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Abstract. Earthquake insurance can reduce potentially disastrous economic losses to house· holds and is therefore a prime method of mitigating against the worst economic effects of damaging earthquakes. The decision to purchase such insurance is a special case in the general study of individual response to uncertainty in the environment. An understanding of this decision process elucidates the ways in which environmental information becomes translated into behavior change. Although California legislation has mandated the disclosure of the availability of earthquake insurance to all residential property owners since 1984, less than half of California homeowners have earthquake insurance. This paper reports on the results of a survey of 3,500 owner-occupiers in Contra Costa, Santa Clara, Los Angeles, and San Bernardino Counties conducted in the summer of 1989. The survey was undertaken to discover the locational concentrations of insurance policy-holders and the socioeconomic, demographic, and attitudinal characteristics that distinguish insured from noninsured homeowners. The results show that insurance purchase is not spatially related to geophysical risk and that the purchase of insurance is not systematically related to income, equity in the home, age of the head of household, or other socioeconomic characteristics. Instead, perceived risk is the primary factor associated with insurance purchase.

Key Words: earthquake hazard, mitigation, insurance, Geographic Information Systems, risk, natural hazards.

THE 1989 Lorna Prieta earthquake in the San Francisco Bay area, which resulted in the loss of 62 lives and an estimated $6 billion of property damage, reminded the public and the press of the immense earth quake hazard that affects not only this region but other parts of the U.S. (Lorna Prieta Reconnaissance Team 1990). The research reported here focuses on one method of mitigating against economic losses associated with earth quakes: the purchase of earthquake insurance. Three questions are addressed: Why do owners of residential property in California choose to purchase or forego earthquake insurance? Are purchase patterns related to spatial pat terns of geophysical risk? And is insurance purchase related to age, home equity, or income? The answers to these questions will not only shed light on the understanding of individual/household response to environmental risk, but also have significant implications for the utility of insurance as a hazard mitigation tool.

Theoretical Issues

This research investigates one segment of hazard vulnerability and environmental response in California. It has been argued elsewhere (Palm 1990; Mitchell et al. 1989) that studies of hazard vulnerability and environ mental response should be cognizant of the constraints and enablements that affect human beings playing out their lives within a web of circumstance and cross-cutting influences. The influences of micro- and macrolevels of decision-making should be considered simultaneously: to focus either on individual home owners may miss the constraints within which decisions are made; to focus on political economy misses the impacts of decision making that ultimately affect political economic structures.

This investigation focuses on one part of this complex web, viz., the purchase of insurance by homeowners. The interactive framework within which this question is addressed includes information about the geophysical hazard in California, the role of insurance in the political economy, influences on the development of federal, state, and local regulations constraining the availability of insurance information available to homeowners about geophysical risk and possible mitigation measures, and influences on individual decision making. The specific question addressed is, given changes in state legislation and an increasing general concern with the earthquake hazard, what is the response of California home owners?

Previous natural-hazards research has addressed several aspects of the individual decision making context. Some relevant findings are that: (1) few owner-occupiers purchase earthquake insurance (Kunreuther et al. 1978); (2) those living at greater geophysical risk based on proximity to a major active fault are more likely to purchase earthquake insurance-a phenomenon known to insurers as "adverse selection" (Kunreuther et al. 1978; Stewart Economics 1989); (3) those more aware of the risk, based on previous experiences with natural hazards or length of residence in the neighborhood, are more likely to purchase insurance (Kunreuther et al. 1978; Laska 1986; Burby et al. 1988); and (4) those with more to lose-with relatively higher net equity in the property and with more discretionary income to spend on insurance-as well as those with a shorter earning future (i.e., the elderly)-are more likely to purchase insurance (Anderson and Weinrobe 1981; Schiff 1977). These findings formed the basis for hypothesis generation and the research design.

Earthquake Insurance in California

Throughout 1990 and 1991 the U.S. Congress debated the merits of new insurance schemes to reduce vulnerability to earthquake hazards. A proposal sponsored by the insurance industry (Earthquake Project) would make earthquake insurance mandatory, but available at relatively low premiums.

In addition, in 1990 California established a state-supervised reinsurance pool titled the California Residential Earthquake Recovery Fund. This legislation was scheduled to go into effect in January 1992 (Tobin 1991). It will provide a mandatory addendum to every single

family homeowner's insurance policy to cover small claims of up to $15,000 (California insurance Code, Ch. 4.5, §5000).

Despite this current flurry of legislative action, catastrophic earthquake insurance is not mandatory and even the small mandatory policies in California were not in effect until 1992. This makes earthquake coverage different from flood insurance.

In the case of flood insurance, lending institutions making mortgage loans in communities participating in the national flood insurance program require homeowners purchasing property in the "one-hundred-year floodplain" to purchase subsidized insurance. In contrast, lending institutions do not require homeowners to purchase such additional earthquake insurance, regardless of geographic location and associated geophysical risk.

California legislation mandates the disclosure of availability of earthquake insurance to homeowners. A 1984 statute (California insurance Code, § 2, 1081) requires that insurance companies inform policy-holders if they do not have earthquake coverage, whenever home owners take out a new policy or renew an existing one. At the time of this disclosure, the company must indicate the availability of earth quake insurance as well as its premium rate and deductible. This mandated disclosure should prevent lack of information about insurance availability from being a factor in the purchase decision.

The cost of insurance to the household is a combination of the premiums and the deductibles charged against claims. Premiums and deductibles are set as a function of the insurance rate zone of the county in which the house is located and the type of home construction. There are three rate zones for the U.S. Most metropolitan households in California are located in the highest rate zone which also included all of the four study counties surveyed in this research. Although rates vary somewhat between companies, they average about $2.00 to $2.50 per $1,000 of coverage with a 10-per cent deductible (as of 1990) for a typical wood frame residential dwelling in the highest rate zone. Thus, for a typical $350,000 California home, whose structure (as opposed to land) accounts for $150,000 of its value, the annual earthquake insurance premium in 1990 would be about $300-375.

