# Factors Affecting Demand for Earthquake Insurance

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## ABSTRACT

*Demand for earthquake insurance is directly or indirectly related to several independent variables. In this study, a sample of 800 owner-occupants of residential units in Tehran was categorized by characteristics of the head of household (age, education, employment, monthly income, attitude toward insurance company, trust in federal disaster relief, geophysical risk) and the structure (type, age, construction quality, value). The effect of these characteristics on the demand for insurance was assessed. The results showed that the level of seismic risk significantly affected the demand for earthquake insurance and that an increase in the premium and value of the structure decreased the demand for earthquake insurance. In addition, the perception of risk significantly increased the demand for residential earthquake insurance. Finally, confidence in federal disaster relief decreased the demand for earthquake insurance. Income level had no significant effect on the demand for insurance.*

**Keywords:**
Earthquake insurance; Building; Premium; Seismic risk; Income; Age; Education

## 1. Introduction

Iran, located on the Himalayan-Alpine seismic belt, is one of the most earthquake-prone countries in the world. It experiences catastrophic earthquakes that result in significant casualties and extensive damage. The Bam earthquake, for example caused over 26,000 deaths in 2003.

Recovery of a community after a natural disaster can be costly; adequate financial resources are required to support recovery and reconstruction. Financing economic recovery requires both private and public funding. Individuals can also take mitigation measures to handle recovery in the form of disaster insurance.

This study surveyed 800 owner-occupants of residential units in Tehran in December 2010. A logistic regression model was used to determine the effect of the characteristics of household heads and the structures on the decision to purchase earthquake insurance. Real data was collected from the questionnaires and the database of the Disaster Management Organization of Tehran. The data exhibits the following parameters:

- Head of household characteristics: age, education, job, experience, attitude toward insurance;
- Characteristics of the structure: type, age, furnishings, quality, value;
- Trust in federal disaster relief;
- The geophysical risk in the zones

To obtain a wide range of data from householders, a two-stage stratified sampling method was used in three zones in northern Tehran having high, medium and low risk fault scenarios. The zones were selected by the Disaster Management Organization of Tehran based on estimated peak ground acceleration parameters. The survey was limited to owner-occupants.

## 2. Seismicity of Tehran

Tehran has a population of about 10 million and is located near the foothills of the south-central Alborz range, a high seismic region, and is surrounded by active faults, including Mosha, North Tehran, Taleqan, Eshtehard, North Rey and South Rey, see Figure (1). The Mosha, North Tehran and Taleqan faults are capable of producing moment magnitudes of 6.62-7.23 [1]. These regional active faults have produced a number of destructive earthquakes (Ms 7.2 in 743; Ms 7.1 in 855; Ms 7.7 in 958; Ms 7.2 in 1177; Ms 7.1 in 1830) [2]. These historical events indicate that the region may experience a major earthquake in the near future. These, along with high population density and its central role in national politics and economy make Tehran vulnerable to damages.

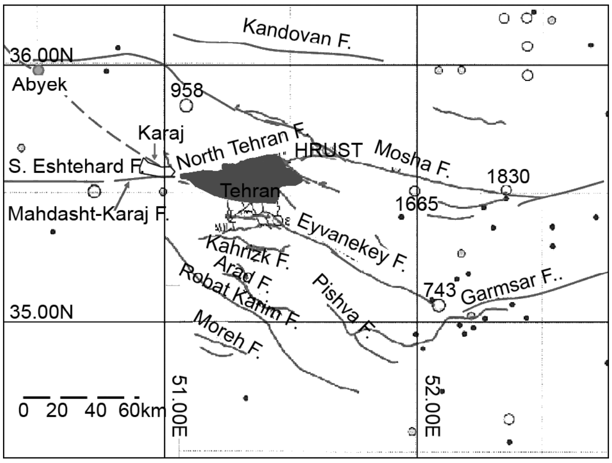



**Figure 1.** Active Alborz faults for greater Tehran region [Map from Zare, IIEES].

## 3. Literature Review

Literature on factors affecting the demand for earthquake insurance is limited. Anderson [3] computed the coefficient of variation for flood, hurricane, tornado, earthquake and total catastrophic property losses for 51 territories in the USA (50 states plus Washington, DC). The results indicated that, except for tornado loss, an insurer writing an all-risk policy exhibited less variability between territories for loss experience than a policy for a specified natural disaster.

