



Modeling Household Earthquake Hazard Adjustment Intentions: An Extension of the Protection Motivation Theory

Yueqi Li¹; Alex Greer²; and Hao-Che Wu³

Abstract: While existing literature has explored how hazard experience, salience, and demographics characteristics shape threat appraisal and hazard adjustment intentions, this study expands on past studies by exploring how additional factors such as qualitative characteristics of the hazard, political ideology, and oil entanglements shape threat appraisals, coping appraisals, and adjustment intentions in response to a technia hazard. This study builds on protection motivation theory (PMT) to explore factors that shape Oklahomans' intentions to adjust to induced seismicity using data collected from households ($n = 866$) across 27 counties in Oklahoma that have experienced varying levels of seismic activity resulting from oil and gas exploration. Correlational analyses and structural equation modeling show that several variables not included in the original PMT, such as feelings of dread or negative emotions associated with earthquakes, are important predictors of intentions to adopt hazard adjustments. This study concludes with examining the effect of additional factors on adjustment intentions and risk perceptions that can help guide future earthquake risk management in identifying and taking appropriate actions that will stimulate precautionary behavior of private actors. DOI: [10.1061/\(ASCE\)NH.1527-6996.0000607](https://doi.org/10.1061/(ASCE)NH.1527-6996.0000607). © 2022 American Society of Civil Engineers.

Practical Applications: This study builds on PMT to explore factors that shape Oklahomans' intentions to adjust to induced seismicity using data collected from households ($n = 866$) across 27 counties in Oklahoma that have experienced varying levels of seismic activity resulting from oil and gas exploration. While our results lend support to PMT hypotheses, we found that several variables not included in the original PMT, such as feelings of dread or negative emotions associated with earthquakes, are important predictors of intentions to adopt hazard adjustments. Results of this research can help guide future earthquake risk management in Oklahoma, providing insights that can be used to help residents identify and take appropriate actions to reduce their earthquake risk to reduce their risk. Local and state governments in Oklahoma should work to raise awareness of earthquake risk and use our research findings to emphasize adjustment measures that have low adoption intentions and high potential to reduce risk, and that are relatively cheap and easy to install (e.g., installing secure cabinets). Likewise, stakeholders across the state should work to eliminate financial barriers by providing subsidies or government loans for costly adjustment measures (e.g., purchasing earthquake insurance) that protect individuals and property from future earthquake hazards. Local emergency managers should also work to increase households' familiarity and knowledge about earthquake risks and communicate the multiuse functions of many adjustment activities, which we find to be a strong predictor of adjustments.

Author keywords: Protection motivation theory (PMT); Technia; Earthquake risk; Oklahoma; Hazard adjustment.

Introduction

Wastewater disposal, or the process of injecting contaminated fluid underground after oil and gas extraction, has led to a dramatic increase in seismicity in Oklahoma since 2009 (Chen and Abercrombie 2020; Zhai et al. 2019). Seismicity in the state increased from averaging one M3 or greater earthquake per year pre-2009 to more than 900 M3 or greater earthquakes in 2015

(Johann et al. 2018). This period of increased seismicity has included some sizable earthquakes, including an M5.6 in 2011 and an M5.8 in 2016, resulting in considerable damage for an area not built to withstand seismic shaking (Taylor et al. 2017; Jones 2016). Even with their rich history of hazards, earthquakes present a novel threat for Oklahomans. The induced seismicity in this case is a technia hazard, or an event where a technological hazard triggers what would be traditionally defined as a natural hazard (Gill and Ritchie 2018). In this paper, we explore how Oklahomans are understanding this technia hazard and how they intend to adjust to this threat.

Hazard risk adjustments are critical for individuals at risk to reduce their hazard exposure. Lindell and Perry (2000) define hazard risk adjustments as hazard mitigation, which provides passive protection at impact, emergency preparedness, which supports active postimpact responses, and the acquisition of insurance, which provides funds to recover when losses occur (Lindell and Perry 2000). When considering what leads individuals to consider adjusting to hazards, the protection motivation theory (PMT) suggests that people's hazard adjustment intentions are shaped by threat appraisals and coping appraisals (Rogers 1975). While several researchers have used the PMT to explain adjustment intentions in response

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to natural hazards (Babcicky and Seebauer 2019; Bubeck et al. 2012; Westcott et al. 2017; Lindell and Prater 2002), the realm of hazards risk reduction for techna hazards has not been fully explored. Seismicity in Oklahoma is widely recognized as a techna hazard (Holland 2013; Ng'ombe and Boyer 2019). The novelty of this hazard may result in deviations in households' hazard adjustment intentions and how the factors shape intentions.

This study uses data collected from households ($n = 866$) across 27 counties in Oklahoma that have experienced varying levels of seismic activity (Petersen et al. 2018). Building on the original PMT and previous work (Murphy et al. 2018; Greer et al. 2018, 2020), we explore factors that shape both threat appraisals and adjustment intentions of Oklahomans, incorporating additional variables beyond the original PMT to advance the theory in the context of a techna threat (Rogers 1975). While the existing literature has explored how experiences, salience, and demographic characteristics shape threat appraisals and hazard adjustment intentions, this study expands on the literature by exploring the effects of qualitative characteristics of the hazard, ideology, and entanglement on threat appraisals. These factors are important because past research has shown that qualitative characteristics (Zwickle and Wilson 2014; Västfjäll et al. 2008; Keller et al. 2006; Slovic et al. 2004), political ideology (Kahan et al. 2012; Choma et al. 2013; Kahan et al. 2007; The New York Times 2016), and benefits gained from hazardous activities (Starr 1969; Cole and Withey 1981; Fischhoff et al. 1978; Renn 1998; Slovic et al. 2004) all affect citizens' evaluation of threats and tolerance of risks. We analyzed these results in the context of both the original PMT and with adding these additional factors by correlational analyses and structural equation modeling (SEM). We close this paper by discussing the implications of our findings and the utility of our identified additional factors for future studies.

Literature Review

Protection Motivation Theory

The PMT, an expectancy-valence theory, attempts to capture the factors that influence intentions to adjust to risks (Rogers 1975). The theory relies on two cognitive mediating processes, threat and coping appraisals, to explain variations in protective responses to hazards (Fig. 1). Threat appraisals (TAs), often referred to as risk perceptions, capture perceived vulnerability to a threat. Coping appraisals (CAs) measure perceived adaptive capacity to an event and comprise three variables: self-efficacy, response efficacy, and response costs. The two efficacy factors, self-efficacy and response efficacy, capture whether an individual thinks they can undertake adjustments and whether they believe the adjustments would effectively reduce the risk posed by said hazard to lives or property, respectively. Response costs refer to perceptions of the effort,

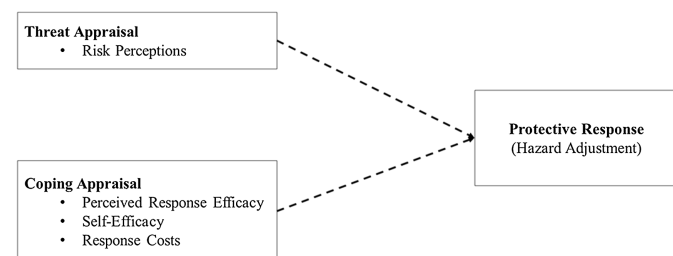


Fig. 1. Protective motivation theory.

specialized knowledge, or funds required to adopt an adjustment (Bubeck et al. 2012).

While this theory was originally designed to explain health-related behavior, several researchers have employed this theory and related theories to explain how individuals consider adjustments to disasters (Ong et al. 2021; Martin et al. 2007; Seebauer and Babcicky 2020; Greer et al. 2020). When studying the adoption of adjustments in response to flooding risk in New York City, for example, Botzen et al. (2019) found that individuals with more risk exposure undertook more mitigation measures, and, in regards to coping appraisals, that both response and self-efficacy correlated with adjustments undertaken while response costs did not. In a study of fire-prone communities in California, Ghasemi et al. (2020) found that perceived effectiveness of adjustments and risk perceptions related to fires drove adjustment intentions among homeowners. These studies generally find that both TA and CA drive intended hazard adjustments, but that CA accounts for more variability in adjustments than TA (Babcicky and Seebauer 2019; Bubeck et al. 2012; Greer et al. 2020; Lindell and Prater 2002).

As noted by Rogers (1975), the model was kept intentionally limited to increase generalizability. That said, Rogers suggested that future researchers should, as appropriate, consider including environmental, cognitive, and other factors that will likely improve the explanatory power of the PMT. Several researchers have expanded on the PMT in disaster research. For example, Grothmann and Reusswig (2006) added prior flood experience when exploring drivers of flooding adjustment, finding that personal experience correlated with protective response. When studying adjustment to floods, Oakley et al. (2020) included personal experience with flooding, emotional responses such as fear, and a variable capturing whether individuals thought adjusting was their responsibility. Lindell and Prater (2002), while exploring adjustment to earthquakes, added usefulness for other purposes, finding that this had a strong correlation with adjustment intentions. With this in mind, we explore other variables not traditionally included in the PMT that past literature has shown may shape adjustment intentions.

Additional Drivers of Adjustment Intentions and Risk Perceptions

Qualitative Characteristics

As one of the most prominently cited drivers of hazard adjustment adoption (Becker et al. 2012; Dooley et al. 1992; Kunreuther and Slovic 1996; Lindell 2013; Lindell and Hwang 2008; Prater and Lindell 2000; Tierney 1993), there is value in considering risk perceptions beyond the perceived likelihood and severity of a given hazard, particularly in the context of techna earthquakes in Oklahoma. As noted by Slovic et al. (2004), risk perceptions cannot be reduced to how individuals *think* about a risk, but how they *feel* about said risk. Studies have suggested that emotional responses, informed by perceived qualitative characteristics of risk sources, past experiences, and benefits associated with that risk source, create an affect heuristic that individuals use to quickly evaluate threats (Zwickle and Wilson 2014; Västfjäll et al. 2008; Keller et al. 2006; Slovic et al. 2004). Such qualitative characteristics include whether hazards are controllable or uncontrollable, voluntarily undertaken or imposed by others, immediate or chronic, novel or familiar, known or unknown to the public, understood or not by experts, whether they are common or dreaded, their catastrophic potential, and equitable distribution of risks and benefits (Tierney 2014; Pidgeon 1998; Sjöberg 1998; Renn 1992; Boholm 1998; Slimak and Dietz 2006; Fischhoff et al. 1978; Renn 1998). These characteristics can be quite different when comparing technological hazards to natural hazards. In general, individuals tend to

view risks associated with technological hazards as more controllable via policy, imposed upon them, unknown, less understood by both experts and the public, more dreaded, and with unequitable risk and benefit distribution (Fischhoff and Kadavy 2011; Kunreuther and Slovic 1996; van der Linden 2015; Renn 1992). Natural hazards, in contrast, are seen as less controllable, more voluntarily undertaken, and more understood by experts and the public (Brun 1992).