Insurance Purchase and Risk

Expected Purchase Patterns

Previous research suggests circumstances under which individuals or households are more likely to invest in insurance or other methods to protect themselves from losses resulting from natural hazards. This section will review four such factors: awareness of geo physical risk at the site, previous experience with or awareness of the hazard, socioeconomic and demographic characteristics of the population that motivate and enable it to purchase insurance, and, finally,

the perception of risk.

Awareness of Geophysical Risk

Persons who live in or near hazardous areas might be expected to be more aware of the associated risk and therefore more likely to adopt mitigation measures such as insurance purchase. This association between distance, awareness, and mitigation has been demonstrated for flood hazards. For instance, in a Denver area study, Montz (1982) suggested that distance of home from flood zones is an important factor in flood insurance adoption and flood proofing. Distance from the risk was also found to affect awareness of danger from volcanoes (Greene et al. 1981) as well as aware ness of flooding and landslides (Geipel1982). The insurance industry shares the assumption that "adverse selection" affects the adoption of insurance: that only those susceptible to the hazard carry insurance (Stewart Economics 1989). If it is true that only those at extreme risk have insurance, then it follows that a single vent-a great earthquake-would be followed by a very large proportion of the policy-holders filing claims. Adverse selection can be examined at several geographic scales. At a national scale, residents of regions more at risk from earthquake-related damage are more likely to adopt earthquake insurance. Thus a higher percentage of Californians than Iowans would be expected to have earthquake insurance. At this scale, "adverse selection" is demonstrably the case. It may also be valid at the metropolitan scale. Thus it should be possible to assign differential geophysical risk to sites and observe a correlation with insurance purchase density. In the specific case, we would expect to find a positive relationship between relative site specific geophysical risk and the density of insurance purchase within the San Francisco and Los Angeles metropolitan regions.

A close relationship between geophysical risk and insurance purchase or “adverse selection” may not exist because of a lack of aware ness of the location of the risk. If homeowners are not aware of the relative geophysical risk associated with their home sites, they may not purchase hazard insurance. It is therefore important to review the microzonation of risk and the extent to which this spatial distribution of risk is known to the general population.

The Geography of Seismic Risk

One of the most widely known active faults in the U.S. is the San Andreas fault zone (Fig.1). No other fault zone so clearly embodies the idea of earthquake risk. In the San Francisco Bay region, the fault zone is marked by such geophysical features as inundated rift valleys containing San Andreas Lake and Bodega Bay. Since this fault system has such notoriety, the relative distance between the homeowner and the San Andreas fault might be expected to affect hazard mitigation.

A second type of geophysical risk zone is the Special Studies Zone. These zones were delimited in accordance with the Alquist-Priolo Special Studies Zones Act (California Public Resources Code, Sec. 2623). A Special Studies Zone bounds a fault that is *potentially active* and *well-defined* (Hart 1985). With some exceptions, potentially active faults have shown evidence of

surface displacement during Quaternary time (the last two million years). Faults that have evidence of Holocene surface dis placement (during the last 11,000 years) are deemed “active.” A fault is also "well-defined" if its trace is clearly detectable by a trained geologist as a physical feature at or just below the ground surface. The Special Studies Zone boundaries are positioned 200-660 feet (61-201 m) away from fault traces to accommodate imprecise fault locations.

In 1975 the Special Studies Zone act was amended to mandate the disclosure of the location of a property within a zone to a prospective buyer. The amendment placed the burden for disclosure on the real estate agent or on the seller, if acting without an agent. Disclosure became standardized by 1977 and the California Association of Realtors developed a contract addendum to the deposit receipt for California realtors. Several boards of realtors printed colored maps outlining the location of Special Studies Zones, which they used in their offices or gave to clients. Special Study Zones are also delineated on popular street atlases. Thus, it could be assumed that buyers of property within these surface fault rupture zones were aware of their location and might be more likely to purchase earthquake insurance.

Despite the disclosure of the location of Special Studies Zones, empirical studies of home buyer behavior showed that most buyers who had recently signed the disclosure forms within no more than six months of the time of the survey did not purchase earthquake insurance and that a very large number did not understand or remember the Special Studies Zone disclosure (Palm 1981). Homeowners who knew they were in a Special Studies Zone were, however, more likely to have purchased insurance than those not aware of their location (Palm 1981).

A third and more rigorous evaluation of the distribution of seismic risk for the study areas in Southern California is based on the modeling of possible future earthquakes, their associated magnitudes and rupture lengths, and local ground conditions that may attenuate or amplify the shaking intensity (Fig. 2). Evernden and Thomson (1985) mapped the maximum potential shaking intensity for 87 postulated earthquakes in the Los Angeles-San Bernardino metropolitan areas. The Modified Mercalli Intensities (MMI) from these postulated earth quakes ranged from less than MMI 5.0 (no damage to structures) to MMI 9.0 (severe dam age to most structures). These calculations showed the existence of a wide range of geophysical risk within the populated portions of Los Angeles and San Bernardino counties. Al though the Evernden-Thomson microzonation of risk is probably the most accurate of the three estimates of objective risk, homeowners are less likely to be aware of this zoning and, therefore, the risk associated with their individual site.

