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EXPLAINING SUPPORT FOR SEISMIC LOSS-REDUCTION MEASURES: DATA FROM A HOUSEHOLD SURVEY IN THE EAST BAY REGION OF NORTHERN CALIFORNIA

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Abstract

A willingness-to-pay framework is used to assess public support for further enhancing the seismic resistance of elements in the built environment. Using data from a survey of 727 households in the Oakland/East Bay Region, a series of models are tested in order to identify factors associated with willingness to pay to further strengthen public safety buildings, utility lifelines, transportation lifelines, schools, and residential and commercial buildings. A substantial proportion of the sample expressed a willingness to pay at least something to strengthen one or more of these structures and systems, with public safety buildings and utility systems receiving the highest priority. Although a variety of factors influenced willingness to invest in strengthening different types of structures and systems, some factors did show a consistent influence across models. Those factors include gender, education, trust in government (particularly the State of California), and having experienced property damage and other problems following the 1989 Loma Prieta earthquake. Findings provide insight into which elements in the built environment community residents value most and help identify pockets of support for stronger earthquake safety measures in a seismically-vulnerable region.

Introduction

Despite the growing emphasis on performance-based design and on developing seismic loss-reduction policies that are consistent with public conceptions of acceptable risk, we currently lack detailed information on how the public expects critical elements in the urban built environment to perform when an earthquake occurs or on what standards of performance residents of vulnerable areas consider acceptable. Both past research and experience in the U. S. present a somewhat contradictory picture of the strength and scope of public support for hazard-reduction measures. On the one hand, there is a substantial body of work in the social sciences suggesting that both the general public and opinion leaders assign a low priority to earthquake and other disaster-related loss-reduction programs (Rossi, Wright, and Weber-Burdin 1982; Drabek, Mushkatel, and Kilijanek 1983; Mittler 1989; Federal Emergency Management Agency 1993). On the other hand, some studies have shown that significant public support does exist for stronger seismic safety measures. For example, Palm and Carroll (1998), focusing on a sample of Northern and Southern California homeowners, found that a majority of their survey respondents favored stricter building codes, mandatory strengthening of public buildings, and improvements in emergency communications systems, even if such measures would have to be paid for with higher taxes. At the same time, however, while survey respondents believed that government should be involved in promoting higher levels of earthquake safety, they tended to see protection against earthquake losses as fundamentally an individual rather than a governmental responsibility.

While some communities have been successful in implementing stronger seismic safety ordinances for existing buildings, such policies have a greater likelihood of being judged politically acceptable in the wake of damaging earthquakes (Alesch and Petak 1986). Following the 1994 Northridge earthquake, for example, the City of Los Angeles adopted an impressive set of mandatory and voluntary seismic safety ordinances and standards, including a mandatory ordinance for pre-1976 tilt-up concrete buildings and voluntary measures to reduce losses in existing hillside buildings, reinforced concrete buildings, and concrete frame buildings with masonry infills. While earthquake disasters are clearly important factors encouraging the adoption of loss-reduction measures, little research exists on what factors influence support for more stringent seismic safety measures in the absence of such events (National Academy of Sciences/National Research Council 1997).

Recent earthquakes have highlighted the need for a better understanding of public and stakeholder expectations concerning disaster impacts, as well as their loss-reduction policy preferences for buildings and lifelines. More information is needed on the significance community residents and leaders attach to seismic damage-reduction measures and to maintaining the functionality of elements in the built environment following earthquakes. Similarly, it is important to learn whether there are infrastructural elements and structures that are considered so essential by community residents that they would be willing—both attitudinally and financially—to support measures to ensure higher levels of performance.