Experience and Salience

Several prior studies have found that experience with natural hazards shapes risk perceptions (Palm 1998; Paton et al. 2000; Asgary and Willis 1997; Kung and Chen 2012; Gotham et al. 2017; Nakayachi et al. 2015; Tracy and Javernick-Will 2020; Whitmarsh 2008; Visschers and Siegrist 2013). Experience is important in the development of risk perceptions because what individuals remember about an event serves as an anchoring point for the likelihood and expected outcomes of a similar occurrence, often leading those with experience to see recurrence as more likely (Boholm 1998; Newman et al. 2014; Eiser et al. 2012; Tversky and Kahneman 1973). Likewise, there is a large body of research that suggests that previous experience with hazards is positively correlated with hazard adjustment adoption (Jackson 1981; Lindell and Hwang 2008; Perry and Lindell 2008; Prater and Lindell 2000). Several other studies, however, do not find these relationships. For example, past studies have shown that near misses, or experience with only minimal losses, can reduce the likelihood of individuals adopting protective measures (Blanchard-Boehm et al. 2001; Dillon et al. 2011; Tinsley et al. 2012). Some research suggests that this discrepancy may be due to mediating variables between experience and adjustments (Ge et al. 2011; Lindell and Hwang 2008), or that experience is inconsistently measured across the literature (Wu et al. 2015).

Hazard salience, or how often an individual thinks about an event, is another factor explored in studies as a driver of risk perceptions and hazard adjustments (Perry and Lindell 1990). Often highest in the immediate wake of an event (Dooley et al. 1992), findings relating salience to hazard adjustments and risk perceptions are mixed. While studies have found a positive correlation between hazard salience and hazard adjustment (Jackson 1981; O'Brien and Mileti 1992; Perry and Lindell 1990; Russell et al. 1995), other studies, such as Peers et al. (2021) and Greer et al. (2018), did not find this relationship. Prater and Lindell (2000) found that salience was correlated with risk perceptions, but more strongly correlated with hazard adjustments. Salience is also closely tied to hazard experience (Pennebaker and Harber 1993; Perry and Lindell 1990), with Lindell and Hwang (2008) finding that salience may act as a mediating variable between experience and risk perceptions, which then contribute both directly and indirectly to hazard adjustments.

Risk Perception

Recent work suggests that the risk perception is multidimensional, and affective responses play a dominating role of holistic judgments among affect, probability, and consequence dimensions, with studies finding that the dimensional structure does not vary across different hazard types (Wilson et al. 2019; Walpole and Wilson 2021). While risk perceptions have been frequently used to predict protective behaviors, multidimensional measures are demonstrated to be more effective in predicting protective behavior than a unidimensional measure (Wilson et al. 2019; Ferrer et al. 2016). To summarize, the existing literature provides rich sources on factors that affect risk perceptions, which in turn predict self-protective behaviors. However, few evaluated the risk perception drivers in the context of predicting protective behaviors with risk perceptions and coping appraisals, and specifically for technica hazard risks.

Demographics, Ideology, and Entanglement

While demographic characteristics have been shown to affect hazard adjustment intentions, findings from previous research are mixed. Studies have found that several factors, such as gender, age, race, and having children, affect individuals' intentions of adopting adjustments (Duží et al. 2017; Kellens et al. 2011; Lindell et al. 2009; Lindell and Perry 2000; Prater and Lindell 2000; Stojanov et al. 2015). In terms of gender, female gender has been found to be positively correlated with adoption of adjustments (Kung and Chen 2012; Lindell and Prater 2000), but other research has found that women report higher risk perceptions and lower levels of adjustment intentions (Prater and Lindell 2000). Russell et al. (1995) found that household income, education level, owning a home, being married, and number of years in the neighborhood are all positively related to earthquake preparedness. In general, though, demographic characteristics tend to have small correlations with adjustment intentions (Lindell and Whitney 2000).

Two additional dimensions are likely complicating risk perceptions in Oklahoma: political ideology and perceived benefits gained from hazardous activities. First, research has found that individuals with a conservative ideology, as is the case for most Oklahomans, are less likely to support interventions to address collective hazards than their more liberal counterparts (Choma et al. 2013; Kahan et al. 2007, 2012). Other research has found that individuals affiliating with a liberal political party are more likely to adopt hazard adjustments (Jenkins-Smith et al. 2017; Ripberger et al. 2017). Likewise, prior studies in Oklahoma indicate that when considering fracking, most individuals are more concerned about issues of water quality and availability than with potential damage from earthquakes (Junod et al. 2018; Pollard and Rose 2019; Jackson et al. 2014; Porter et al. 2019). Second, findings suggest that individuals are more likely to tolerate risks from which they derive a direct benefit (Starr 1969; Cole and Withey 1981; Fischhoff et al. 1978; Slovic et al. 2004; Renn 1998). With the prevalence of oil and gas extraction in the state, we would expect to find that individuals who receive a direct benefit from resource extraction (via a job for themselves or a family member, or royalties from drilling on land they own) are more likely to tolerate increased risk than individuals who do not directly benefit from extraction.

Hypotheses

Given the ambiguous findings in the literature, this study seeks to advance the original PMT by including additional factors that affect risk perceptions and hazard adjustments and conducting a holistic examination using a range of hazard adjustment items (Greer et al. 2020; Wu et al. 2020). The original PMT considers the relationship between threat appraisals, coping appraisals, and hazard adjustment intentions (H6–H11). We propose additional drivers of adjustment intentions and risk perceptions based on the literature cited previously where qualitative characteristics, salience, demographic characteristics, ideology, oil entanglement, and wastewater awareness shape households' risk perceptions, whereas the response cost variable of usefulness for other purposes (multiuse) and demographic characteristics affect adjustment intentions to earthquake hazards. We use the correlation results to further refine our hypothesized structural model.

Salience is predicted to positively affect the earthquake risk perceptions (H5), while salience itself is affected by the experience of property damage (H12) (Lindell and Hwang 2008; Prater and Lindell 2000). Qualitative characteristics including familiarity, self-knowledge, belief of scientists' knowledge, dreadfulness, and negative emotion also are predicted to shape households' risk perceptions (Keller et al. 2006; Västfjäll et al. 2008; Slovic et al. 2004;

Zwickle and Wilson 2014) (H1–H4). Political ideology, including party affiliation and conservativeness, are also incorporated in our hypothesized model given past research suggests that ideology affects households' risk perceptions, particularly relating to technological hazards (Kahan et al. 2012; Choma et al. 2013; Kahan et al. 2007). Because the earthquakes in Oklahoma are triggered by wastewater disposal, oil entanglement, including mineral rights, oil industry employment, and wastewater awareness, is also used to predict households' risk perceptions (Cole and Withey 1981; Fischhoff et al. 1978; Renn 1998; Starr 1969; Slovic et al. 2004).

In addition, we also explore the effects of demographic characteristics on households' hazard adjustment intentions. As indicated previously, identifying as White (Lindell et al. 2009; Lindell and Perry 2000; Prater and Lindell 2000), being a woman (Kung and Chen 2012; Lindell and Prater 2000), being older (Lindell et al. 2009), being married (Russell et al. 1995; Prater and Lindell 2000), being a homeowner (Lindell and Perry 2000; Russell et al. 1995), having dependents in the home (Lindell and Perry 2000; Russell et al. 1995), having a higher education level (Russell et al. 1995), more years of tenure in an area (Lindell and Hwang 2008; Russell et al. 1995), and having a higher income (Lindell et al. 2009; Lindell and Perry 2000; Russell et al. 1995) are all expected to increase the intentions of hazard adjustments. In this study, we postulated that these demographic variables will have similar effects on households' hazard adjustment intentions for

the techna earthquakes in Oklahoma. While many demographic variables may affect adjustment intentions, we only include those that are significantly correlated to adjustment intentions in the structural equation models. The structural model based on our hypotheses is shown in Fig. 3.

Methods

Data Collection

Using the United States Geological Survey's 2018 one-year seismic hazard forecast map for the central and eastern US (Petersen et al. 2018), three earthquake risk areas were identified for collecting our household sample (high, moderate, and low) (Fig. 2). Within each earthquake risk area, 480 household addresses were selected from each African American, Asian, Hispanic, Native American, and White household group. In total, 7,200 addresses were randomly selected from the study area from a household addressee list provided by Experian Information Solutions Inc. The mailing list was then used to match with the mailing address data provided by a survey company, Oklahoma Direct. Among these randomly selected households, 129 were removed from the original mailing list because they had moved to other areas. The questionnaires were sent by Oklahoma Direct from August to November 2019.

