U.S. Earthquake Policy Activity and Coverage

Scott B. Miles,[a) M.EERI, and **Brian Gouran**[b)

The goal of this study was to first develop a systematic data collection strategy to create and maintain a database of policies in the United States that promote seismic mitigation. With this database, indices were developed to facilitate understanding of the relationship between policy activity, policy coverage, and seismic risk, as well as to perform cross-state comparison. The most basic index is a count of the number of policies each state has adopted. An index was developed that directly accounts for the seismic risk of each state. A Guttman scale was developed to characterize states' policy coverage, as well as the level of intensity represented by states' policy activity. The relationship between policy coverage and seismic risk was also explored. For the most part, this study found a moderate relationship between seismic risk and policy activity, as well as a moderately strong relationship between risk and policy coverage. [DOI: 10.1193/060314EQS081M]

INTRODUCTION

The majority of economic loss from future earthquakes in the United States is predicted along the West Coast where earthquake hazard is relatively high. In other U.S. locations, earthquake hazard may be lower but the potential loss represents a larger percentage of exposed property (FEMA 2008). The distribution of earthquake losses relative to the replacement value of local building inventories is much broader than for absolute loss. This means that mitigating earthquake impacts is a cross-state issue (NRC 2011).

A number of federal policies, such as the Disaster Relief Act of 1974 (Public Law 93-288), the Robert T. Stafford Act (Stafford Act, Public Law 93-288), the Disaster Mitigation Act of 2000 (DMA 2000, Public Law 106-390), and the Earthquake Reduction Act (Public Law 95-124), form an umbrella at the federal level that encourages individual states to develop and adopt policies that can promote seismic mitigation. These laws encourage states to implement policies that are aimed at the hazards that occur most commonly in their region. However, they do not mandate the enactment of any policy or legislation in general or focus on any specific natural hazard. One might expect that states along the West Coast and in other earthquake-prone regions, such as the New Madrid seismic zone, would have a greater earthquake awareness and in turn have more policy activity and coverage for mitigating earthquake hazards.

[a) Department of Human-Centered Design and Engineering, University of Washington, Campus Box 352315, Seattle, WA 98195, milessb@uw.edu
[b) Port of Bellingham, 1801 Roeder Ave, Bellingham, WA 98225, gouranb@portofbellingham.com

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Past research examined earthquake-related policies. However, much of it either focused on policy variability between states based on local policy adoption and enforcement or limited the types of policies compared between states. These studies did not account for all state-level policy types and did not look at policies across the entire United States. Additionally, although some noted differences in seismic hazard between states and used them as variables, few or none used a standardized index of seismic risk that accounts for likely damage to exposed property.

The purpose of the study presented here was to determine if greater levels of seismic risk lead states to adopt a greater number of earthquake-related policies that cover a larger range of topics. A corollary to this was to understand if certain policy topics have been covered by higher-risk states but not by lower risk states (as of yet). The objectives of the study were to (1) compile and catalog state-level seismic mitigation policies, (2) create and apply a normalized index of policy activity that accounts for each state's seismic risk, (3) develop a scale of relative intensity for characterizing policy coverage, and (4) calculate correlations between several study variables. Reaching these objectives will help to show if there is a distinct and measurable difference in how states approach seismic mitigation through policy adoption. This research will provide a necessary first step for future work on aspects of policy effectiveness in states' seismic mitigation policy regimes.

The following section discusses previous seismic policy research. In the subsequent section, the data collection strategy and analytical methods for this study are explained. The fourth and fifth sections present and discuss the study findings, respectively, prior to the conclusion.

LITERATURE REVIEW

This study builds on an existing body of research that has examined, to one degree or another, how earthquake-related policies are addressed on the state and local levels. Other studies have looked at the influence of seismic hazard and awareness on policy making. They include research on state and local implementation of federal policies, variability in the effectiveness of state mandates, and comparison of state building-code enforcement.

Berke (1992), after surveying local programs in 260 communities across 22 states with significant seismic risk, found that earthquake-related activities at the local level are much greater in California than in other states. He evaluated these programs using 21 criteria related to development regulations, building standards, planning, property acquisition, taxation and fiscal policies, and information dissemination, finding that the most common policies adopted are not specifically related to earthquakes. Those that specifically address earthquakes were more frequently found in California (Berke, Beatley, and Wilhite 1989).

May (1997) conducted a nationwide comparative analysis of state building codes and variability in enforcement mechanisms. This analysis of 33 states with building codes considered the type of code, the role of regulatory enforcement, the discretion allowed local governments, the existence of revocation authority, and the existence of state review.

The conclusion was that a number of factors, including political culture and taxing authority, contribute to how and why states develop and enforce codes.

May (1991) assessed how state and local jurisdictions implement federal seismic policies and found no correlation between state and local seismic policy regimes and regions of greater seismic risk. Instead, risk perception and awareness were found to influence regional differences in the development and implementation of studied policies. May also observed that limited public attention and factors such as inconsistent or episodic federal focus result in less state or local emphasis on policy development, and noted that the exception to this pattern is most obvious in the immediate aftermath of major hazard (or focusing) events, when the public and government have a heightened awareness of seismic risk. May and Birkland (1994) found that differences in policies depend on local political demands and resources.

