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Abstract

Researchers picking through the debris left by the Northridge earthquake in 1994 and Hurricane Andrew in 1992 found that building codes had not provided the degree of protection against damage many expected. This was due, in part, to a breakdown in code enforcement functions. In this paper, we provide evidence that the seismic provisions of codes receive rather low priority from many local building departments, even in areas of moderate to high seismic risk. Drawing lessons from the experience with programs to foster greater energy efficiency in buildings, we show there is much that can be done to improve the attention local governments give to the enforcement of the seismic provisions of building codes. The federal government and states can bring about greater emphasis on enforcement by requiring state governments to adopt and local governments to enforce building regulations with seismic provisions, by improving state capacity to oversee these functions, and by providing technical assistance to state and local code enforcement personnel.

Building codes are key instruments for improving the resilience of the built environment to earthquakes and other natural hazards. Despite a long history in the United States of codes that address these issues and a strong reputation for good building practices, recent disasters provide evidence of noteworthy shortfalls in code enforcement. The California Seismic Safety Commission's investigation (1995) of damage from the 1994 Northridge earthquake in southern California found there would have been far less damage had seismic provisions of building codes been rigorously enforced. Similar reports following Hurricane Andrew in 1992 attributed a quarter of insured losses to code violations (Institute for Property Loss Reduction 1995). Stronger standards in building codes are often called for after such revelations. But, we argue and show empirically that a good part of the problem is the lack of adequate attention to existing provisions as part of code enforcement.

Finding ways to increase the attention that building officials give to natural hazards is a serious policy problem (e.g., see Burby et al. 1998a; Burby et al. 1998b; Olshansky 1998). Traditionally, building codes and code enforcement have been a state and local government responsibility. Unlike other societal problems, the federal government has made only limited, sporadic attempts to influence code standards and local enforcement practices. When federal legislation was proposed following reports critical of local code enforcement by the Advisory Commission on Intergovernmental Relations (1966) and by the National Commission on Urban Problems (1968), the effort elicited widespread opposition from the building industry and by state and local governments. As a consequence, no federal legislation was enacted.

The hands-off federal stance toward the regulation of building practices has provided states with wide latitude about their approach, if any, to foster safe construction (e.g., see May et al. 1995; May 1997). The resulting variation in state policies creates an opportunity for researchers and policymakers to learn from the state experiences about how to foster more attention to code enforcement among local governments. The lessons to be drawn from seismic provisions are limited because few states, other than California, have had pro-active efforts in this regard. However, there is opportunity to learn from state experiences with energy code provisions for which states, spurred by federal financial and technical assistance, have been much more proactive. As a consequence, we consider that experience to be a useful comparison with state seismic-related efforts.[1]

In what follows, we first examine choices the states have made about building code enforcement and what the federal government has done to foster energy efficiency and seismic safety in the built environment. Next, the data assembled to evaluate how state choices and federal policy have affected local government priorities are described. This is followed by consideration of the priority that local building officials give to these code provisions and the degree to which priority varies with variation in state building code policy. In the final section, we turn to lessons for fostering greater attention to enforcement of the seismic provisions of building codes.

State Approaches to the Regulation of Building Practices

State regulation of building practices in the United States relies on provisions of model codes. Beginning in the late 1920s, these codes were developed by the private sector through a consensus process involving stakeholders such as local building officials, contractors, design professionals, and the insurance industry. At present there are four model codes which have different geographical bases for adoption. These include the Standard Building Code (most widely used in the South), the National Building Code (most widely used in the East), the Uniform Building Code (most widely used in the Midwest and West), and a separate one- and two-family-dwelling code (used throughout the nation). The organizations that oversee these codes are currently working to establish a single national, model code by the year 2000. State governments that have enacted building codes generally reference one of the model codes as the technical source of code provisions while enacting their own provisions regarding responsibility for enforcement.

In an examination of state approaches to building regulation, May (1997) found that seventeen state governments have chosen to leave to local government discretion whether to adopt a building code.[2] Thirty-three states, however, have chosen to establish state building codes that apply to all types of buildings.[3] These typically reference the provisions of one of the model codes and specify the role of local governments in enforcing the provisions of the code. Analysis of these thirty-three state building code programs indicated that they could be usefully divided into three levels of effort, which May termed “enabling,” “mandatory,” and “energetic,” based on the degree of prescription and oversight of local practices.[4]

The eight states classified as enabling have adopted legislation that authorizes local governments to enforce the state code, but at their discretion. These states have established building departments to administer state code provisions, but the departments pay little attention to review of local code enforcement practices. The thirteen states classified as mandatory require, rather than leave to local discretion, local government enforcement of the state code. Like enabling states, however, they also pay little attention to the extent to which local governments actually adhere to state prescriptions. The twelve states classified as energetic also require local enforcement of the state building code, but in these states building officials are much more aggressive in their oversight of local government performance.

