The Impact of Earthquake Risk on Housing Markets: Evidence from Tehran Real Estate Agents

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Abstract

Despite significant developments in earthquake risk reduction measures (ERRMs) in buildings, these measures have not been widely implemented. One reason is that they increase construction costs. Whether households derive any utility from ERRMs, and if so how much, determines willingness to pay for them and the scale of the market-led adoption of them in relation to their costs. The analysis of market prices can under certain circumstances provide a reasonable answer to the benefit of ERRMs.

Using a contingent valuation method, a survey of real estate agents was conducted to find the effects of ERRMs on the housing market in Tehran, Iran. The results show that under existing conditions there is a significant price difference between earthquake-resistant and nonresistant houses, across all districts in the city. This article predicts that increased information about earthquake risks might further increase the price difference between houses.

Keywords: earthquake risk; housing market; contingent valuation; Tehran

Introduction

Significant advances have been made in earthquake risk reduction measures (ERRMs) and techniques over the past several decades, but problems can still be encountered in their implementation (May and Bolton 1986). Evidence suggests that adopting ERRMs benefits homeowners by reducing the risk of injury and death, potential damage to property, and disaster relief costs incurred in a catastrophic earthquake. Despite the growth of a technical knowledge base, however, there has been limited application of ERRMs (Kunreuther and Kleffner 1992; May 1991).

This lack of sufficient social and individual response to the hazards and related mitigation policies has created a dilemma in predisaster planning and management. Social science disciplines such as psychology, sociology, and economics have investigated and addressed this dilemma: whether to implement ERRMs at high social and individual costs or risk significant death and destruction without ERRMs. While psychologists have focused on risk perception (Dooley et al. 1992; Mullis and Lippa 1990), sociologists have studied the social aspects of risks and risk communication (Drabek 1986; Kasperson and Pijawka 1985; Mileti and Fitzpatrick 1992; Turner et al. 1986). Economists have concentrated on the economic evaluation of decisions and policies under risky conditions

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(Brookshire et al. 1985; Cohen and Noll 1981; Colwell and Yavas 1992). Despite an increasing number of studies, there is comparatively little research on these questions in developing countries.

This article concentrates on the economic aspects of ERRMs. One of the major areas of concern is the effectiveness of ERRMs, as revealed through their impact on the housing market. Cost-benefit analysis has shown that some ERRMs, such as uniform building codes (UBCs), are economically feasible (Litan 1992; Pate-Cornell and Eeri 1985; Schulze et al. 1990). But costs and benefits to society are not the same as private financial costs and benefits to individual homeowners and house builders; it is the private financial costs and benefits that are instrumental in the adoption of ERRMs. ERRMs are more likely to be adopted if their costs can be recovered in the sales prices of houses. The question then becomes whether home buyers are willing to pay for ERRMs incorporated into a house. If the market prices of houses are clearly affected by the ERRMs and rise by more than the cost of the ERRMs, developers will install them; otherwise a profit-maximizing developer will implement an ERRM only if a government subsidy covers the additional cost.

This article seeks to determine whether earthquake risk has any effect on the Tehran housing market, as reflected in price differences between earthquake-resistant and nonresistant houses. First, we briefly review the background to the study and then describe the main theoretical issues. After that we outline the research technique adopted and present the main results of the study. The concluding section provides some policy recommendations.

Background

Valuing environmental impacts has been one of the main research topics in environmental economics and planning during the past two decades. In recent years new approaches and techniques have been developed to measure these impacts. In the case of earthquake risk, however, only a few studies have been conducted, mostly in the United States. Brookshire and Schulze (1980) used a contingent valuation method (CVM) to determine the effects of earthquake risk on the California housing market. In their survey of homeowners located in special studies zones (SSZs) in Los Angeles, Brookshire and Schulze asked homeowners how much more they would pay to purchase the same home outside of an SSZ. They found that only 26 percent of respondents expressed a willingness to pay more, but the average of all responses, including zero bids, was $5,920. A series of studies on housing markets and earthquake risks has been undertaken by Palm (1981, 1987, 1990). She conducted a survey of real estate agents to identify the effectiveness of mandated disclosure legislation in California. The legislation requires real estate agents to inform all home buyers about the seismic risk related to a house's location. Like Brookshire and Schulze, Palm found that the housing market showed distressingly little response to earthquake hazards.