May and Feeley (2000) conducted a local seismic policy comparison for 11 western states, surveying building officials to evaluate building code adoption and enforcement. They normalized the survey results by predicted regional peak ground acceleration, which is a measure of seismic hazard intensity. Their results indicate that building officials in states with higher seismic hazard tend to prioritize building codes more than those in states with intermediate or low seismic risk.

Several studies have provided insights into useful methods for conducting relevant policy analysis. May (1997) used a hierarchical cluster analysis to categorize states as “minimalistic,” “enabling,” “mandatory,” or “energetic.” The aim was to reveal factors that influence how and why states develop and enforce building codes. May and Birkland (1994) performed cluster analysis on data gathered from local jurisdictions in California and Washington via questionnaires and interviews. They identified local-level policy “leaders” and “laggers.” Berke (1989) compared local earthquake-planning processes and used regression analysis to evaluate the significance of factors that influence the development of planning programs based on survey responses. This study also used frequency analysis (counts) for comparing California with other states.

Abel et al. (2015) developed a Guttman scale to compare the intensity of state actions related to environmental justice issues. Although not involving seismic policies, their method is applicable to the objectives of this study. Guttman scale analysis is a procedure designed to sequence indicators such that if a given indicator is present, all other indicators that represent less intensity are also present (McIver and Carmines 1981). The researchers scored states based on whether they had taken increasingly intense policy actions of “doing nothing,” “administrative,” “failed legislative or rule-making attempt,” “procedural,” and “substantive.”

In sum, research has examined various components of seismic policy adoption, with the majority focusing on local issues. It has yielded insight into the possible factors influencing the adoption of earthquake-related policies. None of the research presented developed a comprehensive database and catalog of state-level earthquake mitigation polices for the United States, and few, if any, looked at the relationship between policy adoption and earthquake risk (as opposed to earthquake hazard). Lastly, no study attempted to understand the breadth of earthquake mitigation policy topics covered by states and how these topics are related.

METHODOLOGY

This section describes the methods used to identify and compile the policies included in the study database and catalog. It also presents a new index for representing policy activity relative to seismic risk. Lastly, the development of a Guttman scale for representing the policy topics covered by each state is described.

DATA COLLECTION

Prior to the current research, no catalog of state-level policies existed that could be used to create a database of different states' legislative and programmatic approaches to seismic mitigation. Therefore, a key component of this research included the cataloging and encoding of such policies. To accomplish this, state policies were identified, compiled into a catalog of policy text, and encoded into an analyzable database.

For this study, the broad definition of hazard mitigation provided in the Disaster Mitigation Act of 2000 (DMA2K) was used: any sustained action taken to reduce or eliminate the long-term risk to human life and property. This definition was used purposely to capture a broad range of policies and to be consistent with the definition related to the primary data source for this study. The DMA2K refers to this definition in its mandate for state hazard mitigation plans.

The primary data source for identifying relevant policies was state hazard mitigation plans. The Stafford Act as amended by the DMA2K includes a requirement for states to develop a state-wide hazard mitigation plan as a condition of federal disaster assistance (FEMA 2008b). Such plans must meet a number of criteria, including the presentation and description of the policies that address each identified hazard.

For the purposes of this research, policies were defined as state legislative actions, including statutes, codes, and executive orders. These included seismic-specific policies as well as policies not directly related to seismic hazards but having applicability (e.g., land use and zoning requirements). Some earthquake-specific programs were also included, such as membership in seismic safety advisory commissions. Other programs that may not have been mandated by the state's executive or legislature were identified and included in the policy database if they play a strong role in the development and adoption of seismic mitigation policies. Administrative policies such as budget authorizations for particular disasters were excluded. Also excluded were university and other institutional programs related to disasters that may be state-funded but not directly implemented by a state department or division.

Forty-seven state hazard mitigation plans were obtained from sources that included state government websites and direct correspondence with state hazard mitigation officers. Three states (Delaware, Kentucky, and Tennessee) did not make their hazard mitigation plans available because of security concerns. Although the quality of hazard-mitigation policy reporting within each state's mitigation plan likely varies, the quality of the data set compiled from the state plans was appropriate for its intended use in this study. Also, the data set represented a readily accessible data source that could be regularly reanalyzed because it is routinely updated by federal mandate.

Each state's online policy databases were used to supplement data from state mitigation plans. Policies were identified in these databases using the search terms "earthquake," "seismic," "mitigation," and "building code," among others. For example, a search for "seismic" in the State of Missouri online database provided a reference to 9 individual statutes including Revised Missouri Statutes "44-227 Commission on Seismic Safety," "256-155 Interstate Earthquake Emergency Compact," and "319-200 Notice to Cities and Counties Subject to Earthquake to Adopt Seismic Code." Lastly, some ad hoc sources were referred to, such as seismic safety commission reports (Seismic Safety Advisory Committee 1991, Seismic Safety Commission 2000).