Our expectation is that these differences in state roles are important factors in explaining variation in local governmental attention to codes as they relate to energy efficiency and seismic safety. Where the states leave code provisions and enforcement wholly to local government discretion, the states have little leverage to foster attention to problems the states believe are important and no means for improving the capacity of local governments to administer building regulations.

The adoption of a state building code provides an opportunity to draw attention (if not force attention) to state policy objectives concerning energy efficiency and seismic safety. This should lead to greater local government attention to these issues, all else being equal. However, localities are still free to ignore state policy wishes when enforcement of code provisions is discretionary. When states require enforcement of these code provisions, it should be harder for local officials to ignore them. When states actually oversee local performance, they have another tool to direct attention to state policy goals. As a consequence, we expect local officials to give highest priority to energy efficiency and seismic safety in states with mandatory and energetic approaches to building codes. However, since much more attention in federal policy has been given to energy than to seismic safety, we also expect the impacts of the state approach to building codes to be much greater in fostering local priority for energy efficiency than for seismic safety.

The establishment of a state building code function, which has occurred in each of the states that has gone beyond the minimalist approach, also creates the ability for states to take steps to increase the capacity of local governments to enforce code provisions. This can be important, because without adequate capacity to understand and interpret correctly various code provisions, local officials are likely to pay little attention to their enforcement. Indeed, a study of enforcement of hurricane-related provisions by local governments (Southern Building Code Congress International 1992) found that lack of knowledge of code provisions by inspectors was a key impediment to effective enforcement. Given this, we expect the priority that local officials give to code provisions concerning energy efficiency and seismic safety to be greater when states have undertaken training programs about these topics for local code enforcement personnel.

By inducing the states to be more proactive in their approaches to code enforcement, we believe the federal government can at the same time bring about increased local attention to energy efficiency and seismic safety. To have a greater impact, the federal government can take steps to foster state attention to specific problems by encouraging adoption of appropriate code provisions and by providing technical and financial assistance. The federal effort to bring about greater energy efficiency in buildings exemplifies this approach.

The 1973 Arab oil embargo led to concern among federal and state officials about rapidly rising energy costs, as well as the availability and adequacy of energy supplies. These problems created the public support necessary to sustain new initiatives proposed as part of the Carter administration's National Energy Plan, which included requirements for the improvement of the energy efficiency of buildings (Sioshansi 1994).[5] These initiatives included the Energy Policy and Conservation Act of 1975, which created and funded through grants-in-aide the State Energy Conservation Program. In 1977, Congress created the Energy Extension Service, which authorized state pilot programs to investigate the feasibility of a national program, which was subsequently enacted (Hirst 1994).

The National Energy Plan of 1978 contained the Public Utility Regulatory Policy Act as well as the National Energy Conservation Policy Act. These laws required utilities to establish conservation programs, many of which contain incentives for builders to adhere to stringent energy efficiency standards (U.S. Department of Energy 1997a). The laws also contained incentives for the states to amend their building codes to require adherence to energy efficiency standards and to require localities to have in place building inspection systems to ensure compliance with the new code standards.

As of 1995, thirty-six states had statewide energy codes, ten had codes that applied only to state buildings, and only four states had no code at all (Smith and Nadel 1995). The state codes are based on the Council of American Building Officials' (CABO) Model Energy Code, American Society of Heating, Refrigeration, and Air Conditioning Engineers standard 90.2, and the Building Officials and Code Administrators International National Energy Code (Turchen and Conner 1996). The Energy Policy Act of 1992, the most recent federal energy initiative, references the National Model Energy Code, which provides another inducement for states to use it to foster energy efficient new construction. State and local government adherence to the code is also fostered by provisions attached to federal mortgage insurance that require compliance with the code as a condition for receiving FHA- and VA-insured mortgages. The federal energy department also awards grants to states and cities to develop energy efficiency programs (e.g., see Flanigan and Hadley 1994 for examples), and its Office of Energy Efficiency and Renewable Energy awards grants to help communities rebuild in energy-efficient ways after natural disasters (U.S. Department of Energy 1997b).

In contrast with the substantial number of programs and funding for efforts to foster energy efficiency in the built environment ($150 million for state and local programs in 1997 and $570 million overall), federal and state—except for California—

efforts to foster resilience to earthquake hazards have been meager ($28 million for all federal hazard mitigation programs in 1997) (see May et al. 1998). The National Earthquake Hazard Reduction Program that was launched in 1977 has funded research to establish stronger seismic-related provisions for new and existing buildings and has entailed modest efforts, in comparison to those of the energy programs, to foster their incorporation into model codes and adoption by states. These initiatives include funding for state seismic safety offices, education and outreach programs, and some key partnerships with the private sector. Relatively little attention has been given to measures to promote local enforcement of compliance with seismic building code provisions. Recognizing the gaps in state adoption and local enforcement of codes with seismic provisions, the Federal Emergency Management Agency has funded development of a guidebook about code adoption (Olshansky 1998) and is promoting its use for filling these gaps.