Through a survey of 30 California appraisers conducted in late 1982 and early 1983, Palm (1990) analyzed how real estate appraisers incorporate information about earthquake hazards into their practice. Respondents were provided with a sample property to elicit appraisal practice. They were asked to estimate the current price of a 15-year-old tract

or semicustom house with particular characteristics and the price reduction they would expect if the property was in an SSZ or a surface-fault rupture zone. Results showed again that the SSZ legislation did not significantly affect the housing market. Most of the appraisers did not place any more value on an identical house in a lower risk area. They indicated that clients had only rarely asked about seismic hazards, and few purchasers checked for evidence of previous damage from earthquakes or location on a surface-fault trace.

At the same time and in the same location, but using another method, Brookshire et al. (1985) found that the California SSZs program had significantly affected house prices. This study adopted a hedonic price method (HPM) using the sales prices of houses sold in 1978 in Los Angeles County and the San Francisco Bay Area. In contrast to previous studies, Brookshire et al. reported that the mandated disclosure legislation in California had negatively affected prices for houses in the SSZs: They found that prices of houses located in SSZs averaged $4,650 lower than those of houses outside SSZs.

Bernknopf, Brookshire, and Thayer (1990) investigated the effects of earthquake and volcano hazard notices on investment behavior and property values. Using HPM, they also rejected the hypothesis that hazard announcement timing and knowledge of the hazard did not affect the perceived market value of homes. A more recent study completed by Murdoch, Singh, and Thayer (1993) investigated the effect of the Loma Prieta earthquake on the housing market, using objective housing market data to investigate the relationship between housing attributes, including earthquake occurrence, and housing prices. Using HPM, they estimated the impact of the Loma Prieta earthquake on housing values to be about $6,100—a 2 percent reduction—for the average house.

Similar studies have been conducted for other natural hazards, such as floods and volcanoes, with the same results (e.g., Montz 1993; Tobin and Montz 1988). In all cases, the results of these studies suggest the following:

1. Different valuation methods can be used to determine the effect of earthquake risks on the housing market, although they produce somewhat different results.

2. Information and legislation about seismic safety can affect the housing market, especially in the short term.

3. A physical event such as an earthquake can influence the housing market in the short term.

4. There is a lack of knowledge about the effects of the risk of a natural disaster on the housing markets in developing countries.

Although many rigorous analyses have been undertaken during the past decade, only a few have studied the impacts of environmental features on developing countries' housing markets and included the safety value of risk reductions against natural disasters (e.g., Daniere 1994; Megbolugbe 1986; Quigley and Kaufmann 1987). To the best of our knowledge, there has been no study of the impact of earthquake safety attributes on urban housing markets in developing countries where natural hazards are a major problem (Tuker, Trumbull, and Wyss 1994).

Moreover, previous research has focused on particular regulatory measures, such as hazard disclosure; on risk reduction measures; and on the impact of a disaster, such as an earthquake, on house prices. The first issue concerns the effects of earthquake information on the housing market, and in most cases the research has compared differences in house prices between two different seismic zones. The results of such studies can be useful for land use policy decisions. In this study, we analyze the effect of earthquake risk on a housing market with a high earthquake risk. We measure the impacts of construction measures rather than land use policy regulation, holding location constant. In contrast to previous research, what is estimated here is the real difference between houses in terms of resistance to earthquakes of different magnitudes.

Theoretical Issues

According to economic theory, people try to reduce risk by insurance, self-insurance, or other averting behavior. In the absence of market insurance, individuals may choose to be self-insured. In earthquake hazards, self-insuring includes two choices: relocating to an area with low earthquake risk or building an earthquake-resistant house. If consumers have enough information on the spatial distribution of earthquake risks where they live, one would expect to see higher housing values for those areas that are relatively safe. Similarly, if consumers have enough information about houses' resistance to earthquakes, one would expect that the more earthquake-resistant buildings would command higher market values, holding other variables constant. Thus, consumers can choose a level of earthquake self-insurance through their location or ERRMs. These effects are explored through a normative analysis of individuals' behavior within the framework of the utility theory.