As of this writing, the catalog contains descriptions of 310 policies that have been encoded into 310 database records. Each record contains 6 items (columns): (1) a unique identifier that can be used to find the policy in the catalog, (2) the policy title, (3) the state with which the policy is associated, (4) a keyword identifying the primary topic of the policy, (5) the type of policy (legislation, executive order, or program), and (6) whether the policy is earthquake specific. Of the 310 policies collected, 247 are legislation, 31 are executive orders, and 32 are nonlegislative. Ninety-four are specific to earthquake hazard. A partial version of the catalog (not the database) can be found at the Western States Seismic Policy Council's website (WSSPC 2014).

The seismic risk for each state was defined as the annualized earthquake loss ratio (AELR). This is the estimated long-term value of earthquake losses to the general building stock in any single year expressed as a fraction of the building inventory replacement value (FEMA 2008a). The AELR used for each state was calculated by FEMA in 2008 using the loss estimation software HAZUS-MH.

An important potential shortcoming of the data collection strategy used in this study is the chance that some states have adopted comprehensive policies that account for multiple seismic mitigation topics whereas other states have adopted policies more incrementally. This would be understandable given that lagging states can look to the incremental policies of leading states to create fewer but more comprehensive policies. As for the 310 policy descriptions in the current catalog, this does not seem to be the case, but it is a source of potential error (i.e., if instances were not caught in the review of the catalog). Further, as states adopt new policies and release revised hazard mitigation plans, any updates to the database will certainly reflect the possibility that comprehensive policies have been adopted, requiring revision of the data collection strategy used here (e.g., listing a policy multiple times for each topic covered).

ANALYSIS

An index of policy activity was specifically developed for this study that facilitates comparison of the number of policies across states relative to states' AELR. A Guttman scale analysis was also developed to characterize each state's policy coverage and the relative intensity represented by each policy topic covered. The methods of analysis for this study are described next.

Policy Risk Count

The first index of policy activity is simply each state's policy count. The second index is the policy risk count (PRC), which is an estimate of how many policies the state with the most policies would have if it had the same seismic risk as a selected state (Equation 1). This was computed by subtracting the product of the normalized AELR for the selected state and the policy count for the state with the most policies from the policy count of the selected state.

$$\text{PRC} = \text{Policy count of state} - \frac{(\text{Policy count of state with maximum AELR})(\text{AELR of state})}{\text{Maximum AELR of all states}} \quad (1)$$

The PRC is an index of relative policy activity. It does not represent the topical coverage of a state's policy regime; the topics covered by each state's policy set are not accounted for. A single comprehensive piece of legislation adopted in one state might address multiple topics addressed by several policies in another state. The former state would have less policy activity than the other state but similar topical coverage. (As noted earlier, the database analyzed for this study was reviewed to ensure that there were no multitopic policies.) Alternatively, a state could have several pieces of legislation on one seismic mitigation topic whereas another state might have just one. Thus, the former state would have higher policy activity than the latter state but similar topical coverage. (Some states in the study database do have multiple policies for a single topic.) The PRC does not represent the relative intensity of each policy, such as the effort required to adopt different policy types (e.g., legislation versus executive order) or the potential importance of the topic covered. Policy coverage and intensity are represented using the method described in the following subsection. Analysis of the effectiveness of reducing the seismic risk of each policy or policy regime was beyond the scope of the study.

Guttman Scale

A Guttman scale represents cumulative intensity among several indicators of a given variable (Stouffer et al. 1950). The presence of each indicator along the scale implies the presence of all previous indicators along the scale. A Guttman scale analysis attempts to sequence indicators such that each subsequent indicator represents increasing intensity based on characteristics of the analyzed data (McIver and Carmines 1981). It can be used with qualitative or quantitative data (Guest 2000).

A Guttman scale was constructed for this study to complement the policy activity indexes of policy count and PRC. With a Guttman scale, if a state has covered a policy topic that is on the far right of the scale, one can expect that the state has covered topics placed to the left of that topic. This type of scale can complement policy activity information with additional information about the topics covered by a state's policies as well as the relative intensity represented by those topics.

A Guttman scale is presented as a table where rows represent subjects and columns represent indicators. Each table cell is populated with a single binary value (yes/no). The analysis determines the possible sequences of indicators that are cumulatively positive (presence of indicator) with respect to all subjects (Gorden 1977). Perfect scales, where each subject has contiguously positive indicators, are uncommon. Deviations from a perfect scale are referred to as errors (Stouffer et al. 1950). The question of utility is then to what degree deviations from a perfect scale can be tolerated (McIver and Carmines 1981). The amount that a scale deviates from perfection can be represented by the coefficient of reproducibility (CR) (Equation 2), which computes goodness of fit between observed and predicted perfect

Table 1. Indicators for Guttman scale analysis of state seismic mitigation policies