To address these kinds of questions, in 1998 the Disaster Research Center initiated a study in the San Francisco Bay Area's East Bay Region, an area in the U. S. that was selected because of its vulnerability to earthquakes and its similarity to some vulnerable regions in Japan. The general goals of the study are to better understand what levels of seismic performance residents of a high-risk area judge to be acceptable and what factors affect willingness to support stronger seismic rehabilitation measures. More specifically, the study seeks to obtain information on: (1) the expectations that the general public and various stakeholder groups have concerning likely earthquake impacts on the built environment; (2) the importance they attach to the survivability and performance of various elements within the built environment, including lifeline systems (e.g., bridges, highways, utility lifelines) and various types of structures (e.g., residential units, schools, community buildings, hospitals); and (3) seismic mitigation policy preferences, with a particular emphasis on understanding both what East Bay residents consider acceptable levels of performance for different structures and systems and the degree to which they support rehabilitation and retrofit programs that would improve performance. The project employs two methodological approaches: a mail questionnaire designed to obtain information from East Bay residents, and focus group interviews with representatives of selected stakeholder groups.

This paper, which reports results from the East Bay survey, seeks to determine factors associated with support for stricter seismic mitigation measures for elements in the built environment. More specifically, it focuses on the extent to which East Bay residents are willing to pay for higher levels of seismic safety, and if, so, for what systems. To the extent that reluctance to make that investment signals an acceptance of the status quo, willingness to pay can be considered an indirect measure of the degree to which current levels of risk and vulnerability are acceptable. The analytic approach used here makes two assumptions. First it assumes that survey responses revealing differences in willingness to pay for seismic upgrading are at least in a general sense indicative of respondents' preferences and of the value respondents assign to the continued performance of different elements of the built environment in the event of a damaging earthquake. The analysis also assumes that these differences can be explained at least in part by respondents' sociodemographic characteristics, experiences with the earthquake threat, and performance expectations for elements in the built environment.

Study Methodology

Study Sample and Survey Strategy

The mail survey from which the data for this study were obtained was administered using an approach based on Dillman's total design method (1978), which emphasizes the importance of systematic follow-up and remailings to achieve optimal response rates. In early July, 1999, questionnaires were mailed to 1750 randomly-selected households in Alameda County communities; that sample included an oversample of 250 households in the city of Oakland. Approximately two weeks after the initial mailing, postcard reminders were mailed to those who had not responded. A few days after that mailing, telephone calls were made to non-responders for whom phone numbers were available (1,068 households, a substantial proportion of the non-responders) to encourage them to complete the survey. Approximately two months after the initial mailing, a second mailing was sent to households that had still not returned their questionnaires.

A total of 727 surveys were returned. Taking into account cases that were removed from the original sample for various reasons, the response rate for the study, including both the Alameda county regular sample and the Oakland over-sample, was 42.9%. For the former, the response rate was 43.9% (N=638), while for the latter, it was 36.9% (N=89). Those who completed the survey were not entirely representative of study area residents. Compared with the population of Alameda County, survey respondents were more likely to be older, white, earning more than the median income for the county, more highly educated, and more likely to be homeowners. Groups that were under-represented in the survey include adults under age 24, African Americans, households earning less than the median income (approximately $35,000), those who have not attended college, and renters.

Topics Addressed in the Questionnaire

The mail questionnaire used for the East Bay survey sought information on a range of topics, including the following: respondents' sociodemographic characteristics, including age, race/ethnicity, education and income, as well as other information, such as whether respondents own or rent their homes; general perceptions of the severity of the earthquake risk, both compared to other problems facing East Bay residents, such as crime, and compared to other natural and technological hazards; respondents' previous experiences with earthquakes and other disasters, including losses they may have experienced in the 1989 Loma Prieta earthquake; perceptions of the likelihood of a major earthquake within five, ten, and twenty years; expectations about the harm and disruption such an earthquake would cause, both to their households and to the community more generally; household earthquake mitigation and preparedness measures respondents have adopted; and the extent to which they have confidence in the ability of both government and building owners to provide protection from earthquake losses.

To address issues of acceptable levels of risk and support for seismic rehabilitation measures, the questionnaire also contained a series of detailed questions designed to obtain data on the levels of damage and disruption respondents anticipate to twenty different elements in the built environment, including bridges over the Bay, utility systems, and various types of structures, if an earthquake on the scale of the 1989 Loma Prieta event were to occur closer to the East Bay Region. The questionnaire also required respondents to rate the criticality of each of those twenty systems and building types and to select the five that they considered most critical.