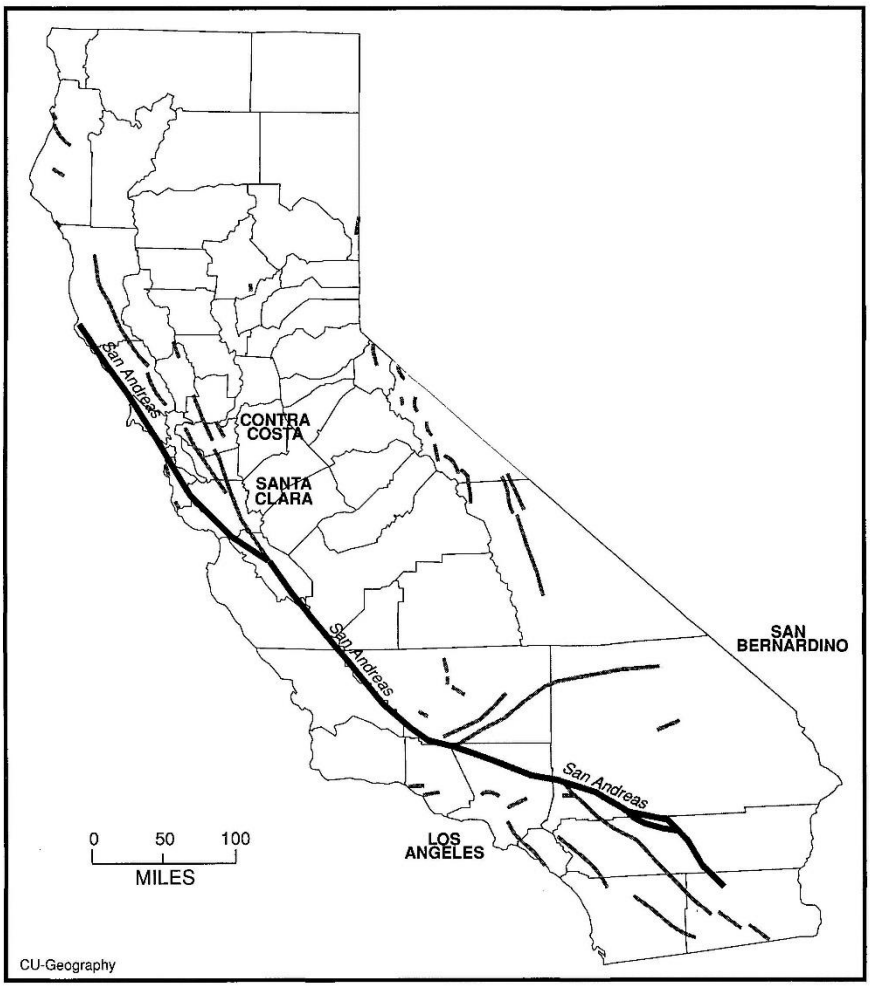

Figure 1. Special Studies Zones are defined as areas encompassing sufficiently active and well-defined surface fault traces. The "zones" are depicted as lines at this small scale and the four counties in this study are shaded. The San Andreas Fault Special Study Zone is depicted in black with a larger line.

Experience with Hazard

In studies of flood hazards, previous experience was the key factor motivating property owners to take steps to mitigate the hazard (Kunreuther et al. 1978; Laska 1986; Burby et al. 1988). Individuals with previous experience of hazards have a more accurate perception of them (Kates 1971; Burton and Kates 1964; Roder 1961; Saarinen 1982), and proximity to hazards tends to cause higher levels of concern (Greene et al. 1981; Geipel 1972). Past experience predicts familiar and repetitive behaviors (Macey and Brown 1983), and attitude, behavior and the adoption of mitigation measures seem to be related to experience (Weinstein 1989a). Research reviewed by Weinstein (1989a) suggests that (1) personal experience may affect the likelihood of future victimization since accessibility from memory influences probability judgments (Kahneman and Tversky 1979; Perloff 1983); (2) personal experience provides information about the severity of the harm and the existence of preventative measures; (3) experience adds to

the concreteness of information (Nisbett and Ross 1980); (4) experience reduces uncertainty about the event (Fazio and Zanna 1978) and increases its salience (Janis 1967; Averill 1987), and (5) experience demonstrates that individuals are not invulnerable (Janoff-Budman 1985; Perloff 1983; Weinstein 1987). Thus, insurance adoption should be affected by experience with the hazard as well as by proximity to hazardous areas. Because major earthquakes occur relatively in frequently, few California homeowners will have had previous experience with earth quakes (either in California or elsewhere).

Socioeconomic Characteristics and Insurance Purchase

Previous studies suggest that economic and demographic characteristic of insurance purchases may differ from nonpurchasers. Such findings would have policy implications. For example, if homeowners with both relatively low annual incomes and high net equity in their homes (house-rich households) are uninsured, they are particularly vulnerable to losing their homes and their major source of household wealth. It is therefore important to identify the relationship between income, age, net equity and the purchase of insurance.

Previous studies have not given much guidance on the impacts of gender on response to natural hazards in general or earthquake hazard in particular within the context of American cities. Unfortunately, this study does not add to the body of knowledge in this arena, since we did not ask the gender of the respondent.

Based on previous research, two relationships were expected. First, older homeowners might tend to be more risk-averse and therefore more likely to purchase insurance. Schiff (1977) has argued that the elderly are more risk-averse because of their cumulative knowledge about proper adjustments to environ mental hazards. Second, income and home equity were expected to affect insurance purchase. Previous empirical research showed that those with the most to lose-those with relatively high net equity-would protect their investment (Anderson and Weinrobe 1981; Willinger 1989).

This might have an interacting effect with the tendency of the elderly to purchase insurance since the elderly, especially those on fixed incomes, may be more likely to have relatively high equity in their homes and to want to protect this equity. Income level may not have an independent relationship with insurance adoption (Kunreuther et al. 1978), but should modify the direct relationship between vulnerability to property loss (from relatively high equity positions) and insurance. House-rich, income-poor households may not have sufficient monthly income to afford insurance premiums; for example, a household with a property originally purchased for $40,000 but now worth $350,000 may not feel able to afford insurance. In such cases, the direct relationship between net equity and insurance purchase could be modified by income level.