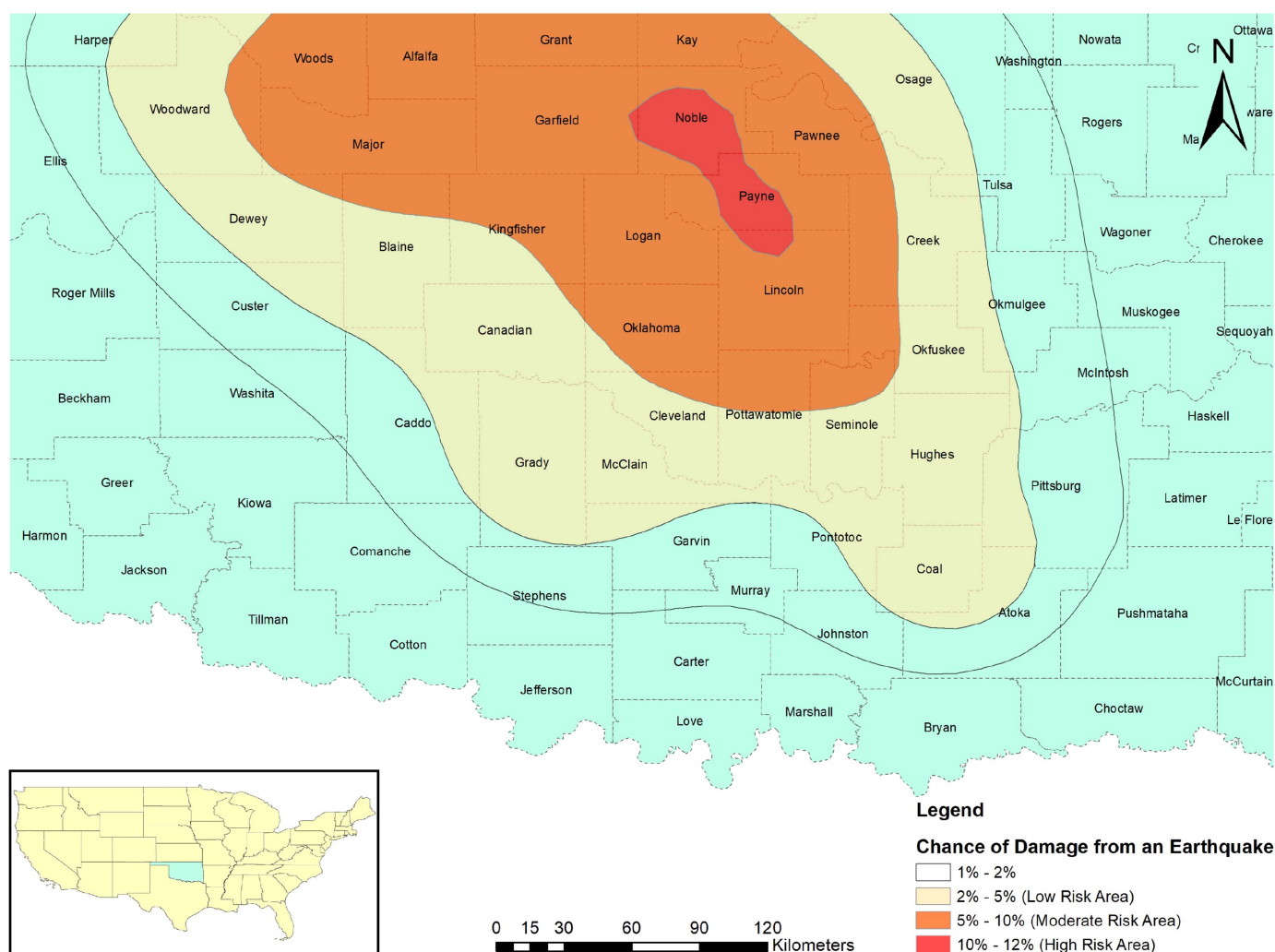


Fig. 2. Oklahoma earthquake risk area map in 2018. (Map by Hao-Che Wu.)

Following Dillman et al.'s (2014) survey procedures, each household was sent as many as three survey packages (Waves 1, 3, and 4) and one reminder postcard (Wave 2), with a pre-incentive (\$5 Amazon gift codes) in one of their packages. In total, 866 complete surveys were returned, 44 households refused to participate, and 2,179 survey packages were undeliverable. The final response rate was 17.86%, which is within the reasonable range according to studies conducted in recent years (Ju and You 2021; Meyer 2016; Steelman et al. 2015; Tracy et al. 2021; Wu et al. 2020; Vásquez et al. 2018).

Measures

Our survey instrument included 49 questions in total, building on previous surveys deployed in California, Washington, and Oklahoma (Lindell and Prater 2000; Murphy et al. 2018; Wu et al. 2020). Adjustment activities include purchasing earthquake

insurance, installing cabinet latches (secure cabinets), learning where and how to shut off utilities, developing emergency plans, having a flashlight, having a fire extinguisher, having a first aid kit, attending first aid training, storing a 3-day supply of food, and storing a 3-day supply of water for each person in the family (Lindell and Whitney 2000). Additional variables capturing qualitative characteristics, political ideology, and oil entanglement were also added to the survey. The measures are summarized in Table 1.

Analyses

To test the hypothesized model, we first conducted correlation analyses using Pearson's r to examine the correlation of each path suggested by the original PMT model. Next, SEM models were built to examine the relationships among variables. SEM has become a popular methodology in analyzing the interplay among the PMT components because of its capability of fully uncovering

Table 1. Measurements of the study

Variable	Measurement	Source
Hazard salience	How often do you think about earthquakes (1 = never to 5 = daily)	Lindell et al. (2016), and Wu et al. (2012, 2013, 2017)
Experience of property damage	In the last few years, has your property had damage from a local earthquake (1 = no damage to 5 = total collapse of home)	
Risk perceptions	Risk perceptions regarding potential damage to their homes or properties, injuries, job disruptions, and daily activity disruptions (1 = not at all likely to 5 = almost certain)	Fischhoff et al. (1978)
Familiarity	Do you consider earthquakes new, novel risks or old, familiar ones (1 = new, 5 = old)	
Perceived self-knowledge	How knowledgeable are you about earthquake hazards (1 = not at all to 5 = very knowledgeable)	Lindell and Whitney (2000)
Perceived scientists' knowledge	To what extent do you think scientists (Oklahoma Geological Survey, US Geological Survey, college professors) know about earthquake hazards (1 = know precisely to 5 = not know)	Lindell and Whitney (2000)
Dreadfulness	Is earthquake risk a risk that people have learned to live with and can think about reasonably calmly, or is it one that people have great dread for (1 = common to 5 = dread)	Fischhoff et al. (1978)
Negative emotions	Please rate how much negative emotion (i.e., anger, fear, disgust) you feel when you think about earthquakes and their impacts (1 = no negative emotion to 5 = high negative emotion)	—
Adjustment intentions	The likelihood that they will adopt each of the 10 hazard adjustment activities (1 = not at all to 5 = very great)	Lindell and Whitney (2000)
Coping appraisals	The perceived attributes (efficacy, cost, special knowledge, cooperation, and effort required) of adjustment activities (1 = not at all to 5 = very great extent)	
Demographic information	Age (years) Women (female = 1, non-female = 0) Race (White, African American, Native American, Asian, Hispanic) Marital status (married = 1, unmarried = 0) Education level (less than high school = 1, high school graduate = 2, some college/vocational school = 3, college graduate = 4, graduate school = 5) Household annual income level (less than \$30,000 = 1, \$30,000–\$54,999 = 2, \$55,000–\$79,999 = 3, \$80,000–\$104,999 = 4, \$105,000–\$129,999 = 5, more than \$130,000 = 6) Homeownership (own = 1, rent = 0) The duration of time living in their current home (years), duration of living in the state of Oklahoma (years) Family composition in terms of age groups [how many members of your family (including yourself) are under 18 years old, 18–65 years old, over 65 years old]	Lindell et al. (2016), and Wu et al. (2012, 2013, 2020)
Oil entanglement (mineral rights)	Have you received payments for the mineral rights underneath your property, either now or in the past (yes = 1, no = 0)	
Oil entanglement (family ties to the oil industry)	Have you or anyone in your household ever been employed by a hydraulic fracturing/oil and gas company, either now or in the past (yes = 1, no = 0)	Ritchie et al. (2021)
Wastewater awareness	How would you rate your awareness on the subject of wastewater injection wells (1 = not at all knowledgeable to 5 = very knowledgeable)	Lindell and Whitney (2000)

the linkages between the PMT components (Babcicky and Seebauer 2019). To test the models, we built 10 basic models that only include original PMT variables. Subsequently, 10 separate SEM models were run for each adjustment activity, with adding variables that can better explain household hazard adjustment behaviors.

All SEM models were built using SPSS AMOS 28 software with raw data using full information maximum likelihood (FIML) estimation. When evaluating the models, we used fit indexes to measure how well a model represents the observed data. This study employed the most frequently used model fit indexes: the comparative fit index (CFI), the normed fit index (NFI), and the root-mean-square error of approximation (RMSEA) (Bentler 1990a, b; Bryne 2010). A model is considered acceptable if the CFI and NFI reach a minimum threshold of 0.90 (Hu and Bentler 1999; Marsh and Hocevar 1985). The common cutoff criterion for the RMSEA is 0.08 (Browne and Cudeck 1992) and the χ^2 /degrees of freedom (df) ratio should not exceed the range of 2–5 (Marsh and Hocevar 1985). Modification indexes were used in our models in identifying statistically significant covariances that would significantly improve the model's fit to the data (Peters et al. 2004).

Results

Descriptive Statistics

Descriptive statistics for the variables can be found in Tables 2 and 3. Our respondents' average age is 55.2 years, 65.1% of respondents identified as White, 50.3% as women, 82.4% are homeowners, and 64.5% are married. Regarding education and income, participating households mostly have at least some college or a vocational school diploma; their income is roughly evenly laid out ranging from less than \$30,000 to more than \$130,000. The mean value of tenure in the Oklahoma area is 38.4 years. Our sample demographics are consistent with census data for the state (United States Census Bureau 2019). The data also show that most respondents identified as Republican (46%), followed by Democrats (33%) and Independents (18%). In addition, the political ideology variable shows that the mean value of the respondents' conservativeness is 3.35, suggesting that while most respondents identified as moderate (middle ground), more lean conservative than liberal in the sample. Some respondents have received payments for the mineral rights underneath their property (14.0%) or have someone in their household who has been employed by an oil and gas company (9%).