The analyses presented here focus on respondents' willingness to pay for the seismic upgrading of different categories of lifelines and structures. We first present data on overall willingness to pay and later move on to discussing factors that predict willingness to pay, both for seismic upgrading generally and for the rehabilitation of specific types of structures and systems.

Study Findings

Willingness to Pay for Seismic Upgrading

Because pilot tests indicated that respondents would have great difficulty making willingness-to-pay judgments about twenty different elements in the built environment, the question concerning willingness to pay asked not about specific types of structures and systems, but rather about six general groupings of elements in the built environment—public safety buildings, utility systems, transportation systems, schools, residential buildings, and commercial buildings—under which those elements were subsumed. The willingness-to-pay question was phrased in the following manner: "Given what you know about the chances of a damaging earthquake in the East Bay, how much would you be willing to pay each year for ten years in extra taxes, fees, or charges to strengthen the following sets of buildings and facilities so they would continue to operate following an earthquake?" Respondents were also asked to take into account their household resources in answering the question and to assume that their contributions would go directly to keeping those structures and systems operational.[1]

Table 1: Percent Willing to Pay to Strengthen Elements in the Built Environment

	Ranking of Elements	**% of cases**
1	Public safety buildings	82.3
2	Utility systems	80.0
3	Transportation systems	79.5
4	Schools	65.9
5	Residential buildings	45.6
6	Commercial buildings	28.9
	Willing to pay: At least one element	85.0

Table 1 presents data on the proportion of survey respondents who were willing to invest at least something to seismically upgrade one or more of the six categories of structures and systems. Overall 85% of respondents were willing to pay at least a minimal amount of money over a ten-year period to strengthen at least some structures and systems in the East Bay. Respondents showed the greatest willingness to invest in enhancing the seismic resistance of public safety buildings, a category that includes fire stations, police departments, other key governmental buildings, and major hospitals. Over 80% were willing to pay at least something to obtain higher

[1] In asking respondents to specify the exact dollar amounts they would be willing to pay for enhancing the seismic resistance of the built environment, the original plan was to derive measures of willingness to pay that could be used as dependent variables in OLS regression models. However, because amount of money people were willing to pay was so widely distributed and because responses to some items were skewed, the willingness-to-pay variable was treated as dichotomous for analytic purposes; that is, respondents were categorized as either "not willing to pay anything" or "willing to pay something" for seismic rehabilitation.

levels of seismic resistance for those structures. A large proportion of respondents also showed a willingness to commit funds for the seismic strengthening of utility systems (80% willing to pay), transportation systems (79% willing to pay), and schools (66% willing to pay). In contrast, relatively few people were willing to use their money to upgrade residential and commercial structures. Approximately 46% of the respondents would pay to upgrade residential structures, and only 29% were willing to pay for the upgrading of commercial buildings.

In deciding on whether and where to invest their funds, respondents appear to be making two kinds of distinctions. First, they seem to be more willing to pay to upgrade buildings and systems that they believe must remain operational for the good of the entire community (e.g., health- and safety-related building, lifelines), as contrasted with those that are less critical from the point of view of the community. Second, they appear to be distinguishing between elements in the built environment that they believe should be strengthened using funds raised from the general public, such as public safety buildings, and those that owners themselves, rather than the public, should pay to make more seismically resistant. For example, of the six categories, respondents show the least willingness to pay for upgrading commercial buildings, perhaps because they see such measures as the sole responsibility of building owners.

Factors Predicting Willingness to Pay for Loss-Reduction Measures

A series of logistic regression analyses were conducted to identify factors that are associated with East Bay residents' willingness to pay for seismic upgrading. Table 2 contains a listing of survey variables that were employed in those models. The majority of those variables were selected for inclusion in the survey because previous research suggests that they influence a broad range of hazard-related behaviors. For example, in various U. S. studies, income, education, prior disaster experience, gender, perceived risk, minority status, home ownership, and presence of children in the home have been found to be associated with higher levels of disaster preparedness, as well as with risk perception, willingness to take self-protective actions when disasters strike, and support for governmental programs to reduce disaster losses (Turner, Nigg, and Heller-Paz 1986; Lindell and Perry 1992; Edwards 1993; Palm and Carroll 1998; Tierney, Lindell, and Perry 2001). We thus reasoned that those factors might also affect willingness to commit financially to enhancing earthquake safety.

