring of the Elbe River (Ulbrich, 2003). The 2013 event was, in contrast, caused by severe rain in combination with high antecedent moisture (Merz et al., 2014), while the smaller floods in 2006 and 2011 were caused by rain and snowmelt (Kienzler et al., 2015). The atmospheric situation that triggered the flood of 2010 was comparable to the one in 2002 (Kienzler et al., 2015).

The 2002 flood peaked at water levels of 9.40 m in Dresden-Laubegast, which exceeded the previous record gauge of 1845 by almost 0.6 m (Grollmann & Simon, 2002). The flood of 2013 reached 8.76 m and impacts were in general less severe (Thieken et al., 2016). In Dresden, this can be regarded as a result of improved local flood management as reported, for example, by Kreibich and Thieken (2009).

3 | METHODOLOGY

This study employs a combination of qualitative and quantitative data, that is, interviews and surveys. This type of mixed-method research approach was chosen, as previous research has highlighted the benefits from formal statistical analysis (e.g., Grothmann & Reusswig, 2006; Raaijmakers, Krywkow, & Veen, 2008) as well as qualitative data analysis to understand risk management (e.g., Otto et al., 2019). Furthermore, Ruark and Fielding-Miller (2016) argued that combining these two methods provides better insights into decision-making patterns, while enabling an additional channel of validation. The design chosen in this study can be best regarded as an explanatory sequential design, that is, a quantitative data collection and analysis is followed by the collection of qualitative data, which are used to explain the quantitative results, for example, underlying processes (Schoonenboom & Johnson, 2017).

3.1 | Survey

The self-response survey consisted of 20 questions, which were mostly close-ended and geared towards providing quantifiable results for statistical analyses.

The study area's business environment is dominated by small-scale businesses, mostly located on the ground floor of buildings. Due to just a few responses to an online survey in November 2015, the questionnaire was distributed building-to-building between December 21, 2015 and January 16, 2016. By this, the rate of response-refusal was kept low, as well as through personal collection of survey responses, as suggested by Kaplowitz, Hadlock, and Levine (2004). Furthermore, the type of survey encouraged effortless responding and allowed participants to provide more in-depth information, where needed. In addition, conversations with participants enabled us to get in touch with dissolved or (partly) relocated businesses. In total, 78 surveys were returned, out of which 14 were incomplete to such extent that they were ignored for the statistical analyses. The response rate was as high as 70%, with nearly 20% of businesses in the area being contacted, that is, 126 out of the 574 businesses that were registered in the district as of January 1, 2016. Businesses located on the ground floor were asked to participate.

The first 15 questions of the survey addressed geographic, demographic and flood-event-related information including questions on insurance coverage and governmental aid to capture financial resources that might support recovery processes as well as a question on post-flood uptake of adaptive measures. The final five questions were designed to rate a participant's perceived flood probability. Five flood scenarios with return periods of 20, 50, 100, 200 and 500 years, respectively, were depicted on flood maps showing the flood extent in the study area. Participants were asked to indicate on a Likert-rating scale from 1 to 4 their perceived likelihood of the depicted flood events to occur in the next 5 years. This format was chosen, since it allows laypeople to indicate their degree of agreement with a statement (Slovic, 2000). The timescale of 5 years reflected the frequency of flooding of the river Elbe since 2002. The combination of all five responses allowed us to construct a psychometric-index illustrating the overall perceived flood probability (see Appendix S1). These questions were placed at the end of the survey considering that images of flood events could trigger strong memories, which in turn could have altered or amplified answers to the other questions (Kang, Hong, Blake, & Woodman, 2011).

Analyses of variance (ANOVA) as well as Kruskal–Wallis tests (for 3 groups) and Mann–Whitney U tests (for two groups) were used to detect variables that differ between response groups. Indicated variables were then used in logistic regression models.

3.2 | Interviews

Two types of interviews were conducted to compile qualitative insights into the business responses and their decision-making process: (a) four semi-structured interviews, consisting of mostly open-ended questions conducted between 4 and January 8, 2016; and (b) eight brief in-person conversations, during drop-off or pick-up of the questionnaires in December 2015 and January 2016.