Correlation Analyses

As indicated in Table 4, all the risk perception variables are significantly and positively correlated with intentions of purchasing earthquake insurance ($0.21 \leq r \leq 0.26$, $p < 0.01$) and installing secure

Table 3. Descriptive statistics

Variable	Mean	Standard deviation
Hazard salience	2.05	0.88
Experience of property damage	1.47	0.75
Risk perception—city damage	2.36	1.12
Risk perception—home damage	2.15	1.07
Risk perception—family injury	1.79	0.95
Risk perception—job disruption	1.73	0.98
Risk perception—activity disruption	1.85	1.01
Familiarity	2.77	1.39
Self-knowledge	2.89	1.08
Scientists' knowledge	3.56	1.00
Dreadfulness	2.90	1.13
Negative emotion	2.51	1.27
Intention—earthquake insurance (EQIns)	2.69	1.63
Intention—secure cabinets (SecCabinets)	2.09	1.29
Intention—shut off utility (ShutUti)	4.22	1.20
Intention—emergency plan (EMPlan)	3.79	1.36
Intention—flashlight	4.75	0.80
Intention—fire extinguisher (FireExt)	4.25	1.23
Intention—first aid kit (FAKit)	4.49	1.05
Intention—first aid training (FATraining)	3.89	1.36
Intention—3-day food (TDFood)	3.67	1.43
Intention—3-day water (TDWater)	3.84	1.40
Mineral rights	0.14	0.35
Oil industry employment	0.09	0.28
Conservativeness	3.35	1.10
Wastewater awareness	2.77	1.25

cabinets ($0.18 \leq r \leq 0.22$, $p < 0.01$). The correlations among the risk perception variables and intentions of having a fire extinguisher, attending first aid training, storing a 3-day supply of food, and storing a 3-day supply of water are also positive and significant ($p < 0.05$).

Some demographic variables are significantly correlated with risk perceptions and adjustment intentions (Table 4). For risk perceptions, our results show that only age is positively correlated with most risk perception variables, and the correlation is not very strong. Overall, being married, income level, and home ownership show significant correlations with most hazard adjustments ($p < 0.05$), but the correlations between demographic characteristics and adjustment intentions are mostly not significant. Therefore, only being married, income level, and home ownership were selected for SEM analyses, and other demographics variables were dropped.

To identify factors that predict risk perceptions, Table 4 shows that both households' hazard salience and earthquake experience are positively and significantly correlated with all five measures for risk perceptions ($0.18 \leq r \leq 0.35$, $p < 0.01$). The correlation between salience and experience is also positive and significant ($r = 0.23$, $p < 0.05$). The qualitative characteristics (dreadfulness and negative emotion) are also positively correlated with risk perception variables ($0.27 \leq r \leq 0.46$, $p < 0.01$). While the correlation is relatively weak when comparing to other qualitative characteristics, self-knowledge is also significantly correlated with risk perceptions ($0.10 \leq r \leq 0.15$, $p < 0.01$). Familiarity is only correlated with risk perceptions of family member injury, job disruption, and daily activity disruption and the correlations are also weak ($0.08 \leq r \leq 0.11$, $p < 0.05$). On the other hand, households' beliefs in scientists' knowledge are not correlated with risk perceptions at all. Therefore, all qualitative characteristics are retained for further SEM analyses except for households' beliefs in scientists' knowledge.

Table 2. Demographic information compared to 2019 Oklahoma census

Variable	Survey	Census
Age	55.2	36.6
Bachelor's degree or higher	57.4%	25.5%
Median household income	\$55,000–\$80,000	\$73,000
Homeownership	82.4%	57.5%
Female	50.3%	50.4%
Married	64.5%	49.3%
White	65.1%	72.3%
African American	4.7%	7.3%
Native American	11.0%	7.6%
Asian	9.6%	2.2%
Hispanic	8.7%	10.6%

Table 4. Intercorrelations among variables

Variable			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hazard salience Experience Risk perceptions	1	Hazard salience	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2	Property damage	0.23	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3	City damage	0.35	0.29	—	—	—	—	—	—	—	—	—	—	—	—	—
	4	Home damage	0.32	0.36	0.86	—	—	—	—	—	—	—	—	—	—	—	—
	5	Family injury	0.29	0.25	0.71	0.80	—	—	—	—	—	—	—	—	—	—	—
	6	Job disruption	0.23	0.20	0.59	0.65	0.77	—	—	—	—	—	—	—	—	—	—
	7	Activity disruption	0.28	0.18	0.68	0.71	0.78	0.78	—	—	—	—	—	—	—	—	—
Qualitative characteristics	8	Familiarity	−0.03	−0.06	0.04	0.05	0.08	0.09	0.11	—	—	—	—	—	—	—	—
	9	Self-knowledge	0.17	0.06	0.13	0.15	0.12	0.10	0.15	0.35	—	—	—	—	—	—	—
	10	Scientists' knowledge	0.05	0.00	0.03	0.01	0.02	0.01	0.01	0.03	0.12	—	—	—	—	—	—
	11	Dreadfulness	0.15	0.14	0.31	0.32	0.29	0.27	0.30	−0.06	−0.02	0.06	—	—	—	—	—
Adjustment intentions	12	Negative emotion	0.33	0.23	0.44	0.46	0.38	0.33	0.38	−0.06	0.09	0.09	0.43	—	—	—	—
	13	EQIns	0.18	0.10	0.21	0.26	0.21	0.21	0.21	0.01	0.10	0.02	0.14	0.19	—	—	—
	14	SecCabinets	0.07	0.09	0.18	0.22	0.22	0.20	0.19	0.07	0.10	0.04	0.15	0.20	0.23	—	—
	15	ShutUti	0.02	0.04	0.00	0.00	−0.06	−0.05	−0.06	−0.06	0.16	0.06	0.02	−0.03	0.07	0.15	—
	16	EMPlan	0.04	0.03	0.02	0.06	0.04	0.06	0.02	−0.04	0.09	0.09	0.08	0.04	0.15	0.28	0.39
	17	Flashlight	0.01	0.04	−0.04	−0.02	−0.04	−0.04	−0.02	−0.09	0.07	0.10	0.05	−0.04	0.09	0.06	0.37
	18	FireExt	0.10	0.09	0.13	0.15	0.09	0.07	0.11	−0.02	0.13	0.03	0.08	0.06	0.14	0.18	0.34
Age Oil entanglement Sex Race	19	FAKit	0.01	0.03	0.04	0.06	0.00	0.04	0.04	−0.01	0.12	0.09	0.04	0.03	0.07	0.18	0.34
	20	FATraining	0.08	0.08	0.13	0.14	0.10	0.12	0.12	0.00	0.09	0.03	0.13	0.10	0.18	0.20	0.21
	21	TDFood	0.05	0.07	0.10	0.14	0.09	0.09	0.08	0.05	0.19	0.07	0.09	0.08	0.15	0.31	0.26
	22	TDWater	0.07	0.04	0.10	0.13	0.09	0.10	0.08	0.05	0.14	0.09	0.12	0.10	0.14	0.31	0.25
	23	Age	0.16	0.09	0.16	0.16	0.13	−0.01	0.10	0.12	0.12	0.02	−0.07	0.05	0.01	−0.10	−0.03
	24	Mineral rights	0.07	0.07	0.03	0.05	0.01	−0.04	0.00	0.08	0.06	−0.07	0.00	−0.03	−0.06	−0.09	0.01
	25	Oil Employment	0.04	0.09	0.01	0.02	−0.03	−0.03	−0.04	−0.01	−0.01	0.03	−0.05	−0.03	0.03	−0.02	0.00
	26	Female	−0.03	0.07	0.09	0.08	0.07	0.09	0.06	0.00	−0.08	0.08	0.10	0.12	0.01	0.07	−0.10
	27	White	0.09	0.00	−0.01	−0.05	−0.11	−0.12	−0.08	−0.06	0.03	−0.01	−0.11	−0.12	0.00	−0.20	0.02
	28	African American	0.01	0.07	0.06	0.10	0.11	0.11	0.13	0.06	−0.03	0.01	0.07	0.10	0.09	0.17	−0.03
Marital status Education Income level Homeownership Tenure Household size	29	Native American	−0.05	0.05	0.02	0.03	0.05	−0.01	0.03	−0.04	−0.06	0.03	0.11	0.02	−0.04	0.02	−0.02
	30	Asian	−0.06	−0.09	0.01	0.02	0.06	0.11	0.05	0.03	0.07	0.01	0.00	0.07	0.01	0.12	0.01
	31	Other	−0.05	−0.02	−0.06	−0.04	−0.01	0.01	−0.05	0.06	−0.03	−0.04	0.01	0.04	−0.04	0.06	0.00
	32	Hispanic	−0.07	−0.02	−0.06	−0.03	0.00	0.03	−0.03	0.05	−0.05	−0.03	0.03	0.05	−0.02	0.07	−0.01
	33	Married	0.05	0.03	−0.02	−0.02	−0.07	−0.04	−0.04	−0.12	0.01	−0.04	−0.07	0.01	0.06	−0.06	0.19
	34	Education	0.10	−0.01	0.03	0.03	0.00	0.03	0.03	−0.04	0.09	0.06	0.03	0.06	0.07	−0.01	0.09
	35	Income level	0.05	−0.02	−0.04	−0.04	−0.11	−0.07	−0.12	−0.13	0.03	0.02	−0.06	−0.06	0.14	−0.08	0.13
	36	Own	0.06	0.06	0.05	0.09	−0.01	−0.06	−0.05	−0.08	0.06	0.03	−0.08	−0.04	0.12	−0.08	0.17
	37	Tenure	0.10	0.11	0.13	0.14	0.06	−0.03	0.04	−0.01	−0.04	0.01	−0.04	−0.01	−0.03	−0.12	0.00
	38	Under age of 18	−0.11	−0.06	−0.08	−0.07	−0.05	0.00	−0.04	−0.04	−0.07	−0.03	0.01	−0.03	−0.07	0.07	0.06
Politics	39	Between 18 and 65	−0.06	−0.02	−0.07	−0.07	−0.07	0.00	−0.04	−0.13	−0.09	−0.06	0.08	−0.01	−0.02	−0.03	0.08
	40	Over age 65	0.10	0.05	0.11	0.10	0.11	−0.03	0.04	0.08	0.07	0.04	−0.07	0.02	−0.03	−0.04	−0.01
	41	Democratic	0.09	0.06	0.05	0.06	0.07	0.03	0.06	−0.05	−0.05	0.07	0.08	0.17	0.05	0.12	−0.04
	42	Republican	−0.01	−0.07	−0.03	−0.05	−0.09	−0.10	−0.08	0.05	0.03	−0.10	−0.08	−0.16	−0.04	−0.14	0.07
	43	Independent	−0.08	0.00	−0.01	−0.01	0.02	0.08	0.02	0.01	0.01	0.03	0.01	−0.02	0.01	0.04	−0.04
	44	Conservativeness	−0.06	0.02	−0.02	0.00	−0.01	−0.03	0.00	0.09	0.00	−0.07	−0.03	−0.19	0.03	−0.09	0.07
	45	Wastewater awareness	0.18	0.11	0.12	0.10	0.02	0.00	0.03	−0.02	0.37	0.05	−0.02	0.08	0.07	−0.01	0.16

Table 4. (Continued.)