Palm and Hodgson [4] surveyed 3500 owner-occupants in Contra Costa, Santa Clara, Los Angeles, and San Bernardino counties in 1989. A random sample was drawn from tax assessor lists of all single family owner-occupants in each county. The survey detected concentrations of insurance policy-holders and the socioeconomic and demographic characteristics that distinguishing insured from noninsured home owners. The results showed that insurance demand is not spatially related to geophysical risk or systematically related to income, equity in the home, age of the head of household, or other socioeconomic characteristics. Perceived risk was the primary factor associated with insurance demand.

Tsubokawa [5] studied the current status and future prospects for residential earthquake insurance in Japan. The research dealt only with household earthquake insurance covering earthquake damage to personal property in Japan and investigated characteristics of Japan's earthquake insurance system and the state of earthquake insurance policies and premiums. Probabilistic earthquake hazard maps were studied for improvements in risk assessment and whether insurance premium rates conform to government earthquake hazard assessment data.

Burcak-Basbug [6] surveyed the earthquake history of Turkey, the development of the insurance sector, and the features of the Turkish Catastrophe Insurance Pool (TCIP). They concluded that the current reserves of the pool are insufficient to cover the loss from an earthquake.

Fujimi and Tatano [7] investigated empirically the ambiguity in the decision to buy earthquake insurance and its relationship to individual characteristics. They found that respondent preference for insurance with 1%, 5%, and 10% non-reimbursement risk are inconsistent with expected utility theory. Respondents also demanded more than 50% reduction in premiums to offset the reimbursement risk.

Yucemen et al. [8] proposed a simple probabilistic model to assess earthquake insurance rates for important engineering structures. The proposed model estimated earthquake insurance premiums for structures in the Bolu Mountain crossing of the Gumusova-Gerede motorway in Turkey. Their model required seismic hazard analysis and estimations of potential damage to structures based on damage probability matrices (DPM). The computations used seismic hazard results and the best estimation from DPM.

Bastami and Takaou [9] studied the experience and the development of a model for earthquake insurance in Japan for the building and housing sectors. They investigated general features of earthquakes in Japan and described the development of earthquake insurance in Japan and evolution of earthquake insurance law and amendments to earthquake insurance coverage. The structure of earthquake reinsurance companies, role of government, share of private companies and government contributions and reinsurance companies in Japan was discussed. The calculation model for pure premiums for earthquake insurance and housing construction in Japan was also discussed.

## 4. Sample Selection

A two-stage stratified sampling method was used for data collection. This sampling method divides a population into smaller groups called strata. In stratified random sampling, the stratum is formed based on the shared attributes of members. A random sample from each stratum is considered proportional to the general population and then pooled to form a random sample.

Three regions in Tehran (Khak-e-sefid, Gholhak, Beryanak) were selected as representative of high, medium and low risk regions, respectively, as rated by the Disaster Management Organization of Tehran, see Figure (2). Figures (3) to (5) show blocks in the sectors that were considered in the survey. The figures also show the number of samples in each block. The sample size was 800. The individuals were assumed to be homogenous within a sector and heterogeneous between sectors. Since each sector was composed of blocks (strata), two stages of sampling were applied. In stage one, the sectors were considered strata and the sample was determined based on proportional allocation ($N_1$=1672, $n_1$=123, $N_2$=4711, $n_2$=351, $N_3$=4347, $N_3$=325). In stage two, blocks are strata and, same as first stage, sample size is determined based on proportional allocation. The survey was limited to owner-occupants (N: Number of total population under study; n: Number of sampling in stage 1 within each blocks; n': Number of sampling in stage 2 within each blocks).