Emergency Management: Legislation establishing an emergency management agency or program.
Building Code: Building code applicable to all state facilities that may be enforced locally by counties and other municipal jurisdictions. Specific code (IBC, UBC, others) and applicability/enforcement may vary state to state.
Land Use/Zoning: Critical areas legislation aimed at reducing impacts to critical areas which may include areas with high seismic risk or unstable slopes/soils.
Seismic Advisory: Sanctioned seismic advisory committee. This may include legislatively adopted or membership/participation in regional seismic advisory committees/consortiums.
School Seismic Safety: Legislation that specifically addresses seismic safety at schools.
Hospital Seismic Safety: Legislation that specifically addresses seismic safety at hospitals.
Unreinforced Masonry: Legislation that addresses seismic risks associated with public and privately owned unreinforced masonry building stock.
Seismic Microzonation: Legislation or program requiring mapping of specific seismic fault zones and other associated hazards such as liquefaction and earthquake-induced landslides.

indicator patterns. A *CR* of 0.90 or higher is commonly taken to mean that an identified scale is an acceptable approximation of a perfect scale and therefore useful (Stouffer et al. 1950).

$$CR = 1.0 - \left[\frac{\#\,\text{of errors}}{(\#\,\text{of stimuli}) \times (\#\,\text{of subjects})}\right] \qquad (2)$$

For this study, a Guttman scale was constructed with the subjects being states and the indicators being policy topics. Each policy identified for this study was reviewed to determine the range of topics covered by the 47 states analyzed. Eight broad policy topics were identified: emergency management, building code, land use/zoning, seismic advisory, school seismic safety, hospital seismic safety, unreinforced masonry, and seismic microzonation. The definitions of the eight topics are given in Table 1.

FINDINGS

The methodology just described was conducted on data developed for 47 state hazard mitigation plans. The average AELR (annualized earthquake loss ratio) for the 47 states is $195 of loss per $1 million of building inventory value. The maximum AELR is $1,452 per $1 million for California. The average number of identified policies per state is 6.6, with the average number of earthquake-specific policies being 2.1. California has the most policies at 34 with 28 specific to earthquakes.

POLICY ACTIVITY INDEXES

Results related to the two policy activity indexes are described next. The first is simply the count of policies identified with the data collection strategy described in the previous section. This index can be used to understand the relationship between policy activity and risk. The other index is the PRC. As explained previously, this index normalizes policy counts by the AELR for each state.

Policy Count

Figure 1 shows the relationship between policy count and AELR; the dashed lines indicate both the average AELR ($195 per $1 million) and the average policy count (6.6). As noted, California has the highest seismic risk (AELR = $1,452 per $1 million) and the most policies (34). Oregon and Missouri are second and third in number of policies (20 and 18, respectively) even though they are fourth and eleventh in amount of risk. Conversely, the second and third most risky states—Alaska and Washington, respectively—have considerably fewer policies: 4 and 10, respectively. The majority of states with above-average seismic risk also have above-average policy counts. The exceptions are South Carolina, Alaska, and New Mexico. Seven of the 16 states with above-average policy counts have below-average risk, which is a small difference; however, average AELR does seem to represent a threshold at which the number of policies goes up significantly.

The two variables, policy count and AELR, have a moderate to strong Pearson (linear) correlation coefficient of 0.71. However, the coefficient reduces to 0.50 if California's extreme values are not included. The Pearson correlation coefficient for the 12 states with above-average AELR reduces to 0.59 and disappears if California is ignored, with a correlation coefficient of 0.08.

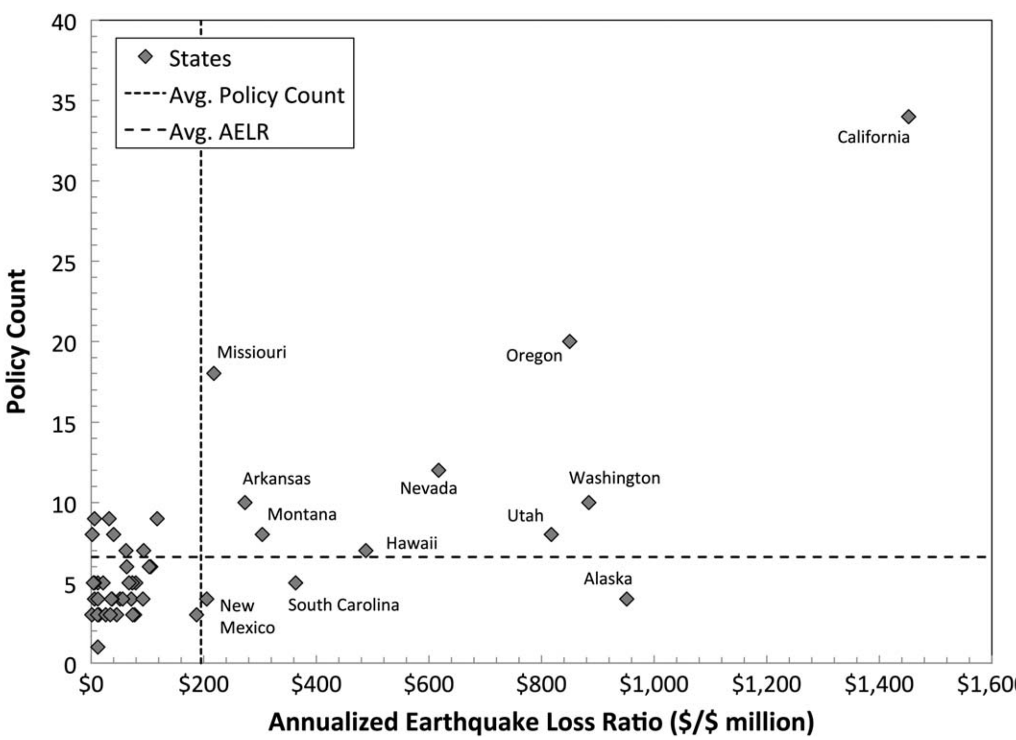


Figure 1. Scatter plot of seismic risk expressed as dollars of expected damage to the value of exposed property for each state versus the number of earthquake-related policies for the respective states.