Variable			16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Hazard salience	1	Hazard salience	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Experience	2	Property damage	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Risk perceptions	3	City damage	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4	Home damage	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5	Family injury	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Qualitative characteristics	6	Job disruption	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7	Activity disruption	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	8	Familiarity	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	9	Self-knowledge	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Adjustment intentions	10	Scientists' knowledge	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	11	Dreadfulness	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	12	Negative emotion	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	13	EQIns	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	14	SecCabinets	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	15	ShutUt	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	16	EMPlan	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Age	17	Flashlight	0.35	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	18	FireExt	0.30	0.36	—	—	—	—	—	—	—	—	—	—	—	—	—
	19	FAKit	0.38	0.46	0.43	—	—	—	—	—	—	—	—	—	—	—	—
	20	FATraining	0.29	0.27	0.28	0.43	—	—	—	—	—	—	—	—	—	—	—
	21	TDFood	0.39	0.24	0.35	0.37	0.32	—	—	—	—	—	—	—	—	—	—
	22	TDWater	0.43	0.28	0.32	0.41	0.32	0.71	—	—	—	—	—	—	—	—	—
	23	Age	−0.19	−0.07	0.02	−0.06	−0.09	−0.02	−0.06	—	—	—	—	—	—	—	—
	24	Mineral rights	−0.09	0.00	0.01	0.02	−0.01	0.04	0.01	0.25	—	—	—	—	—	—	—
	25	Oil Employment	0.01	0.05	0.03	0.01	0.02	0.02	0.00	0.00	0.12	—	—	—	—	—	—
	26	Female	0.12	0.02	−0.03	0.02	0.08	−0.02	0.01	−0.12	−0.02	0.04	—	—	—	—	—
Race	27	White	0.00	0.12	0.13	0.08	−0.04	−0.03	−0.06	0.22	0.16	0.06	−0.01	—	—	—	—
	28	African American	0.04	−0.02	0.01	0.00	0.06	0.07	0.06	0.01	−0.09	−0.05	0.04	−0.30	—	—	—
	29	Native American	−0.03	−0.03	0.00	−0.03	0.06	0.01	0.02	0.00	0.02	0.03	0.04	−0.48	−0.08	—	—
	30	Asian	−0.03	−0.07	−0.09	−0.07	−0.07	0.01	0.02	−0.23	−0.10	−0.09	−0.08	−0.44	−0.07	−0.11	—
	31	Other	0.03	−0.07	−0.12	−0.03	0.03	−0.02	0.01	−0.15	−0.12	0.00	0.01	−0.44	−0.07	−0.11	−0.11
	32	Hispanic	0.03	−0.09	−0.13	−0.05	0.02	−0.01	0.01	−0.16	−0.11	−0.04	0.02	−0.42	−0.07	−0.11	−0.10
	33	Married	0.09	0.09	0.12	0.11	0.00	−0.03	−0.03	−0.03	0.07	0.03	−0.20	0.06	−0.09	−0.12	0.11
Education	34	Education	−0.02	0.04	0.04	0.05	0.08	−0.02	0.01	−0.10	−0.04	−0.01	−0.06	0.02	−0.07	−0.13	0.22
Income level	35	Income level	0.06	0.11	0.09	0.09	−0.03	−0.03	0.00	−0.04	0.02	0.07	−0.14	0.15	−0.13	−0.15	0.09
Homeownership	36	Own	0.03	0.12	0.10	0.09	−0.01	0.04	0.03	0.29	0.14	0.03	−0.10	0.15	−0.08	−0.08	−0.03
Tenure	37	Tenure	−0.15	0.00	0.01	−0.06	−0.06	−0.04	−0.08	0.61	0.32	0.02	−0.02	0.26	−0.03	0.10	−0.31
Household size	38	Under age of 18	0.14	−0.01	0.01	0.07	0.04	0.07	0.06	−0.34	−0.11	0.03	0.09	−0.16	−0.02	0.01	0.07
	39	Between 18 and 65	0.15	0.00	−0.02	−0.01	0.04	0.05	0.05	−0.37	−0.13	0.04	−0.07	−0.14	0.02	0.07	0.07
	40	Over age 65	−0.16	−0.02	0.03	0.05	−0.05	−0.03	−0.05	0.63	0.25	0.01	−0.07	0.15	−0.02	−0.04	−0.11
Politics	41	Democratic	−0.03	0.02	−0.02	0.03	0.02	−0.02	−0.03	0.08	−0.01	−0.04	0.07	−0.12	0.21	0.07	−0.04
	42	Republican	−0.01	0.06	0.04	0.00	−0.01	0.01	0.00	0.10	0.11	0.07	−0.07	0.26	−0.13	−0.04	−0.15
	43	Independent	0.03	−0.11	−0.03	−0.02	−0.02	0.01	0.05	−0.19	−0.11	−0.05	−0.03	−0.16	−0.0	−0.05	0.21
Wastewater	44	Conservativeness	0.00	−0.01	0.04	−0.05	−0.05	0.03	0.00	0.16	0.09	0.04	−0.12	0.10	0.01	0.02	−0.14
	45	Wastewater awareness	0.04	0.08	0.12	0.07	0.10	0.13	0.06	0.21	0.19	0.18	−0.15	0.16	−0.04	−0.05	−0.08

Table 4. (Continued.)

Variable			31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Hazard salience	1	Hazard salience	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Experience	2	Property damage	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Risk perceptions	3	City damage	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4	Home damage	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5	Family injury	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	6	Job disruption	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7	Activity disruption	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	8	Familiarity	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	9	Self-knowledge	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Qualitative characteristics	10	Scientists' knowledge	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	11	Dreadfulness	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	12	Negative emotion	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Adjustment intentions	13	EQIns	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	14	SecCabinets	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	15	ShutUti	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	16	EMPlan	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	17	Flashlight	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	18	FireExt	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	19	FAKit	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	20	FATraining	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	21	TDFood	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	22	TDWater	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Age	23	Age	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oil entanglement	24	Mineral rights	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	25	Oil Employment	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sex	26	Female	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Race	27	White	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	28	African American	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	29	Native American	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	30	Asian	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	31	Other	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	32	Hispanic	0.94	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	33	Married	0.00	−0.01	—	—	—	—	—	—	—	—	—	—	—	—	—
Education	34	Education	−0.07	−0.09	0.17	—	—	—	—	—	—	—	—	—	—	—	—
Income level	35	Income level	−0.09	−0.09	0.46	0.37	—	—	—	—	—	—	—	—	—	—	—
Homeownership	36	Own	−0.07	−0.07	0.28	0.05	0.36	—	—	—	—	—	—	—	—	—	—
Tenure	37	Tenure	−0.19	−0.19	−0.07	−0.21	−0.06	0.27	—	—	—	—	—	—	—	—	—
Household size	38	Under age of 18	0.19	0.20	0.10	0.05	0.03	−0.03	−0.23	—	—	—	—	—	—	—	—
	39	Between 18 and 65	0.07	0.08	0.14	0.02	0.13	0.01	−0.21	0.37	—	—	—	—	—	—	—
	40	Over age 65	−0.06	−0.08	0.07	−0.02	−0.05	0.21	0.40	−0.21	−0.49	—	—	—	—	—	—
Politics	41	Democratic	0.01	0.01	−0.08	0.05	−0.11	−0.06	0.06	−0.05	−0.10	0.10	—	—	—	—	—
	42	Republican	−0.12	−0.12	0.07	−0.10	0.14	0.17	0.14	−0.07	0.01	0.05	−0.66	—	—	—	—
	43	Independent	0.15	0.13	0.00	0.08	−0.03	−0.12	−0.24	0.12	0.09	−0.15	−0.33	−0.43	—	—	—
	44	Conservativeness	−0.05	−0.07	0.10	−0.09	0.11	0.16	0.15	−0.04	0.00	0.06	−0.50	0.60	−0.16	—	—
	45	Wastewater awareness	−0.10	−0.14	0.14	0.15	0.20	0.20	0.20	−0.10	−0.02	0.11	0.00	0.07	−0.08	0.06	—

Note: Significant correlation coefficients are in bold font. Coefficients are significant at the 0.05 level when its absolute value is between 0.07 and 0.09. Coefficients are significant at the 0.01 level when its absolute value is above 0.09. EQIns = intention—earthquake insurance; SecCabinets = intention—secure cabinets; ShutUti = intention—shut off utility; EMPlan = intention—emergency plan; FireExt = intention—fire extinguishier; FAKit = intention—first aid kit; FATraining = intention—first aid training; TDFood = intention—3-day food; and TDWater = intention—3-day water.