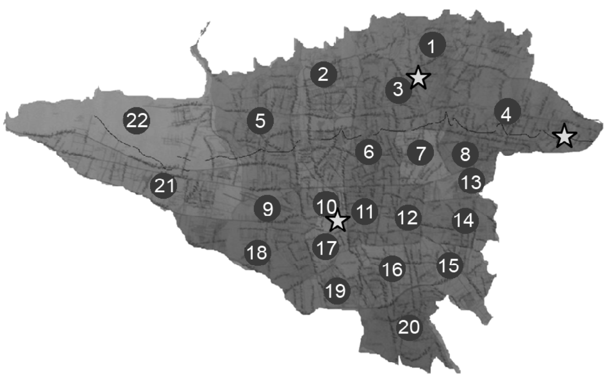
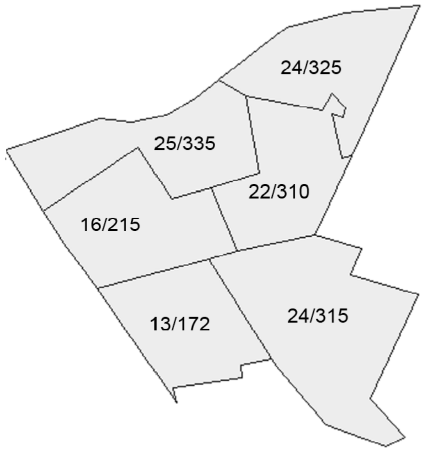
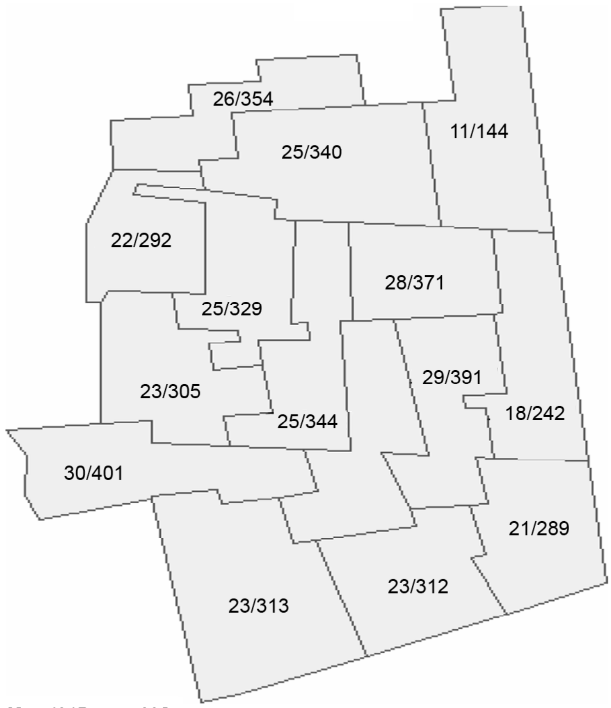



Figure 2. Greater Tehran and location of the studied regions [10].



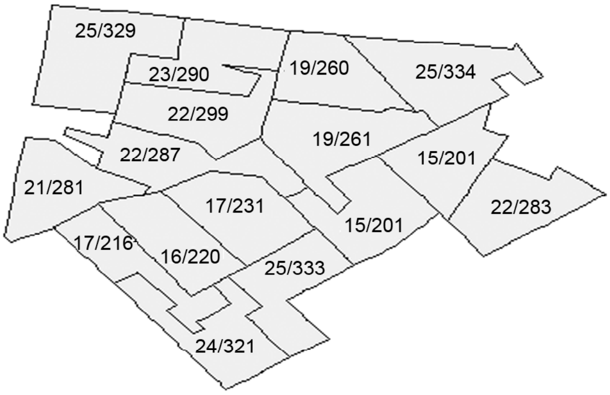

$N_1 = 1672;\ n_1 = 124$
$N'_{11} = 215; N'_{12} = 335$
$N'_{1a} = 310; N'_{14} = 325$
$N'_{15} = 172; N'_{16} = 315$
$n'_{11} = 16; n'_{12} = 25$
$n'_{1a} = 22; n'_{14} = 25$
$n'_{15} = 13; n'_{16} = 23$

Figure 3. Gholhak region as medium risk region showing the number of samples in each sector block (source: Disaster Management Organization of Tehran).




$N_3 = 4347 \quad n_3 = 325$
$N'_{31} = 260; N'_{32} = 261; N'_{33} = 334; N'_{34} = 201; N'_{35} = 329; N'_{36} = 201$
$N'_{37} = 283; N'_{38} = 321; N'_{39} = 231; N'_{3,10} = 216; N'_{3,11} = 220;$
$N'_{3,12} = 287; N'_{3,13} = 333; N'_{3,14} = 281; N'_{3,15} = 229; N'_{3,16} = 290$
$n'_{31} = 19; n'_{32} = 19; n'_{33} = 25; n'_{34} = 15; n'_{35} = 25; n'_{36} = 15; n'_{37} = 22; n'_{38} = 24;$
$n'_{39} = 17; n'_{3,10} = 16; n'_{3,11} = 17; n'_{3,12} = 22; n'_{3,13} = 25; n'_{3,14} = 21; n'_{3,15} = 22; n'_{3,16} = 22$

Figure 4. Khak-e-sefid high risk region showing the number of samples in each sector block (Disaster Management Organization of Tehran).