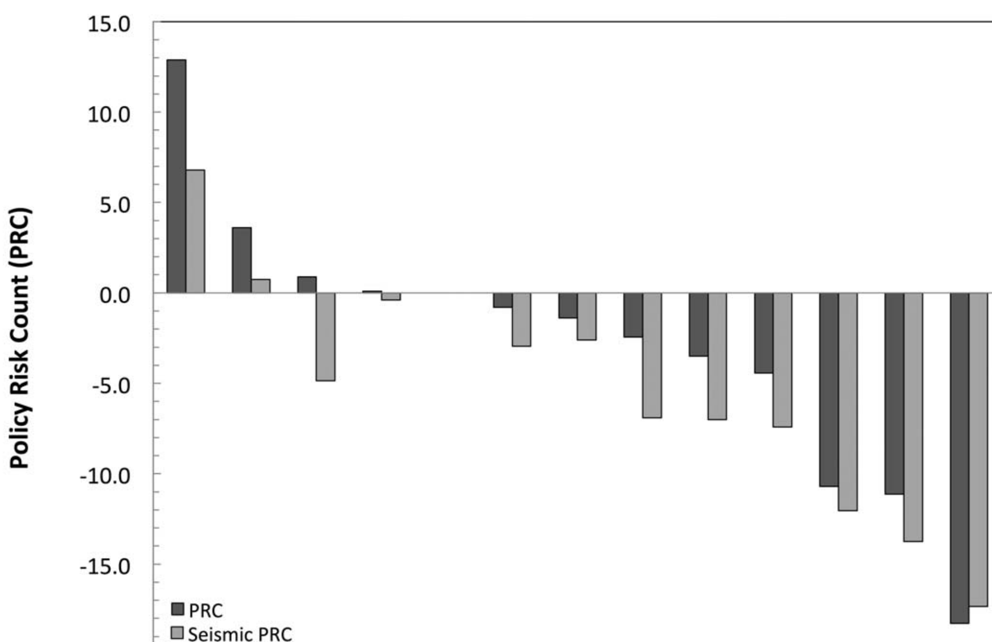
Policy Risk Count

Figure 2 shows the policy PRC values for the 13 states with above-average AELR. Four have a PRC greater than zero (New Mexico, Oregon, Texas, and Montana), suggesting that their policy counts are somewhat proportional to their AELR, taking California as the standard.

The PRC includes nonseismic-specific policies. To account for this, a seismic-specific PRC was calculated for the states with above-average seismic risk using only earthquake-specific policies (Figure 2, light gray bars). Again, California has a zero PRC. For three of the states with PRCs above zero—Missouri, Arkansas, and Montana—there is a notable reduction in values between the general and the seismic-specific PRC. The latter for Montana becomes negative. The PRC values for Oregon are similar. All of the states with a general PRC less than zero also have negative seismic-specific PRC values.

GUTTMAN SCALE

The findings described so far do not reveal anything about the policy topics adopted and how they might relate to seismic risk. It is possible that a state with few policies has focused on particularly specific or strong mitigation policies rather than taking an incremental or



	MO	AR	MT	OR	CA	NM	WY	NV	SC	HI	WA	UT	AK
Risk Rank	11	10	9	4	1	12	13	6	8	7	3	5	2
AELR ($/$1.0E6)	218	273	304	850	1,452	205	187	617	363	488	884	817	951

Figure 2. Plot showing the relative policy activity related to policies developed specifically for seismic safety. Relative seismic risk (by rank and by annualized earthquake loss ratio) for each state is given in the x-axis table.

sequential approach. To gain insight into this possibility, several alternative Guttman scales were constructed and evaluated to find the best fit to the state policy data. As described before, the 47 states in this study were specified as the subjects of the analysis and 8 policy topics were specified as the indicators. Of the 47 states, only California covers all 8 policy topics. Two states cover 5 of the 8 indicators; 13 cover 4; 23 cover 3; 7 cover 2; and 1 covers 1.

Many different indicator (policy topic) sequences were analyzed to find the Guttman scale with the highest coefficient of reproducibility (*CR*). The best scale has a *CR* of 0.96 and is listed in Table 2. In practice, scales with a 0.90 or higher *CR* are considered meaningful and useful (Stouffer 1950). The following sequence of policy topics (in order of increasing intensity) corresponds to the identified scale: (1) emergency management, (2) building code, (3) land use/zoning, (4) seismic advisory, (5) school seismic safety, (6) hospital seismic safety, (7) unreinforced masonry, and (8) seismic microzonation. A total of 13 errors are present in the scale. These are instances where the scale's intended indicator sequence is violated, and they are shown as gray Nos in Table 2. The most common error is not having expected land use/zoning policies, which is the case for ten states. Another is not having expected building code provisions, which is the case for two states. Lastly, one state does not have a seismic advisory policy, as would be expected based on the scale. No individual state has more than 1 error.