Table 5. Correlations among coping appraisal variables and adjustment intentions

Adjustment intentions	Response efficacy (RE)		Self-efficacy (SE)			Response cost (RC)	
	Protect person effectively	Protect property effectively	Require special knowledge	Require efforts	Require cooperation	Multiuse	Cost money
EQIns	0.25**	0.26**	0.07	0.04	0.11**	0.22**	−0.10**
SecCabinets	0.45**	0.41**	0.28**	0.19**	0.27**	0.47**	0.21**
ShutUti	0.25**	0.30**	−0.03	−0.07*	−0.11**	0.33**	−0.13**
EMPlan	0.41**	0.23**	0.08*	0.03	0.17**	0.39**	−0.02
Flashlight	0.12**	0.01	−0.13**	−0.08*	−0.11**	0.31**	−0.05
FireExt	0.24**	0.25**	0.02	−0.03	0.03	0.26**	−0.03
FAKit	0.24**	0.02	0.07	0.01	0.00	0.30**	0.02
FATraining	0.29**	0.07*	0.15**	0.04	0.10**	0.28**	0.01
TDFood	0.41**	0.17**	0.10**	−0.05	0.05	0.43**	0.01
TDWater	0.41**	0.18**	0.07*	0.01	0.07	0.41**	0.02

Note: *Correlation is significant at the 0.05 level (two-tailed); and **correlation is significant at the 0.01 level (two-tailed). EQIns = intention—earthquake insurance; SecCabinets = intention—secure cabinets; ShutUti = intention—shut off utility; EMPlan = intention—emergency plan; FireExt = intention—fire extinguisher; FAKit = intention—first aid kit; FATraining = intention—first aid training; TDFood = intention—3-day food; and TDWater = intention—3-day water.

Party affiliation and conservativeness are mostly not significantly correlated with risk perception variables; therefore, they are not included in SEM analyses. Mineral rights and oil industry employment are not significantly correlated with risk perception variables; thus, they are also not included in SEM analyses. The variable of wastewater awareness is significantly correlated with mineral rights ($r = 0.19$, $p < 0.01$) and oil industry employment ($r = 0.18$, $p < 0.01$).

Table 5 shows the correlations between earthquake adjustment intentions and coping appraisal variables. In general, coping appraisal variables are significantly correlated with adjustment intentions. The response efficacy variable of protecting persons effectively is strongly and significantly correlated with all the adjustment intentions ($p < 0.01$). The other response efficacy variable, protecting property effectively, is correlated with all the adjustment intentions ($p < 0.01$) except having a flashlight and a first aid kit. Table 5 also shows that the self-efficacy variables are only correlated with some adjustment intentions. On the other hand, the response cost variable, multiuse, is strongly correlated with all the adjustment intentions and cost money only correlates with three adjustment intentions. Noticeably, among all the adjustment intentions, the correlations between multiuse and adjustment intentions are especially strong, particularly intentions of secure cabinets ($r = 0.47$, $p < 0.01$) and storing 3-day supply of food ($r = 0.43$, $p < 0.01$) and water ($r = 0.41$, $p < 0.01$). Given the strong correlation between multiuse and adjustment intentions, we include this in the structural models.

SEM Analyses

Results for the intercorrelations of adjustment intentions are given in Tables 4 and 5. Overall, low to moderate correlations were found among adjustment intentions. This indicates that the survey respondents believe these adjustments are implemented independently from each other (Babcicky and Seebauer 2019). Because the 10 adjustments are conceptually distinct and feature good discriminant validity, we did not use the aggregation method that aggregates different variables into compound measures (Grothmann and Reusswig 2006). Instead, we estimated separate SEM models for all the adjustment intentions.

We first tested the relationships suggested by the original PMT model using the 10 earthquake hazard adjustment measures. Table 6 gives the results of the 10 PMT models. These models set base

values regarding model fit indexes and explained variances for our next analyses. These models have the same structure that only includes original PMT components (Fig. 1). In Table 6, the upper five rows represent the paths as hypothesized by the original PMT. The columns are the earthquake hazard adjustment intentions. Each row contains one path between an appraisal variable and the earthquake adjustment items. For example, the row “Risk perception to adjustment intention” shows the path coefficient for the effect of risk perceptions on the intention of adopting the corresponding adjustments. Self-efficacy is created as a latent variable in AMOS that is inferred from the three self-efficacy variables: requiring special knowledge, requiring efforts, and requiring cooperation. The model-specific fit indexes are provided at the bottom of the table. These fit indexes show that the qualities of the original PMT models are all acceptable. According to the squared multiple correlations (SMC), the original PMT models explain 3.9% (the model of having a flashlight) to 23.4% (the model of securing cabinets) of the variance in adjustment intentions.

Findings suggest that intentions of purchasing earthquake insurance and securing cabinets are highly predicted by risk perceptions in the original PMT. This is especially true for the earthquake insurance model. Risk perceptions are significant for the intentions of having a fire extinguisher, attending first aid training, storing a 3-day supply of food, and storing a 3-day supply of water, while the effect sizes are small.

In terms of coping appraisals, we found response efficacy of protecting persons positively predicts all the adjustment intentions. Compared to other appraisals, protecting persons effectively plays a dominating role in predicting households’ intentions to install secure cabinets, develop an emergency plan, store a 3-day supply of food, and store a 3-day supply of water. The response efficacy variable of protecting property strongly predicts the intentions of learning how to shut off utilities and having a fire extinguisher. Self-efficacy only significantly and negatively affects households’ intentions of learning how to shut off utilities and having a flashlight. As for the response cost, it only significantly affects households’ intentions of purchasing earthquake insurance.

Next, we discuss our structural models that draw on the original PMT model by including qualitative characteristics of the hazard, two demographic variables, and the coping appraisal of multiuse. These variables were identified in the literature and found significant in our correlation analyses. The results of the new SEM models are reported in Table 7.

Table 6. SEM results for the original PMT models ($n = 866$)

PMT paths	Earthquake hazard adjustment intentions									
	EQIns	SecCabinets	ShutUti	EMPlan	Flashlight	FireExt	FAKit	FATraining	TDFood	TDWater
TA Risk perception to adjustment intention (H6)	0.22**	0.15**	−0.03	0.02	0.14**	0.14**	0.02	0.10**	0.08*	.07*
CA RE (protect person) to adjustment intention (H7)	0.13**	0.30**	0.11*	0.38**	0.11*	0.11*	0.28**	0.29**	0.42**	.40**
RE (protect property) to adjustment intention (H8)	0.20**	0.14**	0.24**	0.13**	0.17**	0.17**	−0.06	−0.00	0.11**	0.12**
SE to adjustment intention (H9)	0.01	0.07	−0.14**	−0.07	−0.06	−0.06	−0.05	0.02	−0.11	−0.08
RC (cost money) to adjustment intention (H10)	−0.17**	0.02	−0.05	−0.05	−0.08	−0.08	0.01	−0.08	−0.06	−0.04
χ^2 (df)	193.2 (44)	1,730.7 (44)	2,070.4 (46)	1,680.8 (44)	1,480.8 (44)	1,790.1 (43)	1,350.9 (43)	1,220.9 (42)	1,700.5 (42)	1,290.4 (41)
χ^2 /df	4.390	30.948	40.508	30.836	30.383	40.165	30.159	20.927	40.058	30.155
CFI	0.975	0.981	0.975	0.979	0.987	0.980	0.985	0.986	0.980	0.987
NFI	0.969	0.974	0.969	0.971	0.982	0.974	0.978	0.978	0.973	0.981
RMSEA	0.063	0.058	0.064	0.057	0.052	0.060	0.050	0.047	0.059	0.050
90% confidence intervals for RMSEA	0.054–0.072	0.049–0.068	0.055–0.073	0.048–0.067	0.043–0.062	0.051–0.070	0.041–0.060	0.038–0.057	0.050–0.069	0.040–0.060
SMC for the adjustment intention	0.142	0.234	0.122	0.185	0.039	0.091	0.066	0.092	0.189	0.180

Note: * $p < 0.05$; ** $p < 0.01$; and significance levels of standardized path coefficients and correlations. EQIns = intention—earthquake insurance; SecCabinets = intention—secure cabinets; ShutUti = intention—shut off utility; EMPlan = intention—emergency plan; FireExt = intention—fire extinguisher; FAKit = intention—first aid kit; FATraining = intention—first aid training; TDFood = intention—3-day food; TDWater = intention—3-day water; RE = response efficacy; SE = self-efficacy; and RC = response cost.

The new SEM models include perceptions of four qualitative characteristics of the hazard, including familiarity, self-knowledge, dreadfulness, and negative emotion, which predict risk perceptions. These relationships were identified in the literature and detailed in Table 4. Earthquake property damage experience significantly correlates with both salience and risk perceptions in the correlation analyses, but the significant relationship only remains between experience and salience in the SEM analysis. Additionally, our new structural models incorporated two demographic variables: home-ownership and being married. This is based on its significant correlations with earthquake adjustment intentions.

The fit indexes show that the qualities of the new earthquake hazard adjustment intention models all range from good to excellent. According to the SMC, the new SEM models explain 12.7%–29.1% of the variance in the adjustment intentions. Our structural models with incorporating additional factors increase the absolute explanatory power by 3.3% (first aid training) to 9.9% (shut off utility) compared to the original PMT models. Comparing to the original PMT models, the explained variances of new structural models are all improved. The relative increase of the explained variance is extremely high for having a flashlight (from 3.9% in the original PMT model to 13.4% after adding additional variables) and having a first aid kit (from 6.6% in the original PMT model to 13.2% after adding additional variables).

Similar to the basic PMT models, the intention of purchasing earthquake insurance is highly predicted by risk perceptions. Results show risk perception has a positive and stronger effect than all other coping appraisals and demographic variables on purchasing earthquake insurance. With incorporating additional factors, the new structural models also show that negative emotion has a strong effect on risk perceptions when compared to other qualitative characteristics across all the models. Dreadfulness and familiarity are also significant in shaping risk perceptions, while self-knowledge only shows significant effects on the new fire extinguisher model. Hazard salience is significantly and positively affected by the experience of property damage. Finally, hazard salience shapes risk perceptions across all the adjustments.