$N_2 = 4711 \quad n_2 = 351$

$N'_{21} = 242; N'_{22} = 286; N'_{23} = 305; N'_{24} = 354; N'_{25} = 229; N'_{26} = 144$

$N'_{27} = 329; N'_{28} = 340; N'_{29} = 312; N'_{2,10} = 371; N'_{2,11} = 344$

$N'_{2,12} = 289; N'_{2,13} = 313; N'_{2,14} = 391; N'_{2,15} = 401$

$n'_{21} = 18; n'_{22} = 21; n'_{23} = 23; n'_{24} = 26; n'_{25} = 2; n'_{26} = 11; n'_{27} = 25; n'_{28} = 25$

$n'_{29} = 23; n'_{2,10} = 28; n'_{2,11} = 26; n'_{2,12} = 21; n'_{2,13} = 23; n'_{2,14} = 29; n'_{2,15} = 30$

**Figure 5.** Beryanak low risk region showing the number of samples in each sector block (Disaster Management Organization of Tehran).

## 5. Factors Affecting Demand for Earthquake Insurance

Factors affecting demand for earthquake insurance in the regions were examined. The dependent variable was the demand for earthquake insurance as a binary. (0 = purchase earthquake insurance; 1 = does not purchase earthquake insurance).

The independent variables were the age, education, employment, and monthly income of the household head, the structure age and value, geophysical characteristics, premiums codified by the Central Insurance Co. of Iran, owner-occupant knowledge about earthquakes, perception of risk and trust in federal disaster relief. A logistic regression model was applied as follows:

$$\log it(Y) = Ln\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1 x_1 + ... + \beta_n x_n \qquad (1)$$

Define $\pi$ as the possibility of occurrence of earthquake, where $x_n, ..., x_1$ are the independent variables; $Y$ is the demand for earthquake insurance; $\beta_0$ is the constant. $\beta_i$ is the coefficient of $x_i$ and is estimated in Table (1) for all independent variables.

As the table shows, all variables are significant in 95 percent of confidence level.

### *5.1. Effect of Independent Variables*

The effect of the independent variables on the decision to purchase earthquake insurance is examined. $Exp(\beta)$ is the effect of an independent variable on a dependent variable (negative where $Exp(\beta) < 1$, positive where $Exp(\beta) > 1$), see Table (2). $\beta$ is the coefficient of $x_i$. If $\beta < 0$, the independent variable has a negative effect on the dependent variable and if $\beta > 0$, the independent variable has a positive effect on the dependent variable.

Significance level (sig) shows how likely a result is to be affected by chance. The effect of the variable is statistically significant when $sig < 0.05$, see Table (1). The results showed that size of

**Table 1.** Significance of variables.

| Variable | β | sig | Exp(β) |
|---|---|---|---|
| Premium | -7.772 | .000 | .000 |
| Government Influence | - | .022 | - |
| Level 1 | -.2.110 | .017 | .121 |
| Level 2 | -.817 | .017 | .442 |
| Level 3 | -.463 | .041 | .630 |
| Perception of Risk | - | .029 | 3.005 |
| Level 1 | 1.100 | .010 | 2.858 |
| Level 2 | 1.050 | .008 | 1.365 |
| Level 3 | .311 | .043 | 1.365 |
| Value of Structure | -.039 | .000 | .962 |
| Constant | 9.745 | .000 | 17068.67 |