This recounting of the history of energy- and seismic-related efforts suggests two important sets of comparisons for drawing lessons. One concerns the variation among states (and localities) in their efforts to adopt and enforce code provisions. The second comparison is between the extensive federal (and state) efforts to promote adoption and enforcement of energy-related code provisions as compared to the more limited efforts with respect to seismic-related provisions. Of research interest is assessment of the degree to which state building code programs and the federal effort to foster energy efficiency have actually led to stronger efforts on the part of local officials to enforce these provisions of building codes.

Data and Methods

To assemble information to characterize state building code and energy programs, we examined relevant state legislation and rules, and we conducted a mail survey in 1995 of state officials responsible for building regulation and energy programs. Responses were obtained from each of the thirty-three states with a state building code that was not limited to special classes of buildings. To gather information about the priority that local officials attach to enforcement of seismic safety and energy provisions of building codes, we conducted a mail survey in 1995 of local building officials in each of the fifty states. The sample frame for our survey was based on a prior national survey undertaken by the National Conference of States on Building Codes and Standards (1992) that addressed state and local capacity to enforce the seismic safety provisions of building codes. We obtained responses from 82 percent of the officials contacted providing a nationwide sample of 819 respondents. The sample was subsequently weighted so that it is representative of the population of local governments in the United States.

In the analyses that follow, we first examine the priority the national sample of local building officials gives to enforcing energy-efficiency- and seismic-related code provisions. The priority officials assign to enforcement of the basic structural provisions of the building code serves as a point of comparison for these analyses. Because the risk posed by earthquakes varies nationwide, we desegregate the results in terms of three

categories of risk. These are defined with respect to different levels of likely ground shaking associated with earthquake events as defined by a set of maps established by the National Earthquake Hazard Reduction Program (NEHRP). High risk locales include those in states with the highest NEHRP mapped risk: Alaska, California, Hawaii, Idaho, Nevada, Utah, and Washington. Intermediate risk locales include those in states with moderate, but still significant seismic risk: Arizona, Connecticut, Kentucky, Massachusetts, Missouri, Montana, New Hampshire, New York, Rhode Island, South Carolina, Tennessee, and Vermont. Localities in the remaining states were assigned to the low risk category.

In the second stage of the analysis, we look at the role of different aspects of state building code and energy programs in shaping the priority that local officials give to enforcing energy-efficiency- and seismic-related provisions of building codes. The state choices that we examine include the degree of prescription and oversight of local code enforcement, the capacity of the state building code agency, and provision of technical training for local government building code personnel. State energy policy choices include the establishment and maintenance of a state energy department and the delivery to local governments of training materials and other assistance for enforcement of the energy provisions of the state code.

We also undertake multivariate analyses that provide a basis for examing the the relative impacts of different aspects of state programs on local efforts while controlling for various extraneous factors that can affect local priorities. We expect that energy-efficiency- and seismic-related code provisions will receive greater priority from local officials when localities have proactive building code enforcement systems (i.e., expend greater effort and have greater capacity for enforcement), when resources are more plentiful (larger population, higher growth, higher income), when opposition to code enforcement is lower, and when energy consumption and seismic risk are more serious (higher energy consumption per capita, greater seismic risk, and previous earthquake disaster).

Priority Given to Energy Efficiency and Seismic Safety

The priorities that local officials attach to the enforcement of different code provisions are shown in Table 1. On a scale of 1 to 5, more than 70 percent of local building officials report that they give high priority (score of 5) to enforcement of the structural provisions of the building code. In contrast, only 17 percent and 16 percent, respectively, give high priority to the seismic safety and energy provisions of the code. On average, the priority assigned seismic safety (score of 2.6) is below the mid-point of the scale, while energy efficiency (score of 3.0) rates only slightly better. In both cases, there is clearly ample room in the enforcement system for slippage in the attainment of compliance with code provisions. These data provide further evidence for the code enforcement problem facing policy makers that we noted at the beginning of this paper. [6]

Table 1. Priority Given to Energy and Seismic Provisions of Building Codes in

Comparison with Structural Provisions[a]

Priority Scores	Percent of Building Officials Who Assigned a Given Priority Rating to Their Enforcement of Different Provisions of the Building Code: Baseline: Structural Provisions	Energy-Efficiency Provisions	Seismic-Hazard Provisions
Low - 1	1	14	35
2	2	19	16
3	6	33	17
4	18	18	15
High - 5	73	16	17
Mean score	4.5	3.0	2.6
Median score	5.0	3.0	2.0
Number of localities[b]	811	734	619

Notes:
[a]Question: Consider the following provisions of the building code you enforce. For each set of provisions, please give us your assessment of the current priority given to these provisions by the Building Department. (If the code you enforce does not contain the provisions, circle not applicable.)
[b]The large number of missing cases for priority assigned to the energy-efficiency (85 cases) and seismic-safety (200 cases) provisions is due to the report by a number of officials that a rating of priority is not applicable because the building code they enforce does not contain such provisions.