As for the coping appraisals, the response efficacy variable of protecting persons effectively has a strong effect in predicting households' intentions of securing cabinets, developing an emergency plan, attending first aid training, storing a 3-day supply of food, and storing a 3-day supply of water. On the other hand, the intention of purchasing earthquake insurance is better predicted by protecting property effectively when compared to protecting persons effectively. Self-efficacy, measured by how much special knowledge, effort, and cooperation are required, has a significant negative effect on households' intentions of learning to shut off utilities, developing an emergency plan, having a flashlight, and storing a 3-day supply of food. These findings suggest households are less likely to adopt these adjustment activities if it requires higher levels of knowledge, effort, and cooperation. In terms of response cost, multiuse appraisal has a dominating role in predicting all the adjustment intentions in our new structural models except for the earthquake insurance model. Costing money only has a significant and negative impact on households' intentions of purchasing earthquake insurance, having a fire extinguisher, attending the first aid training, and storing a 3-day supply of food.

In addition, homeowners and married individuals both have a higher intention of purchasing earthquake insurance, learning how to shut off utilities, purchasing a fire extinguisher, and having a first aid kit at home. Items unique to homeowners are that they are more likely to have a flashlight and store a 3-day supply of food and water. Married individuals are likely to develop an emergency plan. Interestingly, both homeowners and married individuals show low

Table 7. SEM results for the new structural models ($n = 866$)

PMT paths		Earthquake hazard adjustment intentions									
		EQIns	SecCabinets	ShutUti	EMPlan	Flashlight	FireExt	FAKit	FATraining	TDFood	TDWater
QC	Familiarity to risk perception (H1)	0.12**	0.12**	0.12**	0.11**	0.10**	0.10**	0.12**	0.12**	0.11**	.12**
	Self-knowledge to risk perception (H2)	0.05	0.05	0.05	0.06	0.07*	0.07*	0.05	0.05	0.05	0.05
	Dreadfulness to risk perception (H3)	0.18**	0.18**	0.18**	0.18**	0.18**	0.18**	0.16**	0.18**	0.18**	0.18**
	Negative emotion to risk perception (H4)	0.32**	0.32**	0.32**	0.33**	0.31**	0.31**	0.34**	0.32**	0.33**	0.32**
	Experience of property damage to hazard salience (H12)	0.22**	0.22**	0.22**	0.22**	0.22**	0.22**	0.22**	0.22**	0.22**	0.22**
TA	Hazard salience to risk perception (H5)	0.20**	0.19**	0.20**	0.20**	0.20**	0.21**	0.21**	0.17**	0.20**	0.20**
	Risk perception to adjustment intention (H6)	0.21**	0.14**	−0.02	0.02	0.13**	0.13**	0.02	0.11**	0.07*	.06*
	RE (protect person) to adjustment intention (H7)	0.09*	0.23**	0.05	0.27**	0.08	0.08	0.16**	0.21**	0.26**	.26**
	RE (protect property) to adjustment intention (H8)	0.20**	0.07	0.18**	0.12**	0.11*	0.11*	−0.01	0.03	0.12**	0.12**
	SE to adjustment intention (H9)	−0.01	0.02	−0.20**	−0.15**	−0.05	−0.05	−0.06	−0.04	−0.11*	−0.08
CA	RC (multiuse) to adjustment intention (H11)	0.13**	0.30**	0.27**	0.28**	0.19**	0.19**	0.25**	0.21**	0.33**	0.28**
	RC (cost money) to adjustment intention (H10)	−0.17**	0.01	−0.00	−0.01	−0.10*	−0.10*	−0.01	−0.08*	−0.10*	−0.06
	Homeownership to adjustment intention	0.14**	0.01	0.13**	0.05	0.08*	0.08*	0.08*	0.01	0.08**	0.06*
	Being married to adjustment intention	0.06*	0.00	0.15**	0.09**	0.09**	0.09**	0.09**	−0.01	−0.03	−0.04
χ^2 (df)		607.1 (169)	5,620.4 (168)	6,280.7 (172)	5,120.1 (167)	5,190.2 (171)	4,390.4 (162)	4,440.7 (166)	5,550.5 (170)	5,410.0 (166)	4,700.5 (165)
χ^2 /df		3.592	30.347	30.655	30.067	30.037	20.713	20.679	30.268	30.259	20.852
CFI		0.942	0.952	0.943	0.953	0.962	0.966	0.963	0.945	0.951	0.963
NFI		0.921	0.933	0.924	0.932	0.945	0.948	0.943	0.923	0.932	0.945
RMSEA		0.055	0.052	0.055	0.049	0.049	0.044	0.044	0.051	0.051	0.046
90% Confidence intervals for RMSEA		0.050–0.059	0.047–0.057	0.051–0.060	0.044–0.054	0.044–0.053	0.040–0.050	0.039–0.049	0.046–0.056	0.046–0.056	0.041–0.051
SMC for the adjustment intention		0.193	0.291	0.221	0.258	0.134	0.127	0.132	0.125	0.275	0.242

Note: * $p < 0.05$; ** $p < 0.01$; and significance level of standardized path coefficients and correlations. EQIns = intention—earthquake insurance; SecCabinets = intention—secure cabinets; ShutUti = intention—shut off utility; EMPlan = intention—emergency plan; FireExt = intention—fire extinguisher; FAKit = intention—first aid kit; FATraining = intention—first aid training; TDFood = intention—3-day food; TDWater = intention—3-day water; QC = qualitative characteristics; DC = demographics; RE = response efficacy; SE = self-efficacy; and RC = response cost.

interest in installing cabinet latches or attending the first aid training. Overall, the demographic variables have a small effect size compared to other predictors.

Discussion

The results of the correlation analyses are somewhat aligned with the literature. Similar to Prater and Lindell (2000), Oklahoma households' earthquake hazard salience is correlated with five different earthquake hazard adjustment intentions including purchasing earthquake insurance, securing cabinets, having a fire extinguisher, having first aid training, preparing 3 days of food, and preparing 3 days of water. Noticeably, other than preparing 3 days of food and water, the other four hazard adjustments are considered intentions for hazard mitigation activities that provide passive protection during an earthquake.

Adding qualitative characteristics, salience, experience as risk perception drivers, and multiuse and demographic variables as adjustment intention drivers give us a holistic view of the interactions among hazard salience, risk perceptions, and household adjustment intentions. Previous findings have suggested that both hazard salience and risk perceptions affect hazard adjustments (e.g., Perry and Lindell 1990; Russell et al. 1995; Huntsman et al. 2021; Wu et al. 2020). Our path analysis takes these findings a step further by clarifying these relationships. As indicated in Table 5, higher hazard salience always results in higher risk perceptions; however, risk perceptions do not always have a significant positive impact on hazard adjustment intentions. In fact, in most of the models, risk perceptions only affect hazard adjustment intentions when our correlation analyses show that hazard salience is positively correlated with that specific hazard adjustment intention. This finding suggests that hazard salience does not have a direct impact on hazard adjustment intentions; however, through risk perceptions, it is still an important variable that explains households' hazard adjustment intentions.

This study examines the correlations among five different risk perceptions measures and earthquake hazard adjustment intentions. This approach is different from some studies that use an aggregated risk perception index to examine the relationships (Huntsman et al. 2021; Lindell et al. 2009; Lindell and Perry 2000; Lindell and Whitney 2000). In addition, similar to Botzen et al. (2019), our findings also suggest that risk perception variables are mostly correlated with mitigation activities, especially the intentions of buying earthquake insurance and securing cabinets. Next, while the literature shows that risk perception variables are positively correlated with household size (Lindell et al. 2016), our further analyses showed that risk perceptions (damage to city, family injury, and home damage) are positively correlated with the numbers of elders (over 65 years old) in the household, and negatively correlated with the numbers of adults (18–65 years old) and children (under 18 years old) in the household.

In terms of experience, this study captured the level of earthquake property damage experience and examined its correlations with other variables. As suggested in the literature (Palm 1998; Paton et al. 2000; Asgary and Willis 1997; Kung and Chen 2012; Gotham et al. 2017; Dooley et al. 1992; Jackson 1981; van der Linden 2015; Prater and Lindell 2000), experience is strongly correlated with risk perception variables. However, our findings suggest that experience affects households' risk perceptions through hazard salience. While it is still aligned with the literature (Jackson 1981; Lindell and Hwang 2008; Perry and Lindell 2008; Prater and Lindell 2000), the correlations between experience and hazard adjustment intentions are significant but weak. As for the qualitative

characteristics, similar to Oakley et al. (2020), people who feel stronger dread and negative emotions are more likely to have stronger intentions of adopting earthquake hazard adjustment activities.

Findings regarding demographic variables have some noticeable differences from the literature. While studies have found that women are more likely to adjust to hazards (Kung and Chen 2012; Lindell and Prater 2000), our study provides more nuance to that finding. Our results suggest that women are more likely to intend to develop emergency plans and less likely to intend to learn how to shut off utilities. We found no relation between gender and intentions of adopting other types of adjustments. Similar to previous studies (Lindell et al. 2009; Lindell and Perry 2000; Prater and Lindell 2000), participants who identify as White have stronger intentions of adopting a number of hazard adjustment activities, including having a flashlight, having a fire extinguisher, and having a first aid kit at home. In contrast, participants who identify as White have a lower intention of installing secure cabinets. Other than the correlations between White race and hazard adjustment activities, other correlations between race and hazard adjustment activities are considered low ($r < 0.20$) (Wright 2002). Future research is needed to explore this in more detail.

Some literature suggests homeownership (Lindell and Perry 2000; Russell et al. 1995), higher education level (Russell et al. 1995), years of tenure in an area (Lindell and Hwang 2008; Russell et al. 1995), and higher income (Lindell et al. 2009; Lindell and Perry 2000; Russell et al. 1995) are all positively correlated with hazard adjustments, but our results do not mirror these findings. Most of the correlations regarding these demographic variables are either weak or have opposite effects. This is the same with the variables that measure participants' political views. For example, unlike previous studies (Jenkins-Smith et al. 2017; Ripberger et al. 2017), political ideology and party affiliations generally do not correlate with hazard adjustment intentions in our study. Another example would be household composition, which only matters in relation to household emergency (EM) plan intention. We found that households with minors in the home and larger households are more likely to intend to make plans, but homes with individuals 65 years and older are less likely to intend to make plans. As suggested by the literature, demographics are not good predictors of risk perceptions or hazard adjustment intentions, so that might explain these ambiguous findings (Lindell and Whitney 2000).