**Table 2.** Variable categories levels.

| Variables | Responses | Frequency |
|---|---|---|
| Risk Perception | No (Level 1) | 24 |
| | Mostly No (Level 2) | 63 |
| | Mostly Yes (Level 3) | 341 |
| | Yes (Level 4) | 372 |
| Federal Disaster Relief | Disagree (Level 1) | 37 |
| | Disagree Somewhat (Level 2) | 280 |
| | Agree Somewhat (Level 3) | 389 |
| | Agree (Level 4) | 94 |
| Income | Less than 400 (Level 1) | 42 |
| | 400 to 800 (Level 2) | 387 |
| | 800 to 1500 (Level 3) | 300 |
| | More than 1500 (Level 4) | 71 |
| Knowledge about Earthquake Intensity | None(Level 1) | 262 |
| | Some (Level 2) | 409 |
| | Extensive (Level 3) | 129 |
| Knowledge about Landslides | None (Level 1) | 425 |
| | Some (Level 2) | 344 |
| | Extensive (Level 3) | 31 |
| Knowledge about Faults | None (Level 1) | 67 |
| | Some (Level 2) | 434 |
| | Extensive (Level 3) | 299 |
| Employment | Employed (0) | 189 |
| | Unemployed (1) | 611 |
| Education | University (0) | 450 |
| | No university (1) | 350 |

premium, federal disaster relief, risk perception and value of structure were significant and age, education, employment, income, knowledge about earthquakes and geophysical risk did not affect the demand for earthquake insurance significantly. Table (3) shows that $Exp(\beta)$ for premium, federal disaster relief, perception of risk and value of structure are significantly related to the purchase earthquake insurance.

**Table 3.** Other variables.

| Variable | sig |
|---|---|
| Age | .461 |
| Education | .380 |
| Employment | .188 |
| Income | .203 |
| Age of Structure | .713 |
| Knowledge about Earthquake Intensity | .534 |
| Knowledge about Landslides | .383 |
| Knowledge about Faults | .879 |
| HDC | .699 |
| MDC | .957 |
| LDC | .403 |
| Overall Statistics | .922 |

### 5.2. Variables Omitted from the Model

The results show that age, education, employment, income, age of structure, knowledge about earthquake risk (intensity, landslide, fault), and risk of structural damage (high damage = HDC; medium damage = MDC; low damage = LDC) have no significant effect on the demand for earthquake insurance, thus, they were omitted from the model. Table (3) lists these variables and indicates that their sig is > 0.05. Data for the risk of structural damage (HDC, MDC, LDC) are based on the Disaster Management Organization of Tehran database.

Figure (6) shows that the demand for earthquake insurance increases as the perception of risk increases. Figure (7) indicates that the demand for earthquake insurance decreases as trust in federal disaster relief increases. This result indicates that trust in federal disaster relief decreases an owner's willingness to pay for earthquake insurance. Figure (8) shows that increasing the size of the premium also decreases the demand for earthquake insurance.