The low priority that localities place on seismic provisions is due, in part, to the fact that the risk of an earthquake is very unevenly distributed across the United States. Table 2 shows the variation in priority for enforcement of seismic provisions among localities with different degrees of seismic risk. Where seismic risk is high, a large proportion (65 percent) of local officials report giving high priority to the enforcement of seismic provisions of codes. Among this group, only 14 percent assign it mid-level or low priority (3 or less on the 5-point scale of priority). The more problematic states in terms of the priority given to seismic safety are the New England states, South Carolina, states affected by the New Madrid fault (Arkansas, Kentucky, Missouri, and Tennessee), and, in the West, Arizona and Montana. In these states, the risk of an earthquake is lower than in the high-risk states, but still significant. The concern is that local officials in these states give much lower priority to enforcing seismic provisions. Only a third of the building officials report this as a high priority for enforcement, and over a fifth rate it as a moderate or low priority (a rating of 2 or 1 on the 5-point scale). In states with low seismic risk, a majority of local officials rate enforcement of seismic provisions as moderate or low priority.

Table 2. Variation in Priority Given to Seismic Provisions of Building Codes by Degree of Seismic Risk[a]

Priority Scores	Percentage of Building Officials Assigning a Given Priority Score for Seismic Enforcement by Degree of Risk[b]		
	High Seismic Risk	Intermediate Seismic Risk	Low Seismic Risk
Low - 1	1	8	34
2	2	13	19
3	11	22	19
4	21	25	14
High - 5	68	33	12
Mean Score	4.5	3.6	2.5
Median Score	5.0	4.0	2.0
Number of Localities	203	166	344

Notes:
[a]Question: Consider the following provisions of the building code you enforce. For each set of provisions, please give us your assessment of the current priority given to these provisions by the Building Department. (If the code you enforce does not contain the provisions, circle not applicable.)
[b]High risk local governments are those located in the following states: Alaska, California, Hawaii, Idaho, Nevada, Utah, and Washington. Intermediate risk local governments are those located in Arizona, Connecticut, Kentucky, Massachusetts, Missouri, Montana, New Hampshire, New York, Rhode Island, South Carolina, Tennessee, and Vermont. Local governments in the remaining of the 50 states have a low risk of experiencing an earthquake.
[c]Unweighted data in order to reflect number of local governments in each risk category in full sample. Total unweighted N of 713 reflects fact that 106 local governments reported that the code they enforced did not contain seismic provisions.

Impact of State Code Enforcement Programs

Table 3 shows the role that different aspects of state programs have in shaping local code enforcement efforts. The table entries show the mean priority scores for local governmental enforcement efforts when grouped according to different characteristics of state programs. We report statistical tests of the differences of means for the various entries in order to depict the variability in the data. Our comparisons of characteristics of state seismic programs are limited by the lack of variation among states in the presence of agencies and staff dedicated to seismic programs.

The differences between the effects of state programs on local governmental priorities for energy and seismic provisions are striking. The level of effort states give to building codes has a marked effect on the attention local governments give to enforcing the energy provisions of the codes. When states mandate local adoption and enforcement of the state code (mandatory and energetic states), localities give energy a much higher degree of attention than they do in states that have left code enforcement to local discretion (enabling and minimalist states). This is because at the time of our data collection all but one of the states that mandates a state building code also mandates a state energy code (see May et al. 1995). However, the actual degree of state oversight of local code enforcement (which differentiates energetic from mandatory states) seems to have little effect on local priorites. This may be because state oversight efforts are not that strong in most states. Table 3 also shows that where states have provided training programs for local officials, in both the overall requirements of the building code and its energy provisions, local building officials give the energy efficiency provisions of codes higher priority for enforcement.

The situation is very different for the influence of state programs on local enforcement of seismic-related provisions of codes. There are only minor differences in influence of state approaches to enforcement and for states with moderate to high degrees of seismic risk these cannot be statistically distinguished. Similarly, staff training for local building departments provided by the state accounts for little difference in the local priority assigned to seismic provisions. Stated differently, except for differences among states in the amount of seismic risk, there appears to be similar levels of variability in local priorities among states with different approaches to code enforcement.