Assume the household seeks to maximize its utility subject to an income constraint, with utility being a function of many goods, including self-insurance. Since the consumer's decision-making process takes place under uncertainty, the ordinary utility function cannot be used. The expected utility model (EUM) and subjective expected utility model (SEUM) have been widely used to analyze the consumer's decision-making process under conditions of uncertainty. EUM uses objective probability assessed by professionals, while SEUM uses subjective probability perceived by individuals. The theoretical maximization of these models shows that there should be higher prices for houses that are safer either because of their construction or because of their location with regard to the risk (Brookshire et al. 1985). Thus, in theory, individuals are willing to pay for safety, and therefore they are willing to pay higher prices for more earthquake-resistant houses.

The important issue in this regard is finding an adequate method for testing the results of the above theory. Unlike other goods in the market, safety is difficult to assign a value to. Since there is no real market for this kind of good, some method is required that can measure and test the above theory. During the past decades there have been significant developments in the application of new methods for these purposes. HPM, CVM, and stated preference are among the most important methods used to determine the value of environmental attributes. HPM estimates that the amount an individual is willing to pay for a particular good depends on the good's characteristics. For example, the amount an individual is willing to pay for a new house depends to a great extent on the neighborhood, the number of rooms, access to facilities, the distance to the city center, and so on (Willis

and Garrod 1993). Thus, an improvement in one characteristic of the house should raise the price of that house by an amount equal to the value that the household places on that improvement. The application of HPM requires a sufficient number of observations and data on actual house price transactions. While some studies have used HPM to determine earthquake safety attributes of houses in developed countries, the application of HPM in many developing countries is difficult because of a lack of sufficient data (Daniere 1994). Indeed, there is no database of house price transactions in Tehran that could be used to net out house structure attributes, socioeconomic neighborhood effects, location and accessibility attributes, property rights, and other environmental characteristics, and thereby isolate the value of the house attributable to ERRMs alone.

CVM creates a hypothetical market for a particular good, and individuals are asked to specify the maximum amount they are willing to pay to obtain a specified increase or to avoid a decrease in the quality of a good, or the minimum amount they are willing to accept to forgo an increase or accept a decrease in the particular environmental attribute. According to Brookshire and Schulze (1980), the price that households are willing to pay to buy an earthquake-resistant house can be estimated using CVM. Issues in the application of CVM concern the framing of the study and the design of the questionnaire and survey; the rigorous application of CVM can produce accurate and robust estimates of value.

CVM can be applied without the data requirements of HPM. Moreover, there are only a few studies in which CVM has measured the individual's or household's willingness to pay for ERRMs in developing countries' housing markets. This article uses an indirect CVM approach: It is indirect because it assesses a household's willingness to pay for a more earthquake-resistant house through real estate agents' judgments. This approach has been adopted in cost-benefit studies on the grounds that

> The professional valuer is constantly in touch with prices at which houses change hands and with valuations made for other purposes (e.g. estate duty). His professional skill lies largely in making suitable allowance for the magnitude of factors entering into the valuation of any particular house i.e. that part of the problem which causes difficulty for the statistician. (Commission on the Third London Airport 1970, 39)

Moreover, real estate agents have a central role in the housing market, linking potential sellers and buyers and providing both sides with the portrayal of land values and neighborhood characteristics that can itself affect the evaluation of land use. Through daily contact with sellers, buyers, and other appraisers, valuers, and planners, real estate agents gain a detailed and practical picture of the area in which they sell property (Palm 1990). The role of real estate agents in the Iranian housing market has not been studied extensively, but in general their role is important, and, in contrast to property markets in some developing countries, most people buy and sell their houses through these agents. The valuation of property by real estate agents in Tehran follows an experimental method based on intuitive judgment. Appraisers use different variables in their valuation process. In most cases, however, the property subject to valuation is compared with a similar, recently sold property. The CVM survey instrument adopted in this study also includes a description of the house, its local environment, and neighborhood characteristics.

The justification for adopting the CVM approach based on estate agents' judgment is revealed in the results. There is a close correspondence between the results of this study and those of a separate CVM study of households and their willingness to pay extra construction costs for ERRMs.