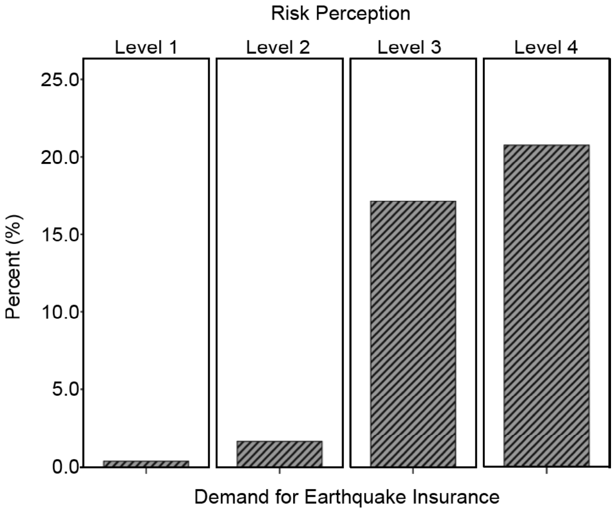



**Figure 6.** Individual perception of risk by demand for earthquake insurance.

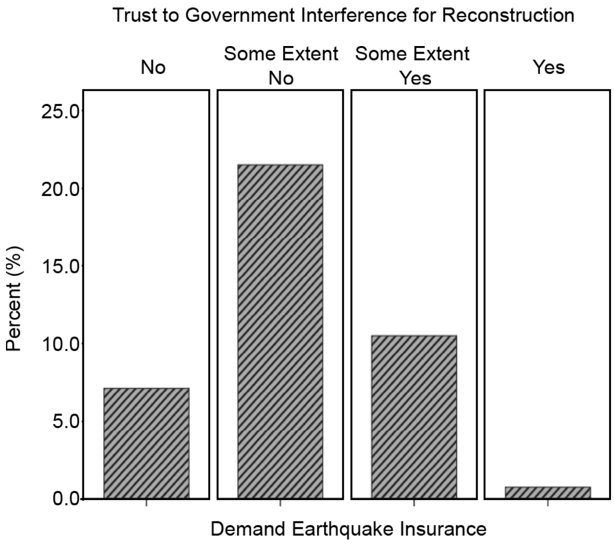



**Figure 7.** Individual trust in government influence by demand for earthquake insurance.

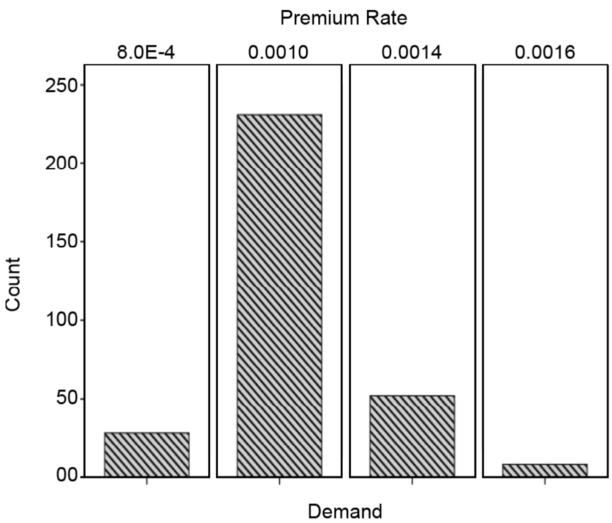



**Figure 8.** Premium by demand for earthquake insurance (Premium rate is calculated as building value/1000).

Figure (9) shows that the demand for insurance decreases as the value of the building increases. This contradiction may result from factors that have not previously been considered, such as the vulnerability of lower income owners of smaller buildings to loss, which increases their perceived need to insure themselves.

Figures (10) to (14) illustrate individual trust in insurance companies, knowledge about earthquake hazard in the three zones of Tehran and demand for