We attribute the striking difference in effect on priority given to energy and seismic code provisions to the differences in federal energy and seismic safety programs discussed earlier. The federal government has paid much greater attention to inducing the states to attend to energy efficiency than it has to seismic safety (e.g., expenditures on state and local energy programs are more than twenty times those of seismic safety programs). As a result, many states have adopted state energy codes and have become active in their implementation. In turn, these efforts have resulted in greater local government attention to the energy-efficiency provisions of the state codes. The federal seismic safety effort through the National Earthquake Hazard Reduction Program has not had the same effect on state adoption of seismic-related provisions or on state actions to promote local enforcement of these provisions. The differences in scale of federal energy and seismic-related programs clearly show that the latter have not been of sufficient magnitude to gain serious state attention.

Table 3. Level of Priority Given by Local Building Officials to Energy Efficiency and Seismic Safety Provisions of Building Code by Characteristics of State Building Code Programs

Characteristics of State Building Code Program	Priority Given by Local Officials to Building Code's (mean on scale of 1 (low) to 5 (high)		
	Energy Efficiency Provisions	Seismic Safety Provisions	
State Approach to Enforcement[a]			
Minimalist	2.4	2.6	(3.8)[b]
Enabling	3.1	2.2	(4.0)
Mandatory	3.6	2.7	(4.2)
Energetic	3.5	2.8	(3.5)
(Statistical significance of difference in means)	($p < .001$)	($p < .04$)	($p<.27$)
Staff Training (general)			
None received from state	2.5	2.6	(3.8)
Staff has received training from state	3.4	2.7	(4.0)
(Statistical significance of difference in means)	($p < .001$)	($p < .54$)	($p<.29$)
State Energy Agency			
No energy agency established	3.0	---	
Energy agency established	3.0	---	
(Statistical significance of difference of means)	($p < .97$)	---	
Staff Training or Financial Assistance with Energy Provisions			
None received from state	2.8	---	
Training or financial assistance received from state	3.6	---	
(Statistical significance of difference in means)	($p < .001$)	---	

Notes:

[a]Minimalist states leave local adoption and enforcement of the building code wholly to the discretion of local governments. Enabling states have established a state building code, but whether local governments enforce the code is left to local discretion. Mandatory states have adopted a state building code and require local adoption and enforcement of the code, but they exert little effort in enforcing local government compliance with this requirement. Energetic states have adopted a state building code, require its enforcement by local governments, and have programs in place to ensure that local governments comply with these directives.

[b]Figures in parentheses refer to local governments in states with a high or intermediate degree of seismic risk (see Table 2 for a list of these states).

Table 4 presents the results of our multivariate analyses of the variation in priority that local building officials attach to energy-efficiency and seismic provisions of building codes. Of interest are the relative effects of state approaches and program provisions, shown in the upper part of the table, on these priorities. In order to isolate these influences, we also control for differences in the commitment and capacity of local governments and for different aspects of the local context. The cell entries are the standardized coefficients from regression models estimated using Ordinary Least Squares estimation. Because the coefficients are standardized, they can be used as a gauge of the relative importance of different factors while keeping in mind differences in levels of statistical significance.

Table 4. Effects of State Programs on Priority Given by Local Building Officials to State Energy and Hazard-Mitigation Policy Objectives

	Standardized Regression Coefficients for Priority Given by Local Building Official to:	
Variables	Energy Provisions of Building Code	Seismic Provisions of Building Code
State Building Code Program Characteristics:		
Proactive state approach to influencing local code enforcement practices	.18***	.07
Staff size (fte of state building code agency)	.09*	-.07
Code enforcement training provided by state to local code enforcement personnel	.09*	-.01
State Energy Policy:		
Energy agency	.08*	---
Energy code training and other assistance provided to local code enforcement personnel	.16***	---
Controls for Local Code Enforcement Commitment and Capacity:		
Local code enforcement effort	.17***	.11**
Local code enforcement capacity	.22***	.20***
Controls for Local Context:		
Population, 1990	-.05	-.02
Growth, 1980-89	-.01	-.02
Income per capita, 1990	.04	.02
Political opposition to enforcement	-.05	-.01
Energy consumption per capita (state)	-.12*	---
Earthquake risk (seismic zone of locality)	---	.45***
Earthquake disaster in last decade	---	.03
Adjusted R^2	.34	.25
F-level	30.26	18.43
Significance	.000	.000
Number of localities	688	564

* $p < .05$ ** $p < .01$ *** $p < .001$ (two-tailed test)

These results are consistent with the earlier comparisons in showing that both a proactive state approach to local governments and the provision of training and financial assistance programs to increase local government capacity lead to greater priority for enforcing energy-efficiency provisions. The state approach works to increase local governmental *commitment* to enforce energy provisions of building codes. Training and financial assistance programs work to increase local government *capacity* for enforcing these provisions. The important finding is that both a proactive state approach to local governments *and* capacity-building programs are important. Among training and financial assistance programs, the provision of specialized training and assistance (in this case, for energy efficiency) clearly has a greater influence (as indicated by the magnitude of the coefficient) than more general programs designed to increase the ability of local building officials and inspection personnel to enforce the state code. Finally, we find a modest, but statistically significant, influence of state capacity (as indicated by the number of personnel working for the state's building code agency) on the priority local officials give to enforcing energy-efficiency provisions.