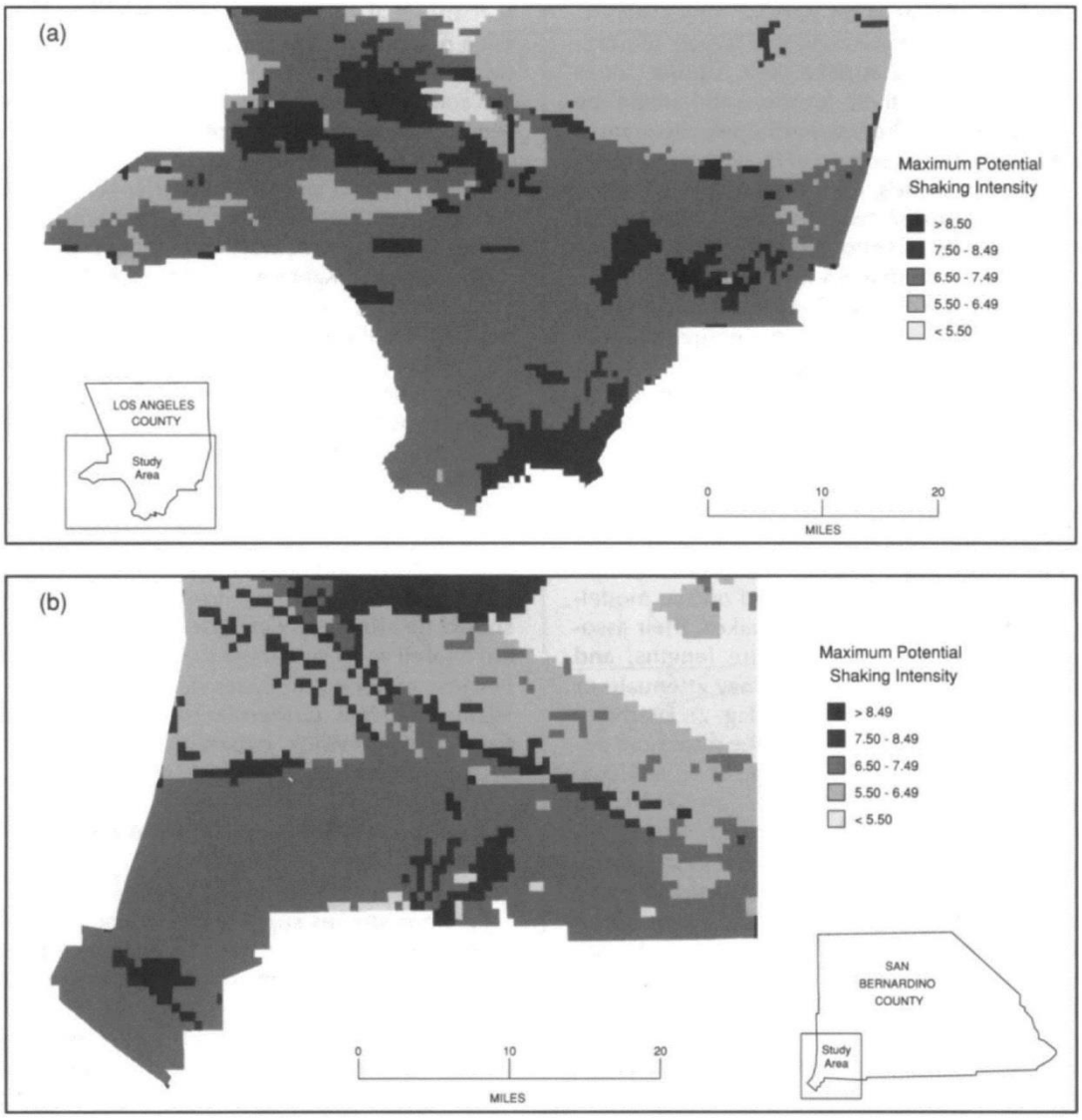

Figure 2. Maximum potential shaking intensity modeled from 87 postulated earthquakes in (a) the los Angeles County study area and (b) the San Bernardino County study area. Modeled intensities are expressed as Modified Mercalli Intensities (MMis). The populated portions of both counties contain a wide variation in shaking intensities, from no damage to modern structures (<5.50) to severe damage (>8.49). Data depicting shaking intensities for this map and the analyses were provided by Evernden and Thomson (1985).

Perception of the Risk

Perception of risk, though theoretically linked to experience and proximity, may be considered an independent factor affecting hazard response. For individuals to respond to a hazard they must be aware of its existence and the hazard must be salient to them, that is, they must translate awareness into a belief that their own lives and property are susceptible to danger (Palm 1990). In addition, an “optimistic bias” may distort the relationship between hazard and action. This bias is an undue optimism about safety from a given hazard, a view "actively constructed" to create self-serving predictions about future events (Weinstein 1989b). Such a bias, according to Weinstein, “may seriously hinder efforts to promote risk reducing behaviors” (p. 1232), interfering with the adoption of insurance.

In short, the individual must perceive the environmental risk as personally threatening to life and property before being motivated to action. A belief in personal vulnerability is expected to be related to the adoption of a mitigation measure such as insurance.

Research Hypotheses

The research hypotheses tested were based on expectations from previous theoretical and empirical work. Three questions were ad dressed. First, do homeowners living in areas of greater geophysical risk, as measured by distance to an active fault, within a Special Studies Zone, or within a relatively high shaking intensity zone, tend to purchase earthquake insurance with greater frequency than those living in areas of lesser geophysical risk? Second, are older persons, those who have more equity in their homes, or some combination of these categories more likely to purchase insurance? And third, are homeowners with higher perceived risk (whether or not they are living in areas of higher actual geophysical risk) more likely to purchase insurance?

Methodology

A mail survey of 3,421 single-family owner occupiers was conducted between May and July of 1989 in four California counties: Contra Costa, Santa Clara, Los Angeles, and San Bernardino. These counties represent four of the largest and most seismically-vulnerable metropolitan areas of the state (the San Francisco Oakland SMSA, the San Jose SMSA, the Los Angeles-Long Beach SMSA and the San Bernardino-Riverside SMSA). The mail survey was conducted using Dillman's Total Design Method (Dillman 1978). This method has been shown to minimize geographic bias while maximizing response rate (Feitelson 1991).