Survey

The survey was carried out in Tehran, the capital city of Iran. Tehran has grown significantly during the past few decades (Urban Planning and Architecture Research Centre 1992) and has become Iran's largest city, with a population of 6,475,527 in 1991. The property market has increased substantially in the city, and the construction industry has become one of the key elements in its economy (Khaliliy-Araghi 1988). The housing market has been subject to less state control than other markets in the economy; therefore there are no major imperfections in the housing market as there are in many developing countries (Megbolugbe 1986).

The city is located in a high-earthquake-risk zone (Berberian et al. 1992); the history of seismic activity in Tehran and its surrounding areas shows a high probability of a significant seismic event (Nowroozi and Ahmadi 1986). Although Tehran has not experienced a major earthquake during this century, historical evidence suggests such an earthquake could happen soon. The human loss and economic damages of a major earthquake would be enormous (Asgary 1993). By contrast, minor earthquakes and tremors are relatively frequent in Tehran.

Although standard codes for earthquake-resistant buildings have existed in Tehran for many years, it was only after the new UBC was established for housing construction in 1989 that higher standards were adopted and rigorously applied. This code regulates only new construction, however, and does not require existing buildings in the housing sector to be upgraded to its standard. For example, the UBC has no restrictions or regulations specifying the disclosure of information on the earthquake resistance of pre-1989 houses when they are sold or on the earthquake risk associated with a location. Thus, there is no mechanism for measuring the effects of the UBC on the housing market. The question that remains, therefore, is whether households consider earthquake risk in their home-buying decisions. Another issue is the lack of widely and publicly available microseismic zoning maps. However, most people are aware that Tehran, like other parts of Iran, is unsafe in terms of earthquake risk.

A 13-item questionnaire (available on request from the authors) was created following standard design principles for CVM; it was based on the work of Willis and Garrod (1993) in relation to estimates for environmental attributes of housing. It consists of three parts: an introduction to the study by the interviewer, valuation questions, and some general questions about the respondents' characteristics and their opinions about the issue. In the first part, respondents were informed about the aims of the study and the way they should answer the questions.

For the valuation questions in the second part, the real estate agents were presented with a specification for two new, nearly identical houses. Both were two-story masonry houses, built in 1994, with high-quality external brick walls, four bedrooms, two bathrooms, two toilets, two kitchens, central heating and gas, car parking space, and storage basement.

The houses each covered 150 square meters, with a garden covering the remainder of the 220-square-meter land plot. The only difference between the two houses was their resistance to earthquakes. It was assumed that one of them was built in conformance with the new UBC and consequently could withstand an earthquake of magnitude 8 on the Richter scale without major human and structural damage, while the other house was constructed without considering the UBC and accordingly could not withstand a magnitude 8 earthquake. The reason for choosing this type of house is that it is the most common house type in Tehran, both for existing dwellings and for new construction outside the central business district, providing homes for about 70 percent of households. In the questionnaire, real estate agents were asked to estimate the market price of these properties based on the provided characteristics. Since all other variables were held constant, the difference between the agents' expressed prices for the two houses determined the house price premium for earthquake resistance.

The third part of the questionnaire asked about the professional characteristics of the respondents and their opinions about any future regulations regarding earthquake risks and their impact on the housing market. The goal of this series of questions was to determine whether the respondents' answers to the valuation questions were affected by their professional experience and attitudes.

A sample of 200 interviews was drawn from systematically chosen parts of the city. The questionnaire survey was completed in summer 1994. Nonresponse reduced the number of completed questionnaires to 173, and these were used in the analysis. The sample covered 11 of the city's 20 districts.