The multivariate analyses for seismic-related aspects of state programs also show that these have little impact on the priority that local governments attach to enforcement of seismic-related provisions of building codes. When we consider only those local governments facing an intermediate or high degree of seismic risk, we find a fairly strong positive (but not statistically significant) influence of the state approach to enforcement upon the priority that local governments attach to enforcement of seismic provisions (beta = .25, $p > .05$). In other words, in states with intermediate- and high-levels of seismic risk, local officials pay more attention to seismic code provisions when the states have adopted a state building code and mandated local enforcement of its provisions. States with higher degrees of risk are presumably more proactive in their oversight of seismic enforcement. In addition, this finding suggests federal efforts to increase adoption and enforcement of seismic provisions of codes are having some effect, given that these efforts have focused on states with the greatest seismic risk.

The multivariate results also provide insights about the influence of different characteristics of local building departments on priorities for code enforcement of energy-efficiency- and seismic-related provisions. Both receive higher priority from building officials when local building departments have greater general capacity to enforce building codes and when they exert more effort on code enforcement tasks (plan checking, inspections, technical assistance, prosecution of violators, public awareness). In related research, we have also shown that effort and capacity are key factors in attaining compliance from the private sector (Burby et al. 1998). This suggests that proactive local enforcement is likely to result both in more attention to enforcement of the seismic-related provisions of building codes and to greater attainment of compliance from the private sector with those provisions.

As expected (and shown earlier in Table 2), the degree of earthquake risk has a strong influence on the priority that local officials attach to enforcement of seismic provisions of building codes. In fact, it is the only factor with a strong effect on the priority given to seismic code provisions. This also likely captures the differences among

states in their attention to seismic code provisions since the states with stronger efforts are those in areas of highest risk. This means that the influence we attribute to seismic risk may also reflect differences in the strength of state seismic-related programs.

It is interesting to note that the amount of energy use does not have a similar effect upon the priority given to enforcing code provisions relating to energy efficiency. In fact, localities in states with lower, rather than higher, energy consumption per capita give higher priority to these tasks. This may be due to two factors. First, energy consumption, per se, has received relatively little media attention since the energy crisis of the early 1970s, while seismic risk periodically is reinforced through the occurrence of large earthquakes. Second, concern for energy efficiency may be seen by building officials less as a response to a pressing local problem and more as something that is demanded both from above (by state requirements) and from homebuyers and others. Some support for this supposition is provided by the association between local support for environmentalism (as measured by the League of Conservation Voters rating given to each locality's Congressional representative for pro-environment votes in 1993) and the priority given energy efficiency (Pearson's $r = .31$, $p < .001$). In contrast, there is little association between environmentalism and the priority given seismic safety (Pearson's $r = .01$, $p > .05$).

The other factors we expected to affect the priority that local governments give to enforcement of energy efficiency and seismic-related codes, and therefore are controlled in the multivariate analyses, have little discernible effect. Priority does not vary significantly with the population of localities, their rate of growth between 1980 and 1990, per capita income, or the degree of political opposition to strong code enforcement. These findings suggest that enforcement priority is primarily a function of choices made by local building officials rather than underlying structural factors that characterize the jurisdictions they serve.

Policy Lessons

We have shown that there are ample grounds for concern about shortfalls in local government enforcement of the seismic provisions of building codes. While these are a high priority among local governments where seismic risk is high, enforcement of these provisions receives much lower priority where the risk is moderate, but still noteworthy. This finding should be of concern to federal and state officials, because risk (and associated state programs) is the key factor for explaining variation in the priority that local governments give to enforcement of seismic-related provisions of building codes. Except in high-risk locales, increased priority for these provisions by building officials, or we suspect the private sector, will likely not occur even with more publicity about that risk. Governmental or some other intervention seems critical. But what form that intervention best takes is an open question. This research points to the federal and state experience in promoting adoption and enforcement of energy-efficiency provisions of building codes as an example of a successful federal and state approach to accomplishing similar goals.

This does not mean that federal efforts in promoting adoption and enforcement of seismic-related code provisions have been nonexistent or wholly ineffective. The federal efforts have been instrumental in pushing some states, particularly those with higher degrees of seismic risk, to adopt relevant code provisions and to require their enforcement by local governments. But, when viewed nationwide it is evident from our research that the current level of the national program to enhance adoption and enforcement of seismic provisions of building codes is too small to have a discernible impact on the priorities that local officials attach to this issue. In contrast, the federal effort to foster adoption and enforcement of code provisions concerning energy efficiency has had a marked effect on the priority that local officials attach to that function.