Other variables used in the models were based on information respondents had provided regarding the extent to which they use different types of structures and systems on a regular basis—for example, whether they have children in public or private schools and whether they typically commute using BART or area bridges. Data on use of structures and systems were employed in models predicting both overall willingness to pay and willingness to pay to strengthen particular categories of structures and systems, based on the assumption that daily use would influence respondents' views on enhancing their performance levels.[2]

Also included in the models were a variable measuring the degree of trust respondents place in the ability of various public- and private-sector entities to provide protection against earthquake damage, as well as two composite importance measures, one assessing importance for the six categories of structures and systems, and the other summarizing respondents' assessments of the importance of all twenty types of facilities and systems in the built environment. It seems

[2] The questionnaire did not ask people if they used electricity and water on a daily basis, because it was assumed that these lifeline systems were used by everyone. The same logic was applied to residential dwellings. Instead, we sought to obtain whether reliance on particular types of infrastructural elements (e.g., schools, highways) influenced willingness to pay.

Table 2: Variables Used in Logistic Models Predicting Willingness to Pay

Variable Type	Variable	Variable Description
Demographics	Gender	0 = female, 1 = male
	Age	In years
	Race	0 = non-white, 1 = white
	Current employment status	0 = part-time or non-employed, 1 = full-time employed
	Highest level of education	Ordinal scale raging from 1 = never attend school to 9 = doctorate degree received
	Number of children aged under 18 years old	Number children
	Ownership status	0 = rent , 1 = own
	Household income	Grouped income level raging from 1 (< 10k) to 10(90k+)
Risk Perceptions	Worry about earthquake	5-point Likert scale with 1 = constantly worry
	Risk of earthquake vs. other hazards	5-point Likert scale with 1 = no risk
	Likelihood of earthquake in next five years	0 = not or some likely, 1 = very likely
	Likelihood of earthquake in next ten years	0 = not or some likely, 1 = very likely
	Likelihood of earthquake in next twenty years	0 = not or some likely, 1 = very likely
	Likelihood that another big earthquake will hit here	Composite item, ranging from –3, not likely all, to 3 = very likely
Community Attachment	Length of time living in Bay Area	Years
	Length of time living in Alameda County	Years
	Length of time living in current home	Years
Use of Facilities	Composite facility use	Sum of answer on life needs items with 0 = no needs
	Child attends public school*	0 = no, 1 = yes (used in the school model only)
	Child attends private school*	0 = no, 1 = yes (used in the school model only)
	Child goes to day care center*	0 = no, 1 = yes (used in the school model only)
	CrossBbay by car*	0 = no, 1 = yes (used in the transportation model only)
	Cross Bay on BART*	0 = no, 1 = yes (used in the transportation model only)
	Take free way regularly*	0 = no, 1 = yes (used in the transportation model only)
	Work in city, county, state or federal building*	0 = no, 1 = yes (used in the public safety model only)
	Work in a building over 6 stories*	0 = no, 1 = yes (used in the commercial model only)
	Work for a utility company*	0 = no, 1 = yes (used in the utility model only)
Household Mitigation & Disaster Experience	Adoption of household mitigation measures	9-item index, ranging from 0=nothing to 8=all measures
	Experienced community disruption in L. P.	0 = no., 1 = yes
	Experienced property damage in L. P.	0 = no, 1 = yes
	Experienced psychological stress in L. P.	0 = no, 1 = yes
	Lived in area at time of L. P.	0 = no, 1 = yes
	Affected by L. P., relative to others	5-point Likert scale with 1 = much less than most people
	Experienced other disaster in the last 10 years	0 = no, 1 = yes
	Index for overall experience	Sum of experience variables. Values range from 0 to 10
Expected Damage—Structures & Systems	Residential buildings*	5-point Likert scale with 1 = no damage or disruption
	Commercial buildings*	5-point Likert scale with 1 = no damage or disruption
	Public safety buildings*	5-point Likert scale with 1 = no damage or disruption
	School buildings*	5-point Likert scale with 1 = no damage or disruption
	Utility systems*	5-point Likert scale with 1 = no damage or disruption
	Transportation systems*	5-point Likert scale with 1 = no damage or disruption
Functional Importance—Structures & Systems	Residential buildings*	5-point Likert scale with 1 = not important at all
	Commercial buildings*	5-point Likert scale with 1 = not important at all
	Public safety buildings*	5-point Likert scale with 1 = not important at all
	Functional importance: school buildings*	5-point Likert scale with 1 = not important at all
	Utility systems*	5-point Likert scale with 1 = not important at all
	Transportation systems*	5-point Likert scale with 1 = not important at all
Trust in Government, Others	Trust state government	5-point Likert scale with 1 = no trust or confidence
	Trust federal government	5-point Likert scale with 1 = no trust or confidence
	Trust local government	Mean score for trust in city/county government
	Trust private sector	Mean score for 4 private sector trust variables
	Trust scientists	5-point Likert scale with 1 = no trust or confidence