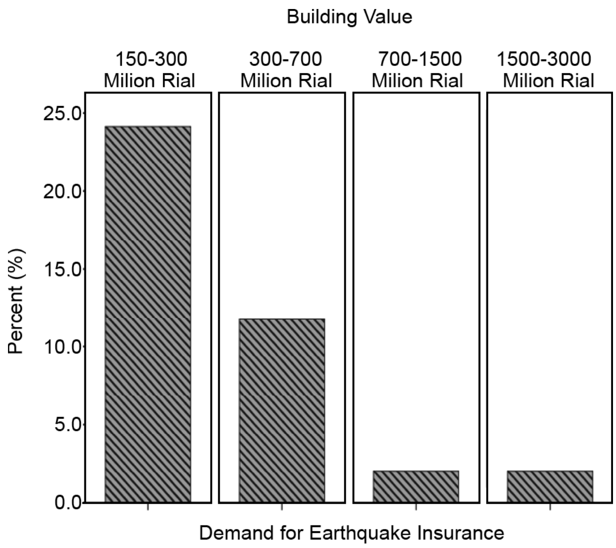



**Figure 9.** Structure value by demand for earthquake insurance.

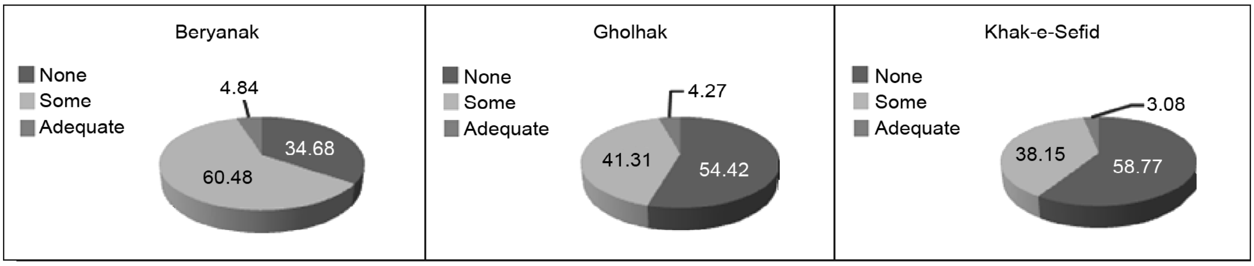



**Figure 10.** Knowledge about landslides by region.

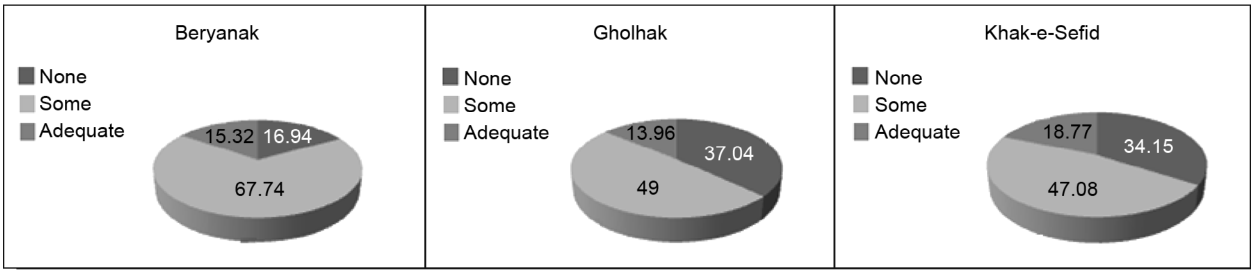



**Figure 11.** Knowledge about intensity by region.

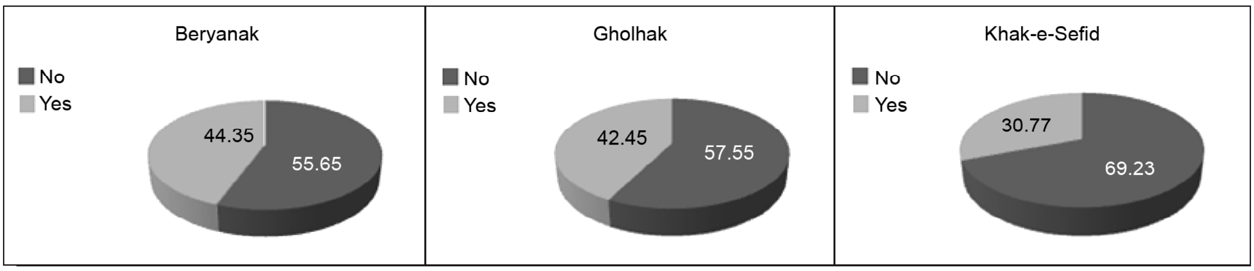



**Figure 12.** Demand for earthquake insurance by region.

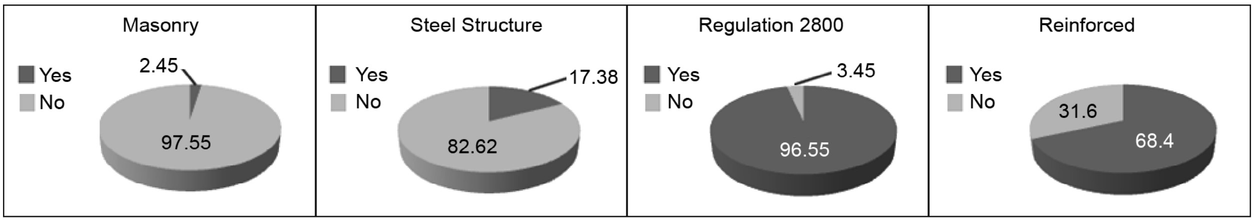



**Figure 13.** Demand for earthquake insurance by structure.

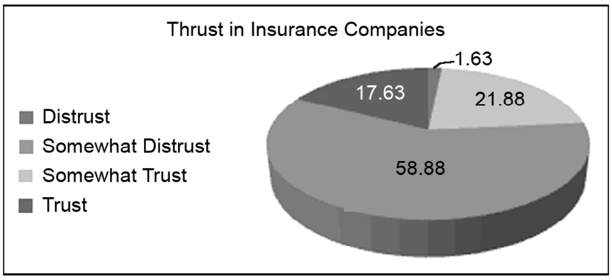



**Figure 14.** Householder trust in insurance companies.

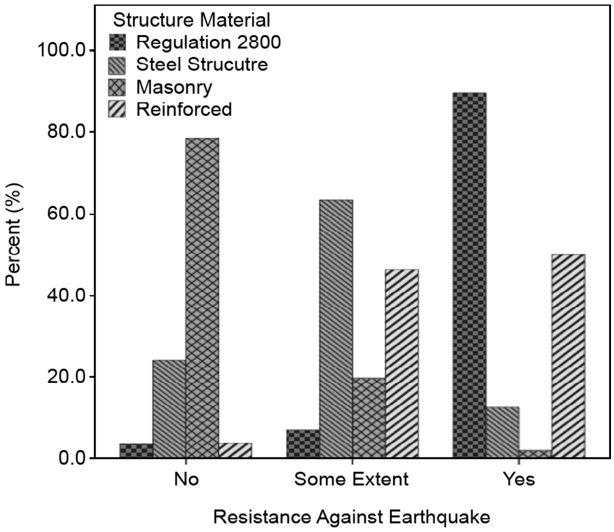



**Figure 15.** Building types and resistance against earthquake in owners' opinion.

earthquake insurance for different structures. Figure (12) shows the level of knowledge about landslides by region. Just 4.84% of householders in Beryanak, 4.27% in Gholhak, and 3.08 % in Khak-e-sefid have an adequate knowledge about landslides caused by earthquakes. Figure (11) shows the level of knowledge about earthquake intensity by region. Just 15.32% of householders in Beryanak, 13.96% in Gholhak, and 18.77% in Khak-e-sefid have an adequate understanding of earthquake intensity.

According to Figure 12, 44.35% of householders in Beryanak, 42.45% in Gholhak, and 30.77% in Khak-e-sefid have purchased earthquake insurance. Figure (13) distributes these percentages by type of structure: 17.38% live in steel structures, 2.45% live in masonry structures, and 68.4% live in reinforced concrete structures. Additionally, 96.55 % of these householders who live in structures built according to the Iranian Code for seismic design of buildings (standard 2800) purchased earthquake insurance. This indicates that owners of vulnerable (non-code) buildings are less likely to buy earthquake insurance.