There is a large drop in the number of states having policies beyond seismic advisory. Twenty-three have seismic advisory policies, and seven go beyond that indicator with at least school seismic safety. Of these seven, only three go beyond school seismic safety. Also, Colorado, Arizona, and Michigan have school seismic safety policies that were not adopted specifically for seismic mitigation, even though they are listed in the mitigation plans as promoting seismic safety.

Because California is the only state with policies related to hospital seismic safety, unreinforced masonry buildings, and seismic microzonation, an additional Guttman scale analysis was conducted without these policy topics to ensure these additional indicators did not skew the results (not shown because of space limitations). The scale without the three indicators resulted in a similar *CR* of 0.95. The sequence of the three indicators does not impact the *CR*.

The identified Guttman scale provides another opportunity to evaluate earthquake mitigation policy relative to seismic risk. California has the highest AELR and the highest policy coverage (Guttman) score, which is 8. Alaska and Washington, with the second and third highest AELR, respectively, have a score of 4. This score is lower than that of 6 other states, not including California, and the same as that of 11. Many of those 11 states have significantly lower AELR. Oregon, with the fourth highest AELR, is tied for second place in policy coverage, with policies covering five topics. Interestingly, it shares the same score with Colorado, even though it has the 30th highest AELR.

As with policy activity, the relationship between AELR and policy coverage score is moderately strong, with a Pearson correlation coefficient 0.72. Removing the extreme value of California results in a correlation coefficient of 0.55—again, similar to the relationship with policy activity. The correlation coefficient between Guttman score and AELR for just the top 12 riskiest states (scores from 3 to 8) is much higher than the coefficient between policy count and AELR (0.80 versus 0.63, respectively). Again, it goes down if California is

Table 2. Guttman scale of seismic mitigation policy indicators (states grouped by Guttman score)

State (risk rank)	Emergency management	Building code	Land use/zoning	Seismic advisory	School seismic safety	Hospital seismic safety	Unreinforced masonry	Seismic microzonation	Score	Errors
CA (1)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8	
OR (4)	Yes	Yes	Yes	Yes	Yes				5	
CO (30)	Yes	Yes	Yes	Yes	Yes				5	
AK (2)	Yes	Yes	Yes	Yes					4	
WA (3)	Yes	Yes	Yes	Yes					4	
UT (5)	Yes	Yes	No	Yes	Yes				4	1
NV (6)	Yes	Yes	Yes	Yes					4	
HI (7)	Yes	Yes	Yes	Yes					4	
SC (8)	Yes	Yes	Yes	Yes					4	
MT (9)	Yes	Yes	Yes	Yes					4	
MO (11)	Yes	Yes	No	Yes	Yes				4	1
MS (14)	Yes	Yes	Yes	Yes					4	
AL (17)	Yes	Yes	Yes	Yes					4	
AZ (19)	Yes	No	Yes	Yes	Yes				4	1
NJ (25)	Yes	Yes	Yes	Yes					4	
MI (42)	Yes	Yes	Yes	No	Yes				4	1
AR (10)	Yes	Yes	No	Yes					3	1
NM (12)	Yes	Yes	No	Yes					3	1
WY (13)	Yes	Yes	No	Yes					3	1
ID (15)	Yes	Yes	No	Yes					3	1
VT (16)	Yes	Yes	Yes						3	
NH (18)	Yes	Yes	Yes						3	
GA (20)	Yes	Yes	Yes						3	
IN (22)	Yes	Yes	No	Yes					3	1
IL (23)	Yes	Yes	No	Yes					3	1

(*continued*)

Table 2. *(continued)*

State (risk rank)	Emergency management	Building code	Land use/zoning	Seismic advisory	School seismic safety	Hospital seismic safety	Unreinforced masonry	Seismic microzonation	Score	Errors
NY (24)	Yes	Yes	No	Yes					3	1
OK (27)	Yes	Yes	No	Yes					3	1
MA (28)	Yes	Yes	Yes						3	
PA (31)	Yes	Yes	Yes						3	
RI (32)	Yes	Yes	Yes						3	
VA (34)	Yes	Yes	Yes						3	
OH (35)	Yes	Yes	Yes						3	
MD (36)	Yes	Yes	Yes						3	
SD (38)	Yes	Yes	Yes						3	
NE (41)	Yes	Yes	Yes						3	
FL (43)	Yes	Yes	Yes						3	
IA (44)	Yes	Yes	Yes						3	
WI (45)	Yes	Yes	Yes						3	
ND (46)	Yes	Yes	Yes						3	
ME (21)	Yes	Yes							2	
NC (26)	Yes	Yes							2	
CT (29)	Yes	Yes							2	
WV (33)	Yes	Yes							2	
KS (37)	Yes	No	Yes						2	1
LA (39)	Yes	Yes							2	
MN (47)	Yes	Yes							2	
TX (40)	Yes								1	
Errors	0	2	10	1	0	0	0	0	—	13
Total count	47	44	30	23	7	1	1	1	—	—

Note: Coefficient of reproducibility (*CR*) equal to 0.96. Errors are shaded gray.

ignored (scores from 3 to 5) but not nearly as much as for policy count versus AELR (0.58 versus 0.19, respectively).