Several lessons stand out from this research about the components of a successful federal program for making building codes a more effective tool for earthquake-hazard mitigation. One lesson has to do with the state role in mandating local adoption and enforcement of building codes and of seismic provisions. Federal efforts to persuade states without such codes to adopt them likely will require substantial funding for states to establish state capacity for this function—much as was done in establishing state energy offices. The adoption of a state building code should be a condition for receiving such funding. In addition, eligibility requirements for federal aid should specify that the states mandate, not just encourage local governmental enforcement of the code and its seismic-related provisions. In this effort, the federal government should target recruitment of state participation those states that are located in areas of moderate to high seismic risk that have weak state building code programs or wholly lack a building code. In states with moderate to high seismic risk that already have in place strong code programs, we foresee few obstacles to the states taking advantage of additional federal technical and financial assistance to enable them to foster seismic safety in local code enforcement.

A second lesson of our research has to do with the commitment of local governments to enforce building codes and seismic provisions. Our research shows that any program that improves local government code enforcement commitment will lead to greater efforts to promote seismic safety. The most notable recent initiative in this regard is the insurance industry's program, administered by the Insurance Services Organization, to offer insurance rate reductions as an inducement to strengthen the code enforcement function in local government. In addition, the Institute for Business and Home Safety has mounted a sustained effort to make the insurance industry and government officials more aware of the key importance of local code enforcement in curbing the rate of increase in insured losses in natural disasters (see, for example, IBHS 1993). These concerns are also part of the current Project Impact program of the Federal Emergency Management Agency. Under this program, fifty-seven communities have been selected to demonstrate the benefits of local efforts to promote hazard mitigation (Federal Emergency Management Agency 1998). While each of these is a sensible undertaking, the implication of the experience with energy programs is that a much larger effort is required to have national impacts.

A third lesson from our research is the importance of education, training, and grants-in-aide that are targeted to local governments and specific to enforcement of particular code provisions. This is critical in raising the commitment and capacity of local personnel to enforce seismic (and other) code provisions. Training and education have been a central component of the federal effort to improve energy efficiency, for which our data clearly show that such assistance has had an impact.

The development of large-scale federal initiatives for promoting the adoption and enforcement of seismic provisions of building codes is, of course, not the only avenue to consider for achieving these policy goals (see May et al., 1998). However, as the experience with the federal program for energy efficiency has shown, it can be a successful approach. These directions require a sea change in the way that the federal government deals with seismic provisions of building codes. In the past, the federal government has focused its efforts on research to devise appropriate seismic safety provisions and modest programs to persuade model code organizations, and by extension states, to adopt the provisions. This effort has been highly successful in bringing about changes in seismic provisions of building codes, but these will have a disappointing impact on losses in earthquakes if they are not mandated by states or not adequately enforced by local governments. It is now time for the government to embark on a new direction. Using national energy policy as a guide, the next step should be aimed at closing gaps in state building code programs and bringing the states on board as full partners in improving the commitment and capacity of local governments to enforce these provisions.

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Notes

1. Disabled accessibility and flood-hazard management also provide opportunities for learning from federal and state policy, but each has limited applicability to mitigation of seismic risks. Federal programs to provide greater access for disabled persons have benefited from a very strong and effective constituency for change. In contrast, an equivalent constituency for earthquakes and other natural hazards has been lacking. Federal programs to reduce susceptibility to flooding through building standards are tied to the flood insurance program, which has provided the carrot to secure state and local participation. Lessons here would be useful should the federal government embark on an earthquake hazard insurance program, but otherwise are limited, since without the insurance carrot, local participation and effort would likely be limited.

2. May's data are based on conditions in 1995. The states without a state code at that time, which May (1997) terms a "minimalist" approach to building codes, are: Alabama, Arizona, Colorado, Delaware, Hawaii, Illinois, Kansas, Maine, Missouri, Mississippi, North Dakota, New Hampshire, Oklahoma, Pennsylvania, South Carolina, South Dakota, and Texas.

3. Additional states have adopted legislation that applies only to certain classes of buildings, such as schools or public buildings.

4. The following states comprised these categories (as of 1995). "Enabling" states included: Arkansas, Georgia, Idaho, Iowa, Louisiana, Minnesota, Nebraska, and West Virginia. "Mandatory" states included: California, Florida, Indiana, Massachusetts, Maryland, New Mexico, Nevada, Rhode Island, Utah, Virginia, Washington, Wisconsin, and Wyoming. "Energetic" states include: Alaska, Connecticut, Kentucky, Michigan, Montana, North Carolina, New Jersey, New York, Ohio, Oregon, Tennessee, and Vermont.

5. For more detailed descriptions of energy efficiency programs and an assessment of their potential to serve as a model for programs to foster the mitigation of natural hazards, see McMillan an Burby (1998), May et al. (1998), and May and Bolton (1991).

6. This situation is also indicated by the relatively large number of local building officials (10 percent for energy provisions and 24 percent for seismic provisions) who reported that the code they enforced did not contain provisions related to energy efficiency or seismic safety.