* Variables used in overall model and specific models that matched with their contents.

reasonable to assume that members of the public will not be willing to invest in programs unless they place at least some degree of trust in the entities that would be administering and implementing those programs. Similarly, we expected that support for strengthening elements in the built environment would be associated with views on the importance of maintaining the functionality of those structures and systems.

Table 3 presents the results of a series of logistic regression analyses that were conducted, first to identify predictors of overall willingness to pay for seismic upgrading, and then to identify factors associated with willingness to pay to make each of the six infrastructural elements more seismically resistant.

The first model identifies significant predictors associated with support for enhancing the seismic safety of *any of the six categories of structures and systems.* As indicated in the table, women are more likely then men to be willing to commit additional funds for seismic upgrading, a finding that is consistent with other research indicating that women differ from men both in their risk perceptions and in their readiness to adopt loss-reduction measures. Willingness to commit funds for loss reduction over a ten-year period is also associated with higher levels of education.

Additionally, overall support for seismic upgrading is associated with both risk perceptions and previous earthquake experiences. Those who indicate that they worry more frequently about the possibility of an earthquake in their community are more likely to support seismic loss reduction measures, as are those who view the probability of an earthquake as likely in the next twenty years.[3] Respondents who experienced property damage in the Loma Prieta earthquake are also more likely to be willing to pay for higher levels of seismic safety. Individuals who have lived a longer time in their current homes are slightly less willing to pay, a result that may be explainable by the fact that length of residence is moderately correlated with age, a factor that appears to be associated with reduced support for seismic upgrading. The degree of trust residents have in the ability of the State of California to provide protection to communities is a positive predictor of willingness to invest in programs to strengthen elements in the built environment, suggesting that trust in government influences positions on willingness to pay.

Because survey results indicated that members of the public place a higher priority on some elements in the built environment than on others, analyses were also undertaken to identify factors associated with support for enhancing the earthquake resistance of each of the six categories of structures and systems—residential structures, commercial structures, public safety buildings, schools, utility lifelines, and transportation lifelines. Following the results for the overall model, Table 3 also contains results of logistic regression analyses focusing on specific categories of built environment elements.

In the first model, which focuses on support for the seismic upgrading of residential structures, race/ethnicity was a significant predictor variable, with nonwhites more likely than whites to indicate they would support strengthening measures for residential dwellings. This is an

[3] Interestingly, individuals who saw a major damaging earthquake as highly likely within a shorter time periods—five years and ten years—are no more likely to be willing to pay for seismic upgrading. It is unclear why this is the case, but the relationship between a longer-term risk time horizon and willingness to pay was also shown to be significant with respect to the other models that were analyzed here. Perhaps respondents who believe that another earthquake is highly likely in the short term do not believe that loss-reduction measures can be put in place quickly enough to prevent damage and disruption from an immanent event.