This study was limited to single-family detached owner-occupiers. Condominium dwellers were excluded from this sample because collective insurance decisions by a homeowners' association involve negotiations and group interactions that confound the simple decision process. Similarly, renters were not included in the sample since tenants do not decide whether to insure a structure against earth quake damage. Finally, we restricted the survey to owner-occupiers-owners who actually lived at the site. A random sample was drawn from tax assessor's lists of the entire

population of owner-occupiers in each study county.

The Survey

A 13-page questionnaire was designed, evaluated, and modified using an advisory committee, a field test, and a focus group. An advisory committee composed of university, state and federal government, and insurance industry representatives met twice during the study to develop and evaluate the survey instrument as well as critique the study methods. The questionnaire was field tested in Contra Costa County using 80 homeowners. A focus group of 12 homeowners assisted in refining the survey questions and each received an honorarium of $25 for participation. The survey was modified in response to the invaluable suggestions, opinions, and perceptions of the advisory committee and focus group members.

The Total Design Method (TDM) approach of mail surveys promises astoundingly high response rates (greater than 70 percent). The key portion of the TDM is a sequence of mailings and follow-ups designed to increase response rate. The survey involves four mailings: (1) the initial mailing of the cover letter and questionnaire; (2) seven days later, a postcard thanking respondents and reminding nonrespondents to return questionnaires; (3) 21 days after the initial mailing, a letter and replacement questionnaire to nonrespondents; and (4) 49 days after the initial mailing, a letter and replacement questionnaire to nonrespondents by certified mail. Each step increases the response rate. Our study modified the TDM and pre tested this modification. Instead of an automatic third mailing after 21 days, as specified in the classic Dillman model, the respondent was contacted by telephone.

Response rates for the full mail survey varied from a high of 70 percent in Santa Clara County to a low of 58 percent in Los Angeles County (Table 1). Bias in geophysical risk between respondents and nonrespondents was tested with t-tests. The results of the statistical tests indicated no significant differences between respondents and nonrespondents in the three measures of geophysical risk.

Determination of Homeowner Locational Characteristics

The survey sample was geocoded either by the individual county's GIS center (if available) or by a private contractor: The GIS centers of Santa Clara and Los Angeles Counties for their respective samples, and Geobase, Inc., for San Bernardino and Contra Costa Counties. Up dated street address files were used in the ad dress matching process.

In order to examine the relationship between insurance purchase and geophysical risk, it was necessary to measure the distance between each respondent's home and nearby Special Studies Zones and to assign a maxi mum potential shaking intensity to the home site (such models were only available for Los Angeles and San Bernardino counties). The cartographic representations of the Special Studies Zones were digitized from copies of the original 1:24,000 scale topographic maps upon which the zones were compiled. The turning points (critical points) of

each zone were digitized, producing a polygonal set of zone boundaries. The Euclidean distance from each surveyed homeowner's geographic location to the nearest Special Studies Zone was computed, as well as the distance of each survey residence in Contra Costa and San Bernardino counties to the San Andreas Special Studies Zone. A simple point in-polygon test was used to determine whether the resident was inside or outside of a Special Studies Zone.

The maximum probable shaking intensity for each survey residence was computed using the geocoded home locations and modeled shaking intensity maps. Evernden and Thomson (1985) modeled the maximum potential shaking intensity for I km x 1 km grids cells in Los Angeles and San Bernardino Counties. The maximum probable shaking intensity for each survey residence was determined by digitally overlaying coverages of home locations on Evernden and Thomson's shaking intensity maps and assigning the shaking intensity at the site to the residence.

Table 1. Response Rates to the Mail Survey

	Counties			
Survey Status	**Contra Costa**	**Santa Clara**	**Los Angeles**	**San Bernardino**
Mailed out	864	855	743	683
Returned to sender	99	61	158	98
Mailed back [a]	521	556	337	372
Percentage Response Rate	68.1	70.0	57.6	63.6

[a] Does not include refusals or returned to sender

Results

The percentage of households with insurance had increased dramatically from the five percent found in the 1978 study by Kunreuther et al. In each of the four counties surveyed, more than one out of five, and as many as two out of five homeowners, now had earthquake insurance (Table 2). The largest concentration of uninsured was in Contra Costa County, while the smallest percentage was in Santa Clara County, the site of the Lama Prieta earth quake that was to occur shortly after the survey.

Table 2. Percentage of Respondents Purchasing Insurance

	Counties			
Response	**Contra Costa**	**Santa Clara**	**Los Angeles**	**San Bernardino**
Have insurance	22.4	40.0	39.6	29.3
Previously insured	5.4	4.7	3.1	3.8
Never insured	72.2	55.3	57.3	66.9

Analyses of Locational Effects

This study examined the relationship between geophysical risk and response for a small region within a metropolitan area. No assumptions were made about the functional relationship between geophysical risk and homeowner attitudes or behavior (e.g. linear, logarithmic). But a positive monotonic relationship was hypothesized to exist between decreasing geophysical risk and hazard perception/mitigation measures. For instance, homeowners closer to active faults are more likely to perceive the hazard as threatening and more likely to take mitigation measures.

There is no doubt that in other regions of the country, earthquake insurance is less prevalent. In that sense, there is no doubt that at a national scale "adverse selection" takes place. But the issue of interest was the impact of earthquake risk at a very local scale. Since it is possible to make distinctions between more or less vulnerable areas within California or even within metropolitan areas, the tests under taken here were intended to investigate ad verse selection at the metropolitan scale, viz., to test for the impacts of proximity to a Special Studies Zone or for the even more accurate measures of vulnerability (the shaking intensity zonation) on insurance adoption.