Finally, Table 3 gives the correlations among hazard adjustment intentions and coping appraisal variables. Some self-efficacy measures are positively correlated with hazard adjustment intentions. That means higher levels of requirements on knowledge, efforts, and cooperation are associated with higher levels of adjustment intentions. While these correlation results do not align with the PMT literature, the results of the SEM models show that the relationship between self-efficacy and hazard adjustment intention aligns more clearly with the literature after we control for other variables (Tables 4 and 5).

Regarding the findings of the SEMs, the basic PMT model suggests CA variables are better predictors than the TA variable. Different CA variables also predict specific hazard adjustment intentions differently. For example, protecting persons, one of the response efficacy variables, is good at predicting hazard adjustment intentions such as securing cabinets, developing emergency plans, first aid kits, first aid training, having a 3-day supply of food, and having a 3-day supply of water. Another response efficacy variable, protect property effectively, also has stronger predictive power on hazard adjustment intentions that are related to property protection such as earthquake insurance, learning how to shut off a utility, and having

fire extinguishers. As for the TA variable, risk perceptions are generally a weaker predictor in most of the models when compared to CA variables. This is quite similar to the literature (Babcicky and Seebauer 2019; Bubeck et al. 2012; Greer et al. 2020; Lindell and Prater 2002), with the exception of the earthquake insurance model. In this model, TA is a stronger predictor of intentions to purchase earthquake insurance when compared to other CA variables. While some literature suggests that when a hazard adjustment activity is more complex or difficult to do, threat appraisal is a dominant factor that shapes whether or not it is worth adopting (Huntsman et al. 2021), this finding deserves further inquiry, particularly given issues related to uptake of earthquake insurance across the state.

In terms of the new structural models, we included additional variables based on the existing literature and correlation analyses. Overall, the model fit indexes showed that adding additional variables provided more meaningful findings when compared to the basic PMT models. As Rogers (1975) indicated, there is a need to include other meaningful variables in the basic PMT model because our intention here is to explore hazard adjustment behaviors of a technia hazard, Oklahoma earthquakes. When examining the results of our models after incorporating additional factors, we found that TA, risk perceptions, can still predict hazard adjustment intentions in some models. TA is also strongly affected, however, by dreadfulness, negative emotions, and hazard salience, often not included in other PMT studies. While Oakley et al. (2020) suggest negative emotion can predict hazard adjustment, our findings suggest these relationships are more complicated than a direct relationship. In addition, the paths in the new structural models also showed that experience of property damage predicts hazard salience, which in turn positively predicts risk perceptions and then hazard adjustment intentions.

When looking at the ways in which CA variables predict hazard adjustment intentions, the results show that the newly included CA variable, multiuse (Lindell and Prater 2002), is the most important predictor of adjustment intention when compared to all other

variables that predict hazard adjustment intentions. This is true for all the models except that of purchasing earthquake insurance. Like the basic PMT model, the best predictor of this model is risk perceptions. Noticeably, our model is better at predicting the intention of secure cabinets. The secure cabinets model has the most explained variances in both the basic PMT (23.4%) and our new structural models (29.1%). The next-best model in both basic PMT and our new structural model is 3 days of food.

Two additional demographic variables, homeownership and marital status, were also included in the new structural models. Table 5 shows that homeownership and being married can predict some hazard adjustment intentions but not all, while no demographic variables have shown strong correlation with risk perceptions in the correlation analyses or consistent and significant effects on households' risk perceptions in SEM models. The effect of demographic variables is generally small, but these two variables did increase the overall explained variances. In comparison to coping appraisals, the effect size of homeownership and being married only gets close to that of coping appraisals in predicting households' intentions of learning to shut off utilities. Interestingly, income level and homeownership show similar patterns in their correlations with adjustment intentions but dropped income level in SEM models because it lost significance while homeownership was included in the model.

Conclusion

Our findings have important implications for future research and future policymaking. This study provides insights regarding how households in Oklahoma are intending to adjust to their newfound seismic, technia risk, and what factors shape their adjustment intentions. Our findings stretch beyond the original PMT to consider how additional factors shape threat appraisals, coping appraisals, and adjustment intentions (Fig. 3). These new variables beyond the original PMT show how different types of qualitative characteristics,

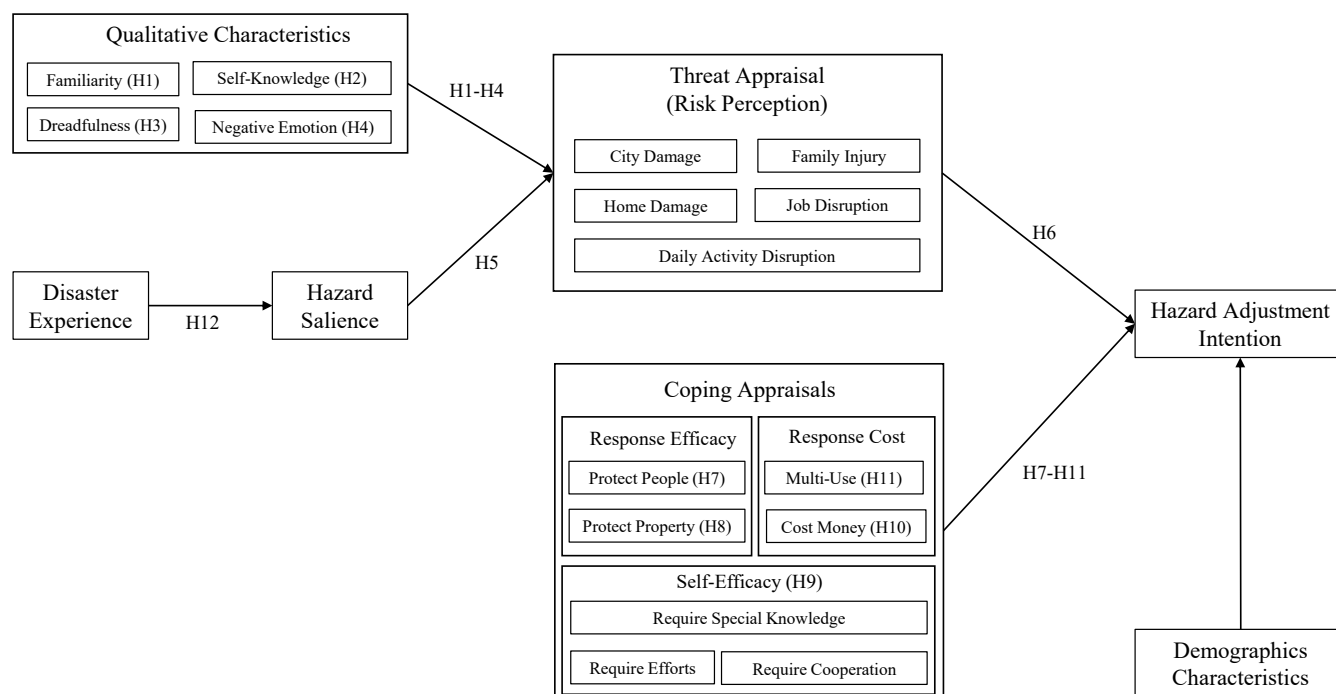


Fig. 3. Hypothesized structural model.

disaster experience, and hazard salience affect threat appraisal. We also included usefulness for other purposes in coping appraisals, which was found to be a critical variable in explaining adjustment intentions.

When considering the practical implications of this study, results of this research can help guide future earthquake risk management in Oklahoma in identifying and taking appropriate actions that will stimulate precautionary behavior of private actors. People often rely on the government to control and mitigate technogenic hazards (Kasperson and Pijawka 1985). The relaxed political response to technogenic earthquakes in Oklahoma, however, contrasts with policies in other states that experienced similar technogenic hazards (Campbell et al. 2020). Therefore, local governments in Oklahoma should work to raise awareness of earthquake risk and use our research findings to emphasize adjustment measures that have low adoption intentions but high potential to reduce risk and are relatively cheap and easy to install (e.g., installing secure cabinets), eliminate financial barriers like providing subsidies or government loans (Babcicky and Seebauer 2019) for costly adjustment measures (e.g., purchasing earthquake insurance), and protect individuals and property from future earthquake hazards. Based on our findings, emergency managers should also be communicating the multiuse function of many adjustment activities to increase adjustment intentions. Given that previous studies have found that individuals perceive information provided by scientists and the federal government as more credible than state and local governments (Wu et al. 2020; Tracy and Javernick-Will 2020), emergency managers at the federal agency level should also educate the public in terms of the earthquake risk and adjustment measures.

This study has several limitations to consider when considering study findings. First, we did not have a direct measure for the self-knowledge variable. Instead, we measured households' perception of their knowledge level on earthquakes, which could deviate from their actual level of knowledge and not accurately represent the relative knowledge level on earthquakes among Oklahomans. Second, our respondents have a relatively older average age, in comparison to other studies in this area (Derakhshan et al. 2020; Greer et al. 2018; Ng'ombe and Boyer 2019; Wu et al. 2020), which may not sufficiently represent the whole targeted population. Third, most of our respondents identified as White, which could lead our data to have less representativeness of minority groups. Fourth, some factors that we dropped, such as ideology, income level, the oil entanglement factors, and wastewater awareness, which show a significant correlation in some cases but not in the SEM, can be evaluated in future studies for inclusion where appropriate. Last, we acknowledge that technogenic hazards may be unique in regard to the emotional response they produce, thereby limiting the generalizability of adding the identified additional factors to other types of hazards in different areas. Future work should examine the effectiveness of adding these additional variables to the original PMT in different contexts. In conclusion, future work should attempt to overcome the limitations of this research by using actual self-knowledge levels to predict risk perceptions, oversample younger age groups and minorities, and contrast the effect of these additional variables for technogenic and natural hazards.

Data Availability Statement

All data, models, or code that support the findings of this study are available from the corresponding author upon reasonable request.

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