Table 3: Statistically Significant Predictors in Logistic Regression Models of Willingness to Pay

Models	Predictors	B	SE	Wald	Sig.	Odds Ratio
Model 1: Overall model	Gender	-.690	.333	4.299	.038	.502
	Education	.236	.110	4.599	.032	1.266
	Worry about earthquake	.423	.155	7.398	.007	1.526
	Length of time in current home	-.041	.013	10.010	.002	.959
	Experienced property damage	.376	.182	4.269	.039	1.457
	Trust State government	.356	.160	4.913	.027	1.427
	Likelihood of Earthquake in 20 yrs.	.971	.406	5.717	.017	2.642
	Constant	-1.290	1.005	1.650	.199	.275
Model 2: Residential model	Race	-.349	.180	3.763	.052	.705
	Functional importance (residential buildings)	.412	.098	17.741	.000	1.509
	Trust local government	.282	.096	8.578	.003	1.325
	Experienced property damage	.178	.091	3.812	.051	1.195
	Constant	-2.159	.479	20.289	.000	.115
Model: Commercial model	Education	-.128	.063	4.188	.041	.880
	Trust State government	.296	.110	7.211	.007	1.344
	Trust private sector	.286	.141	4.095	.043	1.331
	Experienced stress	.458	.219	4.360	.037	1.581
	Functional importance (commercial buildings)	.409	.093	19.366	.000	1.506
	Constant	-2.519	.639	15.526	.00	.081
Model 4: Public safety model	Gender	-.592	.269	4.840	.028	.553
	Risk of Earthquake	.308	.121	6.531	.011	1.361
	Education	.273	.084	10.689	.001	1.314
	Length of time in current home	-.024	.010	5.848	.016	.976
	Trust State government	.386	.132	8.500	.004	1.471
	Experienced property damage	.301	.146	4.285	.038	1.352
	Constant	-1.569	.813	3.724	.054	.208
Model 5: School model	Gender	-.481	.212	5.134	.023	.618
	Age	-.014	.007	4.031	.045	.986
	Education	.154	.067	5.286	.021	1.166
	Worry about earthquake	.209	.096	4.775	.029	1.233
	Overall earthquake experiences	.103	.039	6.826	.009	1.108
	Public School attendance	.962	.242	15.833	.000	2.617
	Functional importance (schools)	.402	.108	13.936	.000	1.495
	Constant	-1.793	.745	5.798	.016	.166
Model 6: Utility model	Gender	-.744	.261	8.133	.004	.475
	Education	.273	.082	11.004	.001	1.314
	Likelihood of Earthquake in 20 yrs.	.695	.310	5.021	.025	2.004
	Risk of Earthquake	.322	.116	7.689	.006	1.380
	Length of time in current home	-.022	.010	5.065	.024	.978
	Trust State government	.372	.127	8.580	.003	1.451
	Constant	-1.660	.806	4.239	.040	.190
Model 7: Transportation model	Gender	-.556	.254	4.788	.029	.574
	Education	.291	.080	13.057	.000	1.337
	Earthquake risk	.441	.115	14.756	.000	1.555
	Length of time in current home	-.028	.010	8.215	.004	.972
	Trust State government	.389	.127	9.404	.002	1.475
	Experienced property damage	.322	.136	5.588	.018	.092
	Constant	-2.384	.785	9.215	.002	.092

interesting finding which could be explainable in part by the fact that nonwhites in our sample tend to live in apartments, rather than in less-vulnerable single-family homes. They also tend to be renters. Support for strengthening residential buildings among nonwhites may thus be a reflection of the fact that they nonwhites tend to reside in more vulnerable dwellings. Nonwhites in the sample are also significantly more likely than whites to indicate that they worry often about earthquakes. The importance respondents assigned to the continued functionality of residential structures in the event of an earthquake was also positively associated with willingness to pay. While trust in the state government to protect the community in the event of an earthquake is associated with overall willingness to pay, trust in local government—that is, city and county government—emerges as a significant predictor of support for residential seismic safety measures. This is understandable, since it is local government that is most likely to enact and enforce residential seismic safety measures. As in the overall model, those who experienced property damage as a result of the Loma Prieta event were more likely to be supportive.