To test for the impacts of proximity to a Special Studies Zone on the purchase of earth quake insurance, cartographic products were produced from the survey sample portraying the homeowner location and status of insurance coverage for each of the four counties. Additionally, cumulative frequency curves between percentage of homeowners insured and distance from the nearest Special Studies Zone were created and visually analyzed. No visual relationship was apparent to suggest that the location with respect to the Special Studies Zones affects insurance purchase. The relationship between location with respect to these geophysical risks and insurance purchase was also explored using t-tests. A significance level of .05 was used to reject the null hypothesis that there was no difference between the average distance of insured and uninsured home- owners to the nearest Special Study Zone within each county.

In addition, because of the significance of the San Andreas fault in the mind of Californians, this particular fault was singled out for special analysis. A set of "t-tests" measuring the differences between the average distance from the San Andreas fault for insurance purchasers and nonpurchasers was conducted for home owners in San Bernardino and Santa Clara Counties. These tests indicated no statistically significant relationship existed between insurance purchase and distance to the nearest Special Study Zones for any of the study counties (Table 3). Similarly, no significant relationship was found between insurance purchase and distance to the San Andreas fault for homeowners in Santa Clara and San Bernardino Counties.

Table 3. Significance of t-tests between Distance to Special Studies Zone and Insurance Purchase

	Counties			
Distance to:	Contra Costa	Santa Clara	Los Angeles	San Bernardino
Nearest SSZ	.30	.78	.26	.07
San Andreas fault	n.a. [a]	.32	n.a. [a]	.10

[a] n.a. means not applicable.

The relationship between the maximum potential shaking intensity at the home site and insurance purchase was also probed using chi square tests. Because the shaking intensity calculations were only available for southern California, these comparisons were done only for the Los Angeles and San Bernardino County respondents. The results showed no significant relationship between insurance purchase and the shaking intensity category.

Finally, isoline maps were created to examine other spatial variations in insurance purchase not detected by simple comparisons between average distances. A general spatial interpolation model was used to map the percentage of insured homeowners for each of the four survey counties. Only the derived map for Los Angeles County exhibited a clear spatial variation in insurance purchase (Fig. 3). In the other counties, either the spatial pat tern-density and distribution-of residences was not adequate for mapping the patterns or a true spatial variability in insurance purchase failed to exist. The region of highest percentage insured (60-80 percent) is in the San Fernando Valley, the site of the 1971 earthquake, whereas only 30-40 percent of the homeowners in southeastern Los Angeles County are insured. This pattern may suggest homeowner response to experience with the 1971 San Fernando earthquake.

In summary, the statistical analyses of home owner location with respect to Special Studies Zones, the San Andreas fault, and maximum potential shaking intensity indicated that location and the resulting geophysical risk are not associated with patterns of earthquake insurance purchase at the metropolitan scale. The spatial modeling of the insurance status surface of Los Angeles County suggests that some spatial pattern may, however, exist between experience and insurance subscription.

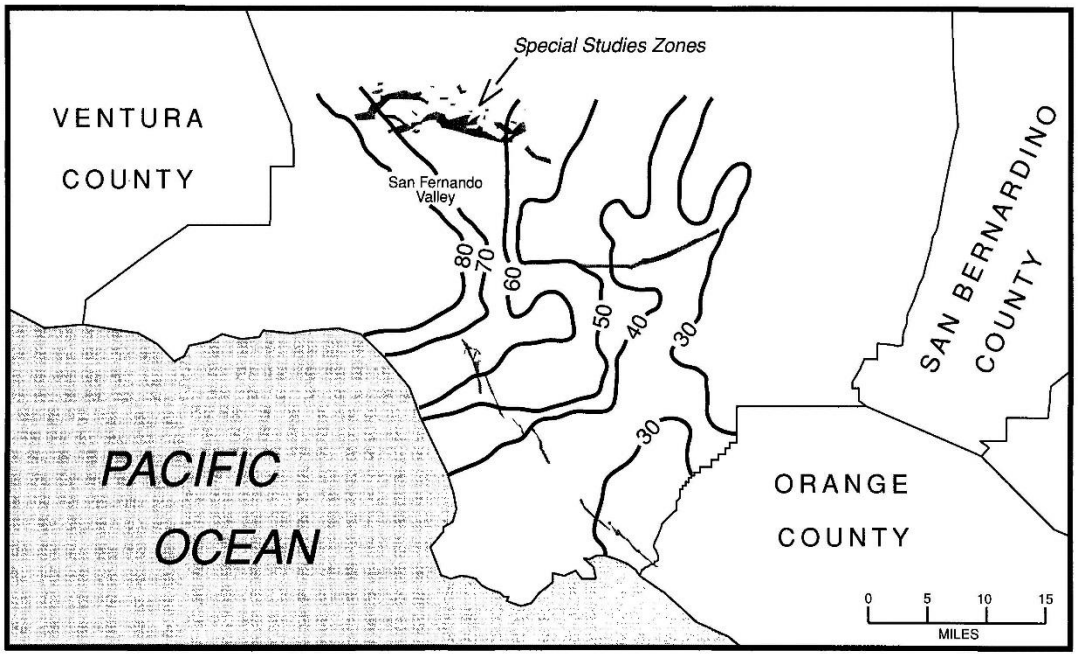

Figure 3. lsolines showing the percentage of the respondents insured. Special Studies Zones mapped in the Los Angeles County study area are also shown. No relationship exists between percentage insured and distance to a Special Studies Zone, but the highest percentage insured were in the San Fernando Valley, site of the 1971 earthquake.

Home Equity, Age, and Insurance Purchase

Previous research has suggested a positive relationship between higher home equity and the purchase of insurance as well as between age and the purchase of insurance. Percentage of home equity was defined as the market value divided by the total claims against the property (e.g., total outstanding mortgages). The percentage of total net worth of the household represented by this net equity was also examined. Net equity was the major component of total net worth for most respondents, constituting at least 50 percent of net worth in all study counties for both insured and uninsured populations. T-tests, though, indicated that percentage of equity in the house and percentage net worth made up by home equity were generally unrelated to insurance purchase (Table 4). Only in Contra Costa County was percentage of net equity related to insurance purchase, and even there the percentage of total net worth made up by this net equity was unrelated to insurance purchase. We conclude that home equity position generally does not differentiate between insured and uninsured households.