Lastly, the Guttman scores for each state make it possible to see if more policies translate into more policy topics covered. The linear correlation coefficient between policy count and policy coverage is 0.79–0.60 if California is ignored. If only the 12 riskiest states are analyzed, the coefficient is 0.87; without California it is 0.55.

DISCUSSION

From the findings, it is clear that the study's methodology distinguishes states with respect to the adoption of policies related to earthquake mitigation and each state's seismic risk. There is a wide range of seismic risk across the United States. States engage in a correspondingly wide range of policy activity related to this risk which covers a moderate range of seismic mitigation policy topics.

INFLUENCE OF SEISMIC RISK

Like Berke (1992), who looked at local policies in 22 states, this study found California to be the most active state in dealing with earthquake hazards. Like the authors of the current study, Berke found that the majority of relevant state policies in California were not developed specifically for dealing with earthquake risk. Berke et al. (1989) also found that California has the most earthquakes-specific local policies. The current study draws a similar conclusion for state-level policies. Whereas May and Feeley (2000) found that building officials tend to prioritize seismic application of building codes in higher-risk states, this study found that states with higher seismic risk tend to have more policy activity and cover more earthquake mitigation topics.

This study found that the relationship of policy activity and policy coverage with seismic risk is only moderately strong. This is not surprising given that there are other factors that have been found to influence seismic mitigation policy regimes. Matisoff and Edwards (2014) found that similarity in political culture, rather than geographic proximity (shared borders), has strong relationship with energy policy adoption by states. Extending this insight to seismic mitigation policy might explain why the relatively geographically and seismically similar states of California, Oregon, Washington, and Alaska do not have similar policy activity or coverage. May (1997) observed that political culture has a large influence on the degree to which states develop and enforce building codes. Also informative is May's (1991) findings that risk perception and awareness have a larger influence than absolute risk on policy.

Analyzing only the states with higher than average AELR suggests that the relationship between Guttman score (a proxy for policy coverage) and seismic risk may be more robust than that between policy counts and seismic risk. Removing the less risky states reduces the strength of relationship for both variables but not nearly as much as for Guttman score. This is likely because the range in policy count among the riskiest states (between 3 and 34) is considerably larger than the range in Guttman score (between 4 and 8). Most of the states with higher than average risk have relatively few seismic policies given that risk.

It is important to consider the relationship between PRC and AELR, which based on Figure 2 appears negative. Some states with higher than average policy counts significantly lag behind states with lower policy counts when normalized by their risk. As a result, the correlation between AELR and policy count (Figure 1) seems less meaningful overall. This finding is more pronounced when counting only policies developed specifically for earthquakes. For example, Montana went from looking relatively active to looking relatively inactive considering the difference between its PRC and its earthquake-specific PRC. This finding is not consistent with May and Feeley (2000), who after normalizing for seismic hazard found that building officials in states with higher seismic hazard tended to prioritize seismic building code application. May and Feeley's study looked at one policy topic, whereas this study analyzed a range of policy topics. Their study also normalized results by peak ground acceleration rather than AELR, which accounts for likely property damage relative to exposed property.

POLICY ACTIVITY VERSUS INTENSITY

Policy count and PRC are imperfect indexes of policy activity. For example, they do not account for failed or incomplete policies, such as proposed but not passed legislation, which is important for understanding policy adoption (Abel et al. 2015, Jordan and Huitema 2014). Some states might be more active than represented here but possibly less successful than other active states in getting policies adopted. Policy count and PRC also do not represent the range of topics that states cover. More important, they do not provide insight into the relative difficulty associated with states' success in addressing the policy topics they cover.

Insight into these issues is partially provided by each state's policy coverage (Guttman) score, which accounts for the policy topics addressed. This score indicates not only the topics covered but also the relative intensity of each topic—topics farther along the scale represent higher intensity (McIver and Carmines 1981). As in Abel et al. (2015), the Guttman score can be interpreted here as indicating a more intense level of effort needed to achieve each subsequent indicator—policy topic in the case of this study. In other words, the Guttman scale shows that it takes less effort to adopt policy for "emergency management" and "building code" than for the "unreinforced masonry" and "seismic microzonation." The indicator sequence with respect to increasing intensity or level of effort—"emergency management," "building code," "land use/zoning," "seismic advisory," "school seismic safety," "hospital seismic safety," "unreinforced masonry," and "seismic microzonation"—is interpreted next.