Results

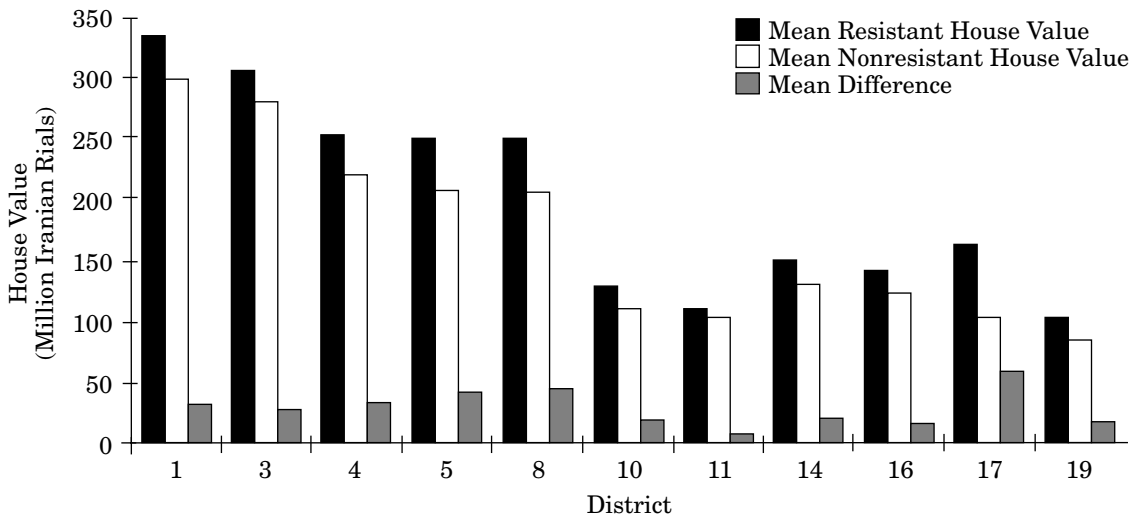
The average price of the earthquake-resistant house over all 11 districts was 161.16 million Iranian rials (Rls), with price estimates varying from Rls 63.00 million in the 19th district to Rls 400.00 million in the 1st district. (At the time of the survey, in September 1994, Rls 2,700 = U.S. $1.) The average price of the nonresistant house was Rls 135.99 million, with price estimates varying from Rls 50.00 million in the 19th district to Rls 350.00 million in the 1st district (table 1). These values mirror quite closely actual land and house prices in the districts of Tehran (see figure 1).

Table 1. **Real Estate Agents' Valuation of Earthquake-Resistant and Nonresistant Houses, Based on a Standard House (Million Iranian Rials)**

	Resistant House	Nonresistant House	Difference
Mean	161.16	135.99	25.17
Standard deviation	73.50	64.10	21.40
Maximum	400.00	350.00	120.00
Minimum	63.00	50.00	00.00

The average difference between the resistant house and the nonresistant house was Rls 25.17 million, varying from Rls 120.00 million to zero. According to a test conducted to determine whether the mean values of the two prices were valid, the difference was

Figure 1. **Mean Values of Earthquake-Resistant Houses and Nonresistant Houses in Districts of Tehran**



statistically significant, which means that the average value of the difference is also significant. This average represents 15.61 percent of total value of an earthquake-resistant house. Thus it can be concluded that the null hypothesis—that earthquake risk is not reflected in house values of the sample properties—can be rejected. The value of earthquake-resistant housing can also be expressed in terms of the house alone, after removing the price of land from the valuation. The average land price given by the real estate agents was approximately Rls 89.20 million. This suggests that the total construction cost for an earthquake-resistant house is approximately Rls 71.96 million. Thus, the difference in value between resistant and nonresistant houses would be nearly 35 percent of total construction costs.

The robustness and accuracy of the results can be assessed in terms of construct validity: the convergence between these results and other measures of the same theoretical construct, and the degree to which the findings are consistent with theoretical expectations (Mitchell and Carson 1989).

The difference between real estate agents' judgments of the value of earthquake-resistant and nonresistant houses was Rls 25.17 million. This figure is very close to the findings of a subsequent CVM study of households themselves, which revealed that they expressed a willingness to pay about Rls 25.95 million for construction measures to reduce earthquake risk (Asgary and Willis 1995). The correspondence between these two independent measures of the value of ERRMs suggests that the results of the real estate agents' judgments are relatively robust and accurate.