On the average, heads of households in the survey were in their late forties to mid-fifties with generally older homeowners in Los Ange les County (55 years for insured and 54 for uninsured) and younger homeowners in San Bernardino County (48 for the insured and 49 for the uninsured). Age of head of household did not distinguish between insured and uninsured except in Contra Costa County, where older homeowners were more likely to purchase insurance. This

relationship held true for the entire sample as well as subsamples of those householders under age 55 and under age 40. In general, in the four study counties, we cannot conclude that age of head of house hold is a predictor of insurance purchase.

Other socioeconomic and demographic variables-including length of tenure in California, length of tenure in the home, age of the house, years of school completed, presence of children under age 18 in the household, presence of persons over age 65 in the household, family income, and estimated home value--were also tested for differences between insured and un insured frequencies (Table 4). Scattered relationships were evident between insurance purchase and these variables. For example, insured households were less likely to include children under age 18 in Contra Costa County, and persons with more years of school completed were more likely to have insurance in Los Angeles and San Bernardino Counties. In addition, family income was related to insurance purchase in Santa Clara and San Bernardino counties. But no consistent relationships were evident across the four counties between these socioeconomic and demographic variables and insurance purchase.

Table 4. Significance Levels of t-tests for Insurance Purchase

	Counties			
	Contra Costa	Santa Clara	Los Angeles	San Bernardino
Percentage of net equity	.02*	.74	.26	.57
Net equity as % of total wealth	.25	.92	.24	.87
Age of head of household	.00**	.96	.81	.44
How long lived in CA	.86	.16	.60	.19
How long lived in home	.15	.50	.75	.99
Age of house structure	.72	.05*	.33	.98
Years of education	.10	.74	.00**	.03*
Children in household	.00**	.38	.08	.96
Persons over 65 in household	.34	.82	.71	.03
Estimated home value	.95	.05	.10	.41
Family income [a]	.71	.03*	.14	.05*

*Significant at the .05 level

**Significant at the .01 level

[a] Level of significance for chi square test

Finally, second-order relationships between insurance and the key independent variables, such as age of head of household, percentage of equity in the home, family income and percentage of total net worth comprised by the net equity, were investigated. Only in Contra Costa County did the relationship between age and insurance purchase, which was significant as a first-order relationship, hold up when control ling for income, equity, and net worth. In the other three study counties, no statistically significant relationship was found between age and the tendency to purchase insurance when controlling for the economic characteristics of the household (Table 5). Similarly, percentage of home equity did not generally discriminate purchasers from nonpurchasers when control ling for age, income or net worth (Table 6).

Table 5. Partial Correlations for Age of Head of Household and Insurance Purchase (R-square and Significance Levels)

	Counties							
	Contra Costa		Santa Clara		Los Angeles		San Bernardino	
Age, Controlling for:	R	(sig.)	R	(sig.)	R	(sig.)	R	(sig.)
Income	−.18	(.00**)	−.04	(.21)	−.11	(.07)	−.01	(.47)
Equity	−.11	(.03*)	−.02	(.34)	−.01	(.44)	−.01	(.47)
Net worth	−.17	(.00**)	−.02	(.38)	−.05	(.24)	.03	(.32)

*significant at the .05 level
**significant at the .01 level

Table 6. Partial Correlations for Home Equity and Insurance Purchase (R-square and Significance Levels)

	Counties							
	Contra Costa		Santa Clara		Los Angeles		San Bernardino	
Home Equity, Controlling for:	R	(sig.)	R	(sig.)	R	(sig.)	R	(sig.)
Age	−.03	(.26)	.01	(.41)	−.08	(.14)	−.11	(.05*)
Income	−.15	(.01**)	−.02	(.37)	−.12	(.05*)	−.09	(.09)
Net worth	−-.15	(.01**)	−.00	(.49)	−.11	(.07)	−.07	(.16)

*significant at the .05 level
**significant at the .01 level

In sum, the key independent variables that had been hypothesized to influence insurance adoption were not empirically systematically related to the insurance purchase decision. Even when modified for a second-order relationship, no consistent pattern was seen between demographic or economic characteristics and insurance purchase behavior.

Perceived Vulnerability and Insurance Purchase

Although the level of geophysical risk is not related to insurance purchase, previous research suggested that perceived risk may be an important factor in the purchase decision (White and Haas 1975; Drabek 1986; Turner et al. 1979). We tested for relationships between perceived vulnerability with actual geophysical risk and perceived vulnerability with insurance purchase. To measure perceived risk, the survey included four questions. The first asked for an estimate of the probability that a major (1906 San Francisco-type) earthquake would occur in the next 10 years in the respondent's community. The second requested an estimate of the likelihood that the respondent's own home would be seriously damaged by such an earth quake. The third question elicited an estimate of the probability of an earthquake causing more than 10-percent damage to the home. And the fourth asked for an estimate of the dollar value of probable damage to the home and contents following a major, damaging earthquake. Kunreuther et al. (1978) posed three of these questions in an earlier survey of hazards insurance purchase.

Respondents indicated a high overall concern about a damaging earthquake affecting their community. In Los Angeles County, for example, 69 percent said there was at least a one in ten chance of an 8.2 (M) earthquake affecting their community in the next ten years; in Santa Clara County (the site of the 1989 Lorna Prieta earthquake that followed shortly after the survey), 24 percent estimated that a major earthquake would cause $200,000 or more in damage to their home and its contents.