Because federal law requires that every state have an emergency management administrative policy to be eligible for federal disaster funding, it is logical to assume that all states have already adopted such a policy. The "emergency management" policy indicator is foundational, but it also represents nominal difficulty with respect to building a policy regime for earthquake mitigation. Similarly, standard building codes that have a seismic component are widely accepted and recognized as necessary. Adopting a statewide uniform code is possibly more difficult than adopting an emergency management policy because of a lack of federal mandate and the potential for passing on costs to citizens. Land use and zoning laws, such as critical areas legislation, can be controversial from a property rights perspective, and they meet resistance when viewed as having a negative impact on economic development.

The remaining policy topics are seismic-specific, meaning that it is unlikely that states with no seismic risk have such policies. Seismic advisory committees often advocate specific policy development and can increase political awareness of seismic hazards. Thus, this policy can be seen as a precursor of more focused policy adoption. “School seismic safety” policies are likely to have broad appeal because of their subject. Indeed, “school seismic safety” was the first topic ever to be addressed by earthquake-specific legislation in the United States (California’s 1933 Field Act). The next indicator along the scale is “hospital seismic safety” policy, which is more difficult to adopt than school seismic safety policy because many more hospital facilities are privately owned, making political capital more difficult to build. This challenge is even more severe when dealing with the large number of privately owned unreinforced masonry buildings in high-risk states. The Guttman scale presented here suggests that “seismic microzonation” represents the highest intensity and, in this interpretation, requires the highest level of effort. One might argue that gaining political support for the adoption of “seismic microzonation” policy is challenging because of the large scale involved (i.e., study area, cost, human resources, and intellectual capacity) and the possible perception that it will have less immediate impact than other policies (even though it supports other policies). Because California is the only state that addresses “school seismic safety,” “hospital seismic safety,” and “seismic microzonation,” the interpretation here should be considered hypothetical and subject to future evaluation.

Policy activity alone is not enough to explain the intensity needed for policy adoption (Jordan and Huitema 2014). However, it does tend to create new political actors or constituencies that influence additional policy innovation (Voß and Simons 2014). This study found a moderately positive relationship between a state’s policy activity, as represented by policy count, and its policy coverage score, although it is limited because only a few states cover more than one seismic-specific policy topic. California has nearly twice as many relevant policies as the state with the next highest number of policies. The relationship between policy activity and intensity may not be linear; each step along the Guttman scale may require exponentially higher effort. The step between adoption of land use policy and adoption of seismic advisory policy is conceivably smaller than that between adoption of seismic advisory and adoption of school seismic safety. Also, each indicator on the policy coverage scale can represent a considerable range in intensity that is not explicitly represented in each indicator. For example, Alaska and Washington have the same Guttman score because they both have seismic advisory policies. However, Alaska’s seismic safety commission is mandated by statute whereas Washington’s seismic safety committee is voluntary. Passing legislation arguably takes more effort than organizing a voluntary body of passionate individuals.

CONCLUSION

This study developed a systematic data collection strategy to create and update a database of U.S. state-level earthquake mitigation policies. With this database, a set of indexes was computed to facilitate cross-state comparisons as well as analysis of relationships with other variables. The most basic index is a count of the number of policies each state has adopted. An additional index was developed to account for the possible influence of states ‘relative seismic risk. Lastly, a Guttman scale analysis was conducted to understand the relative intensity of policy coverage and determine its relationship, if any, to seismic risk.

The data collection strategy was built on information provided in each state's hazard mitigation plan, which was a useful primary data source that accounted for a large majority of the policies for this study. Such plans facilitated systematic updating of the policy database because they are federally mandated, have a relatively consistent format, and are required to be updated every three years. The price for this convenience is consistency. First, three states did not provide their hazard mitigation plans for this study, and it is difficult to say if this will be a problem in the future. There is a general consistency between state plans because of the federally required format. However, variability was observed across plans regarding their respective interpretation of relevant policy. The ages of the state plans were not consistent because each one is on a different update cycle, but the age difference will never be that great if states conform to the required three-year cycle. It is not clear how vigilantly states will maintain their relevant policies or how effectively FEMA's evaluation of states' hazard mitigation plans will be. These plans will always require supplementation with other sources.

The policy database will need regular updating, perhaps by the states themselves or by FEMA or through crowd sourcing. Before updating, however, it will need to be modified slightly. Currently, the database indicates whether a policy is legislation, an executive order, or a program, and if it is earthquake-specific, and only one covered topic per policy is allowed. As states look to others states, such as California and Oregon, they may take a more comprehensive or portfolio-based approach to policy development. Or they may address multiple topics in a single policy. The database will be important for calculating a state's policy coverage score, among other factors.

A major contribution of this study is the introduction of new variables to the earthquake policy literature that can be used to quantitatively study policy adoption and effectiveness. Policy counts, PRC, and policy coverage scores can be analyzed in relation to potentially influential variables that represent, for example, political culture. The Guttman scale can be integrated into analysis of policy topic effectiveness in reducing overall seismic risk. An additional Guttman scale can be useful where policy success and effectiveness are explicitly represented, as in Abel et al. (2015). This will require much more effort in data development to determine, for example, whether states have attempted but failed to adopt policies. More significantly, extensive research is needed to understand the relative effectiveness of existing state policies and its influences.

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