These interview types were chosen, because they offer especially rich insights into emotional factors influencing businesses' flood responses. Pre-defined questions initiated the conversation during the interviews, but allowed the conversation to develop individually. The interviews were transcribed or paraphrased and used to contextualise findings from the quantitative analysis.

4 | RESULTS AND DISCUSSION

Ninety-two percent of the surveyed businesses (59/64) were small businesses with less than 15 employees. Around 60% of surveyed businesses were in the retail and services sector (38/64), others belong to the health, hospitality, manufacturing or financial sector. Furthermore, 66% of the businesses (42/64) were located in close proximity to the river at less than 250 m; 34% were located farther away. Businesses that had resided in the district prior to 2002 and could have encountered the two major flood events in 2002 and 2013 were considered long-term residence, of which there were 27 (42%). Sixteen percent of the surveyed companies (10/64) indicated that they had moved to the district after 2013. Only 9% of all companies (6/64) had dissolved or moved away—at least essential parts of their business, although 47% of the businesses (30/64) had been affected by both floods (32 by the 2002-flood and 47 by the 2013-flood).

Thirty-eight of all surveyed companies (59%) had no insurance coverage. However, from those insured, 12 companies reported that less than 50% of their claimed damage had been paid. In the following, these were grouped together with the uninsured to a "low insurance coverage" group. It should be noted that 25 companies (39%) had received governmental aid after a damaging flood. Altogether, these characteristics underline that the sample is well balanced across businesses with different levels of flood experience, residence length and recovery aid.

4.1 | Risk perception and adaptation

The statistics in Table 1 are split by the flood response outcomes, namely that a business either (a) adapted by (partly) moving their business out of the district or dissolving it, (b) took adaptive action of some kind at the property level and (c) took no action. Due to the small sample size, it was not possible to further classify these core groups. The data reveal that 37 businesses (58%) had taken no action in response to the flood events, whereas 27 businesses took actions, such as moving away or dissolving (6; 9%), as well as implementing adaptive measures (21; 33%). Interview data revealed that adaptive behaviour captured a range of measures from setting up straight-forward emergency plans to renewing the buildings' electricity or tiling the entire sales area.

Table 1 further illustrates that there is a difference in the perceived flood probability index (PI) as an indicator of risk perception which was constructed with the Likert-scale responses on perceived flood probabilities of flood scenarios. In the whole sample, the potential minimum and maximum of the perceived flood probability index (PI) are covered; hence, the PI varies from 40.6 to 162.4 (mean: 105.4). However, the average PI varies considerably between moving/dissolving (outcome 1) and taking no action (outcome 3) or taking protective action (outcome 2; Table 1).

An ANOVA was conducted on the mean risk perception values across the three response groups. If all three groups are treated separately there is no strong indication of differences in mean values (p value = .17), the same is true if we combined outcomes 1 + 2 and compared towards outcome 3 (p value = .18). However, there was a significant difference if outcome 1 was compared to the combined outcome 2 + 3 (p value = .09). This is in line with Table 1 and can be taken as an initial indication that the strongest relation between risk perception and business responses is between staying in or leaving a flood-prone area. The threat of flooding for these businesses may outweigh the continued benefits of locating in that area despite the intangible benefits of remaining there (as discussed in the next section). However, this must be viewed with caution. Firstly, the risk perception indicator is only weakly related to the actual protective actions of respondents. A reason might be that Likert-scale cross-sectional questionnaires are subject to biases (Bertram, 2009) of their subjective nature, which—while important for explaining action—can be difficult to measure behaviour, for instance, in case of feedback loops: a

TABLE 1 Businesses' flood responses (n = 64)

Outcome	Frequency	Percentage	Average indicator of risk perception
(1) Businesses moved/dissolved	6	9.2	127.3
(2) Took protective measures	21	32.8	107.6
(3) Took no action	37	57.8	100.6

business undertakes protective actions when risk perception is high, which is then lowered because the business owner now feels more secure (see Bubeck et al., 2012).