To examine theoretical validity, the impact of variables contributing to the determination of the value of earthquake safety attributes in housing was assessed using a multiple regression model. The model attempts to explain the value of the earthquake safety attribute (ESA) of the house as a function of seven variables:

1. EV, the valuer's years of experience in housing valuation

2. LV, the average value of land in the area (in rials per square meter)

3. ELHA, the expected life of the house according to the valuer's opinion (in years)

4. SBRH, the sensitivity of borrowers to the earthquake resistance of the house (1 = not at all sensitive, 2 = somewhat sensitive, 3 = very sensitive)

5. KERA, whether the valuer has knowledge about earthquake risk in the area (0 = no, 1 = yes)

6. VPEE, whether the valuer has personal experience of earthquakes (0 = no, 1 = yes)

7. AIERNH, the valuer's ability to identify earthquake-resistant and nonresistant houses (1 = great, 2 = some, 3 = none)

The function is linear, with an intercept b_0 and seven coefficients represented by b_1 through b_7:

$$\text{ESA} = b_0 + b_1\text{EV} + b_2\text{LV} + b_3\text{ELHA} + b_4\text{SBRH} + b_5\text{KERA} + b_6\text{VPEE} + b_7\text{AIERNH}.$$

The results of ordinary least squares regression are displayed in table 2. The explanatory power of the model is statistically significant ($R^2 = 0.214340$). Most of the variables have the a priori expected signs, suggesting validity of the results. The most influential variables explaining the value of ESAs are the valuer's years of experience, the average value of land in the area, the valuer's knowledge about earthquake risk in the area, and the valuer's ability to identify earthquake-resistant and nonresistant houses. The other variables have no significant influence on ESA.

Real estate appraisers' opinions about the effectiveness of any future mandated disclosure on ERRMs in the housing market are relevant for policy appraisal. Respondents were asked two questions. The first question concerned the effectiveness of such mandatory disclosures, and the second concerned the impact of ERRM regulations on housing prices. Many of the agents (60.1 percent) believed that such regulations could be effective; 16.2 percent believed that they would not be effective; the remaining 23.7 percent were uncertain about the effect and responded with "don't know." These results are similar to those found by Palm (1981). The second question about the effect of earthquake risk zoning is basic for any mandated disclosure of housing prices. In this case, 7.6 percent of the respondents answered that earthquake risk zoning would have no impact on the market, 26.5 percent answered that it would reduce land and house prices but not by very much, and 46.2 percent indicated that such information and regulations would significantly reduce land and house prices in the city. The remaining 19.7 percent responded with "don't know."

Table 2. **Ordinary Least Squares Regression of the Determinants of the Value of Earthquake Safety Attributes**

Variable	Parameter Estimate	Statistical Significance	Mean	Standard Deviation
EV	0.043708	0.0091	20.630	9.770
LV	0.038890	0.0032	40.553	13.780
ELHA	–0.005362	0.7726	26.867	10.179
SBRH	0.277966	0.1259	1.994	0.878
KERA	–1.130840	0.0027	1.731	0.445
VPEE	–0.228794	0.3319	1.702	0.727
AIERNH	–0.497084	0.0441	1.620	0.834
Intercept	2.928569	0.0403		
Multiple R	0.462970			
R^2	0.214340			
Adjusted R^2	0.178630			
F	6.00201	0.0000		

Conclusion

This study demonstrates that it is possible to obtain fairly reasonable estimates of the earthquake safety attributes of houses through an indirect contingent valuation method. It shows that the housing market is sensitive to the earthquake resistance features of houses and that the provision of more information will improve this sensitivity. It follows that there is a willingness to pay for earthquake safety attributes in the city, and this could be a positive sign for further earthquake mitigation measures, especially in terms of information tools. The results of this study also provide some indication of variance in the willingness-to-pay value. However, more studies of this kind would be necessary to address the sensitivity of willingness to pay across areas of the city and between socioeconomic groups.

The values of ERRMs in Tehran are relatively higher than those estimated in previous studies in the United States by Brookshire et al. (1985) and Murdoch et al. (1993) using HPM. Further research is required to determine the extent to which the willingness to pay for ERRMs varies across countries and cultures. The application of methods such as HPM, in addition to CVM, would provide additional understanding of the real estate market response to earthquake risk and its mitigation measures; however, because there was no database, this was not possible for Tehran.

In regulatory terms, policy makers need to make sure that the market encourages property owners to implement ERRMs. A useful start would be to ensure the distribution of existing earthquake risk information to all decision makers, including individuals and institutions, in the housing market.

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