References Cited

Advisory Commission on Intergovernmental Relations. 1966. *Building Codes: A Program for Intergovernmental Reform*. Report A-28. Washington, DC: ACIR.

Burby, Raymond J., Steven P. French, and Arthur C. Nelson. 1998a. "Plans, Code Enforcement, and Damage Reduction: Evidence from the Northridge Earthquake," *Earthquake Spectra*, 14, 1 (February 1998): 59-74.

Burby, Raymond J., Peter J. May, and Robert Paterson. 1998b. "Improving Compliance with Regulations: Choices and Outcomes for Local Government," *Journal of the American Planning Association* 64 (3): 324-334.

California Seismic Safety Commission. 1995. *Northridge Earthquake: Turning Loss to Gain, Seismic Safety Commission Report to Governor Pete Wilson.* Report SSC 95-01, Sacramento: The Commission.

Federal Emergency Management Agency. 1998/ Project Impact: Building a Disaster Resistant Community. Press release 1 June. Washington, D.C.: Federal Emergency Management Agency, Washington, D. C.

Flanigan, Ted and Stan Hadley. 1994. *Analysis of Successful Demand-Side Management at Publicly Owned Utilities*. Oak Ridge, TN: Oak Ridge National Laboratory, August.

Hirst, Eric. 1994. "A Bright Future: Energy Efficiency Programs at Electric Utilities," *Environment* 36 (9): 10-21.

Insurance Institute for Property Loss Reduction. 1995. *Coastal Exposure and Community Protection: Hurricane Andrew's Legacy*. Boston: Insurance Institute for Property Loss Reduction.

Institute for Business and Home Safety. 1993. *Building Codes: Defining the Insurance Industry Role*. Boston: IBHS.

May, Peter J. 1997. "State Regulatory Roles: Choices in the Regulation of Building Safety," *State and Local Government Review* 29 (2): 70-80.

May, Peter J. and Patricia Bolton. 1991. "Assessing Floodproof Retrofitting Implementation Prospects: Implications of Energy Conservation Efforts," in *Floodproof Retrofitting: Homeowner Self-Protective Behavior*, Monograph No. 49, Shirley Laska, ed. Boulder, CO: Institute of Behavioral Science, University of Colorado.

May, Peter J., Dan Hansen, and Mark Donovan. 1995. "State Building and Energy Code Administration: Report to Respondents to a National Survey of State Agencies."

Seattle, WA: Department of Political Science, University of Washington, September.

May, Peter J., Raymond J. Burby, and Howard Kunreuther. 1998. "Policy Design for Earthquake Hazard Mitigation: Lessons from Energy Conservation, Radon Reduction, and Termite Control," *Earthquake Spectra*, forthcoming.

McMillan, Sandra C. and Raymond J. Burby. 1998. "Energy Efficiency Programs as a Model for Policy to Promote Hazard Mitigation in Single Family Residential Buildings." DURPS Working Paper No. 53. New Orleans, LA: College of Urban and Public Affairs, University of New Orleans, July.

National Commission on Urban Problems. 1968. *Local Land and Building Regulation: How Many Agencies? What Practices? How Much Personnel?* Research Report No. 6. Washington, DC: Government Printing Office.

National Conference of States on Building Codes and Standards (NCSBCS). 1992. *Seismic Provisions of State and Local Building Codes and Their Enforcement*. Washington, DC: National Institute of Standards and Technology, U.S. Department of Commerce, May.

Olshansky, Robert B. 1998. *Promoting the Adoption and Enforcement of Seismic Building Codes: A Guidebook for State Earthquake and Mitigation Managers*. FEMA 313. Federal Emergency Management Agency, Washington, D.C.

Randolph, John. 1984. "Energy Conservation Programmes: A Review of State Initiatives in the USA," *Energy Policy* 12 (4): 425-438.

Sioshansi, Fereidoon P. 1994. "Restraining Energy Demand: The Stick, the Carrot, or the Market?" *Energy Policy* 22 (5): 378-392.

Smith, Loretta A. and Steven Nadel. 1995. *Energy Code Compliance*. Washington, DC: American Council for an Energy-Efficient Economy.

Southern Building Code Congress International, Inc. 1992. *Coastal Building Department Survey*. Chicago: Natural Disaster Loss Reduction Committee, National Committee on Property Insurance.

Turchen, Stephen and Craig Conner. 1996. "Making Sense of the Model Energy Code," *Home Energy* 13 (2): 21-25.

U.S. Department of Energy, Building Standards and Guidelines Program. 1997a. *About the Model Energy Code*. Washington, DC: U.S. Department of Energy, at http://www.energycodes.org.

U.S. Department of Energy. 1997b. *Rebuilding Your Home Sustainably*. Washington, DC: U.S. Department of Energy at http://www.sustainable.doe.gov.