Analyses identified four significant predictors of support for the seismic upgrading of commercial structures. In contrast with the overall model, education was negatively associated with willingness to pay, suggesting that better-educated respondents tend not be supportive of this type of seismic upgrading—or at least that they are not willing to pay for it. Trust in both state government and the private sector was positively associated with willingness to pay, as was having experienced emotional stress as a consequence of the Loma Prieta earthquake.

Turning next to factors predicting willingness to pay for the seismic upgrading of public safety buildings, gender (that is, being female), perceived earthquake risk—the predictor variable in this case is perceived risk of death or serious injury to the respondent or his/her family from a future earthquake—education, trust in state government, and having experienced property damage in the Loma Prieta earthquake are all significant predictors of willingness to pay. The length of time respondents have lived in their current homes is once again negatively associated with support for strengthening loss reduction measures, but not strongly. This model very closely resembles the model explaining overall willingness to pay—which is understandable, given that more than 80% of all respondents are willing to pay at least something to strengthen public safety buildings.

Some the same factors predict support for the seismic strengthening of schools, although in this case new variables also emerge as significant. Women and the better-educated are more willing to pay, as are those who worry more about the earthquake threat. Having experienced more consequences of the Loma Prieta earthquake (a variable that includes consequences such as property damage and business damage as well as other negative impacts) is a positive predictor of willingness to pay. Also significant are having children in the home that attend public schools and placing a high priority on the survivability and continued operation of schools following an earthquake—both findings that make intuitive sense. Interestingly, this is the only model in which age appears as a significant predictor of willingness to pay, with older respondents indicating they are less supportive of strengthening schools than younger ones.

The models explaining willingness to pay to strengthen utility and transportation systems are similar to one another and also similar to other models discussed above. Significant predictors in the utility system model resemble those in the overall willingness-to-pay model as well as the model predicting support for upgrading public safety facilities. Risk perception variables are important predictors in both the utility and the transportation model, though the measures themselves are slightly different. Some results derived from these analyses are confusing. For example, why should having experienced property damage be important for supporting higher levels of seismic safety for transportation systems, but not for utility lifelines? While some analytic results are relatively easy to interpret, others are not.

General Observations on Willingness-to-Pay Models

As indicated in Table 4, significant predictors in each of the seven models do a reasonably good job of predicting outcomes on the dependent variable. However, the models only explain a small amount of the observed variation in willingness to pay. The model predicting overall willingness to pay is strongest in terms of variance explained, while the model that focuses on support for residential seismic upgrading is the weakest.

Table 4: Summary of Logistic Regression Models for Willingness to Pay

Models	Chi-square	df	Sig.	Nagelkerke R Square	Overall Correct Predictive Rate	Sensitivity Rate	Specificity Rate
Overall	53.635	7	.000	.225	75.5	77.4	63.0
1. Residential	40.908	4	.000	.093	62.7	68.6	56.0
2. Commercial	62.011	5	.000	.143	63.7	69.4	60.3
3. Public Safety	47.359	6	.000	.149	71.0	73.3	56.6
4. School	77.070	7	.000	.188	67.7	69.4	63.5
5. Utility	53.929	6	.000	.163	67.2	67.4	65.9
6. Transportation	64.733	6	.000	.191	73.6	77.2	56.0

Notes:

1. Sensitivity is defined as the proportion of events predicted to be events.
2. Specificity is defined as the proportion of non-events predicted to be non-events.
3. Chi-Square tests the null hypothesis that the all coefficients, except the constant, are 0.
4. The Nagelkerke R square, a modification of Cox and Snell R^2, represents the proportion of variance explained by the model.
5. Set method = Forward Stepwise (likelihood Ratio).