Table 7. Perceived Vulnerability and Insurance Purchase: Likelihood of Serious Damage to Home from a Major Earthquake [a]

	Counties			
Variables	Contra Costa**	Santa Clara**	Los Angeles**	San Bernardino**
Very likely				
Insured	3.4	8.3	10.7	24.4
Uninsured	3.6	3.2	13.8	11.0
Somewhat likely				
Insured	40.4	48.5	55.3	51.2
Uninsured	24.2	23.7	37.6	36.2
Somewhat unlikely				
Insured	34.8	31.4	19.1	16.3
Uninsured	29.8	30.8	22.1	22.1
Very unlikely				
Insured	21.3	11.8	11.7	8.1
Uninsured	42.4	42.3	29.5	29.9

**difference between insured and uninsured significant at .01.

[a] summarized as percentage of respondents by insurance status.

These measures of perceived risk were unrelated either to geophysical risk (proximity to a fault, location in a Special Studies Zone, or location in an Evernden risk zone) or to economic and demographic characteristics. For example, the calculated coefficient of determination between distance to the nearest Special Studies Zone and estimated probability of a damaging earthquake affecting the community ranged from -.01 in Contra Costa County to -.09 in San Bernardino County. Clearly, individual perception of risk is not significantly influenced by proximity to a fault or predicted patterns of earthquake damage; either individuals are unaware of the underlying distribution of risk, or they are not interpreting this pattern in the same way that scientists would.

Despite the lack of relationship between geophysical and perceived risk, a consistent relationship was found between the belief of personal vulnerability and the adoption of earthquake insurance.

In three of the four counties, estimated probability of a damaging earthquake affecting the community and the home was significantly higher among the insured than the uninsured population. In all four counties, the estimated likelihood of their own home being seriously damaged by an earthquake was significantly higher among the insured than the uninsured (Table 7). Finally, in all four counties, the estimated dollar damage from a major earthquake was significantly higher for the insured (Table 8).

Table 8. Perceived Vulnerability and Insurance Purchase: Estimated Dollar Damage to Home from a Major Earthquake [a]

Variables	Counties			
	Contra Costa**	Santa Clara**	Los Angeles**	San Bernardino**
Less than $10,000				
Insured	4.0	4.5	4.5	6.5
Uninsured	11.8	17.2	20.6	16.6
$10,000 - $50,000				
Insured	17.3	20.8	22.2	28.3
Uninsured	26.5	25.6	27.0	34.6
More than $50,000				
Insured	78.7	74.5	73.3	65.4
Uninsured	61.6	57.1	52.5	48.9

**difference between insured and uninsured significant at .01.

[a]Summarized as percentage of respondents. The responses to this question have been categorized for reporting purposes.

Thus most Californians surveyed were highly aware of the earthquake risk and there is a strong and consistent relationship between perceived risk and insurance purchase. This relationship is stronger and more consistent than any relationship with socioeconomic, demographic, or locational characteristics, a finding that is in accord with earlier work on the adoption of innovation (Brown 1980).

Conclusions

The empirical results of this study have broad implications for response to earthquake hazards in other regions as well as to other natural hazards. First, the finding that earthquake insurance is unrelated to geophysical risk suggests that the provision of information on risk alone is insufficient to induce the adoption to protective measures. This finding is similar to the results of many studies of risk-taking behavior, including smoking and other health-related behavior, where the simple provision of information does not result in changes in behavior. It will take far more than the simple creation of new maps or their disclosure by real estate agents or in newspapers to induce California residents to take actions such as purchasing earthquake insurance in order to protect themselves.

Second, the finding that insurance adoption is unrelated to socioeconomic characteristics is also in accord with many studies of response to natural hazards (Drabek 1986). This finding implies that vulnerability to uninsured losses is widespread throughout the population.

Third, the finding that insurance purchase was related to perception of risk implies that the linkage between information provision and attitude change needs further attention. Again, much previous research in a variety of contexts has shown that information must be carefully presented if it is to have an impact on attitudes and behavior. The empirical case of earth quake insurance adoption in California pro vides yet another example of the importance of careful presentation of information if the goal is to induce behavior change.

The findings have implications for current public policy discussions of interest both to the insurance industry and to legislators. First, the finding that earthquake insurance is not related to socioeconomic characteristics implies that all homeowners regardless of income or age are vulnerable to major uninsured losses. Thus any plan, such as that currently sponsored by the insurance industry (Earthquake Project 1989) to subsidize or mandate earth quake insurance will affect all segments of the population. Second, the finding that geophysical risk is not associated with insurance purchase suggests that federal, state and local in formation campaigns to inform Californians about site-specific risks have not resulted in hazard mitigation behavior. Since a large investment by agencies such as the U.S. Geological Survey and the Federal Emergency Management Agency has already been made in pro viding information, these results suggest that agencies reconsider the modes by which information is being disseminated. To induce hazard mitigation, it is important to personalize the understanding of vulnerability; if individuals feel more personally vulnerable, they are more likely to take mitigation measures including purchasing insurance.

Two topics for future research are suggested by this study. First, the spatial pattern of insurance purchase in Los Angeles County suggests that experience may have a strong effect on hazard mitigation. The 1989 Lorna Prieta earth quake near Santa Clara County provides an opportunity to test the role of experience with a major damaging earthquake on hazard perception and mitigation. Future research should ex amine the relationship between relative levels of experience on perception, geophysical knowledge, and mitigation adoption.

Second, future research should investigate the effect of small mandatory policies on the patterns of purchase of catastrophic insurance. In 1990, the State of California legislated a mandatory insurance program to ensure coverage for relatively small losses (up to $15,000). A question that arises from this action is whether homeowners will substitute the small insurance policy for catastrophic insurance, making themselves even more vulnerable to major losses, or whether the purchase of this small mandatory policy will induce greater rates of subscription to catastrophic insurance. Previous research in cognitive psychology suggests that either outcome is possible.

In any case, information about the insurance purchase decision making process should be used to inform public policy as Congress and state legislators consider methods to reduce losses. Only in this way will legislation be developed that will effectively mitigate against some of the serious financial losses that will accompany the truly disastrous California earthquake that looms ahead.

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