4.2 | Drivers of businesses' flood adaptive responses

Since risk perception does not seem to be a reliable predictor for adaptive response, this section explores other potential drivers. To produce an initial exploratory quantitative analysis of what can lead to adaptive responses, we employed a logistic regression where the dependent variable takes the value "0" for outcome 3, and "1" for outcome 1 or 2. Once estimated, the marginal effects are reported in Table 2, while the underlying coefficients are presented in the supplementary materials S2 and S3 (Appendix). Three independent variables were isolated from the dataset: flooded (a binary variable for if the company had been flooded); high insurance coverage (a binary variable for if the company's damage was paid by 50% or more); a binary variable if the business had received government aid after a flood. These variables were selected because Kruskal–Wallis tests indicated potential differences across the three outcome groups listed in Table 1. Mann–Whitney *U* tests confirmed these results when comparing the adaptive (outcome 1 + 2) to the non-adaptive group (outcome 3). In addition, long-term-residency and confidence in the business location were revealed as being significantly different. They do, however, correlate with the number of experienced floods (tested by Spearman's rho) and were thus neglected. In fact, the strongest variable, both in terms of statistical significance and marginal effect, is experienced flooding (Table 2); it is hence the most powerful driver of action. This is much the same with households, indicating a potentially similar mechanism at play, at least in small businesses as was found, for example, by Chinh et al. (2016) in Vietnam. The financial assistance a firm received did not strongly impact adaptation decisions in the sense of statistical significance, but marginal effects indicate that insurance coverage might have a larger positive impact than (unreliable) government aid (Table 2). This is a potentially similar result to Hudson, Botzen, Czajkowski, and Kreibich (2017) who found overall that private households who tended to be proactive in preparing for floods also tended to buy insurance coverage. A similar mechanism may be in play as the qualitative interviews indicated businesses may tend to be more constrained in their capacity to act as compared to households.

In fact, during discussions and interviews with business owners, a key reason for outcome 3 (no action) was revealed: most business owners face limitations in their capabilities to take actions. While financial constraints play a considerable role, the fact that most businesses merely rented their business locations indicates a lack of freedom to implement the protective measures they desire to take. In the interviews, business owners further identified a key reason for staying in the district being the tradition the business had at its location, the vicinity to their clients, as well as a sense of belonging. Other studies have shown that social environments can lead to a shift in judgement of a risk (Birkholz et al., 2014) and thus could influence businesses' response to flooding. Furthermore, Renn, Burns, Kasperson, and Slovic (1992) argued that the social environment and the sense of a community can amplify a sense of security and an emotional attachment to the business location can lead to reduced risk perceptions (Hunka, 2008). Bubeck et al. (2018) also identified social environments as important factor for protection motivation of residents.

During the interviews, the notion arose that floods can be key components in maintaining and developing solidarity and cooperative spirits between business owners in affected districts. This solidarity and cooperative spirit has shown to prevail in the absence of floods.

TABLE 2 Marginal effect estimates of the probability of undertaking adaptive action

	(1)	(2)	(3)	(4)
Has been flooded before	0.38*** (0.11)	0.34*** (0.13)	0.35*** (0.13)	0.4*** (0.11)
High insurance coverage		0.19 (0.16)		
Has received governmental aid after a flood			0.1 (0.14)	
Risk perception index				0.003 (0.002)
Observations	64	64	64	64

Note: Logit model standard errors in parentheses.
***$p < .01$.

The resulting "flood community", that is, those who can be impacted by a flood again, is then less likely to move away, as it gains resilience from this social security.

5 | CONCLUSIONS

Overall, the findings of this study allow for several preliminary conclusions for future research to build upon. The findings on the risk perception indicator illustrate the difficulties in determining unbiased estimators for risk perception, especially from cross-sectional data. Still, results indicate that perceived flood probability has potentially an effect only on businesses that consider responding to flooding by moving or dissolving. The largest driver of adaptive behaviour is, however, experiencing flood events. The qualitative interviews further highlighted the importance of intangible factors such as tradition and a sense of community to play a role for staying in the area. Moreover, it was indicated that more adaptive behaviour of businesses could be achieved by a policy that accounts for the fact that business locations are often rented. Hence, property owners should be explicitly addressed and motivated to implement adaptive measures. Further research is needed to isolate if businesses respond to insurance and governmental aid in the same way than private households do. Finally, our preliminary study is only limited to a specific district with a small sample and it cannot be said that findings in this district can be transferable nationwide or even beyond Germany.

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DATA AVAILABILITY STATEMENT

The survey data that support the findings of this study are available from the corresponding author upon reasonable request. The interview data are subject to data privacy issues and cannot be shared.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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