Several variables appear consistently as significant predictors of willingness to pay across two or more models. More-educated community residents are more willing to invest financially in higher levels of seismic safety, and women are more willing to make those investments than men. Support for higher levels of seismic safety is also related to trust in government—particularly trust in the state of California—and to experiences respondents had in the Loma Prieta earthquake, the last event that caused serious damage in the study region. Respondents who have not lived very long in their current homes are more supportive of enhanced seismic safety than longer-term residents. Among the more interesting findings to emerge from the models is the fact that despite their lower income levels, nonwhites appear to be significantly more willing to pay for the seismic upgrading of residential structures than are white residents of the East Bay.

Model results also contradict expectations in a number of ways. For example, although some risk perception variables achieve significance in one or more models, their influence is not consistent across models. Contrary to what might be expected, these analyses found no relationship between household adoption of mitigation measures and willingness to pay to strengthen structures and systems in the community. This latter finding is probably related to the fact that so few households in the sample had undertaken even basic mitigation actions, producing little variation on that factor.

Conclusions

Using the willingness-to-pay framework to make inferences about public support for loss-reduction measures clearly has limitations. Developing reliable and valid measures of the underlying values influencing views on public goods such as safety and environmental quality is invariably problematic. Numerous analysts have pointed to sources of instability and distortion in willingness-to-pay judgments (see, for example, Fischhoff, 1991; O'Doherty, 1996; Bjornstad and Kahn, 1996). Some critics (e.g. Diamond and Hausman, 1994) argue that contingent valuation methods are simply inappropriate for revealing individuals' preferences with respect to nonmarket goods.

More generally, it has long been recognized that attitudinal statements are notoriously poor predictors of subsequent behavior. Just as in other studies on attitudes, survey data on willingness to pay may have little to do with how people actually respond when faced with choices about investing in seismic safety. Fisher (1996), for example, cites a number of studies in which relatively small proportions of respondents who had indicated a willingness to contribute to environmental causes actually did so when given the opportunity later. Obviously, individuals who indicate in surveys that they support particular measures may not actually follow through when asked to vote on those same issues. Questions addressing support for seismic loss-reduction measures in the Bay Area are further complicated by the fact that survey respondents may not actually recognize how much they are currently paying to mitigate earthquake losses to the built environment.[4]

Despite these limitations, if used properly, data such as those reported here are useful in a variety of ways. First, they provide a general idea of which types of structures and systems community residents believe it is most important to protect—that is, where they are willing to tolerate damage and disruption and where they are not. Put another way, data like these provide a good starting point for addressing questions related to the acceptability of seismic risks. Second, these findings help identify structures and systems in which the public believes they have some responsibility to invest. These respondents, for example, show a clear preference for investing in strengthening the public infrastructure, but not private residential or commercial buildings, and they are most interested in the survivability of public safety buildings.[5] Third, these findings help to identify pockets of support for seismic loss reduction, suggesting for example, that women, the better-educated, and those who tend to trust the government to protect the public in the event of an earthquake are potential supporters of stricter loss-reduction measures.

Of course, data like those reported here should not be considered in isolation. Rather, they should be combined with other sources of data on public preferences with respect to earthquake loss reduction—for example, information on who actually supports seismic safety laws and ordinances at the state and local level. Quantitative survey results must also be interpreted in light of other types of data, such as findings from qualitative studies on community residents' expectations and preferences. That will be done in the next phase of the current study, which will compare survey findings to data collected in focus group interviews in which participants were asked to consider many of the same types of questions.

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[4] For example, tolls have been raised on the San Francisco Bay Bridge to help cover the costs of seismic retrofits, but it is unclear what proportion of bridge users—or Bay Area residents generally—know this, despite the fact that the issue has been discussed extensively in the media.

[5] It is also interesting to note that willingness to pay for the seismic upgrading of public safety facilities is not related to how much damage respondents expect these facilities to sustain in the next earthquake. Respondents actually believe that such structures should perform reasonably well. Nevertheless, they appear to support even stricter measures to raise the seismic resistance of these structures.

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