Figure (14) shows the level of trust in insurance companies. About 17.63% of householders trust insurance companies, 1.63% distrust insurance companies, 58.88% somewhat trust and 21.88% somewhat distrust insurance companies.

Figure (15) shows the relationship between the type of structure and its resistance to earthquake damage. It was found that 90% of owners believe that structures designed according to standard 2800 are resistant, 7% believe they are somewhat resistant and 3% believe they are not resistant to earthquake. Furthermore, 50% of owners believe that reinforced concrete structures are resistant, 46% believe they are somewhat resistant, and 4% believe they are not resistant to earthquake damage; 10% believe that steel structures are resistant, 65% believe they are somewhat resistant and 25% believe they are not resistant. Most owners (78%) believe that most masonry buildings are not earthquake resistant, 2% believe they are resistant, and 20% believe they are somewhat resistant.

Figure (16) shows the relationship between structure age and resistance to earthquake. It confirms that, as the age of a building increases, its resistance to earthquake decreases. Figure (17) shows that the owners believe 55% of buildings of good quality are resistant, 38% are somewhat resistant and 7% are not resistant to earthquake damage. They also believe that 20% of structures of medium quality are resistant, 68% are somewhat resistant and 12% are not resistant. Owners indicated

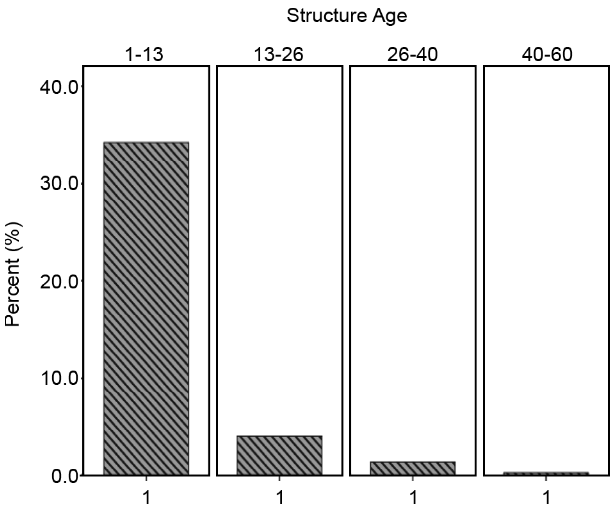



**Figure 16.** Demand for earthquake insurance by structure age.

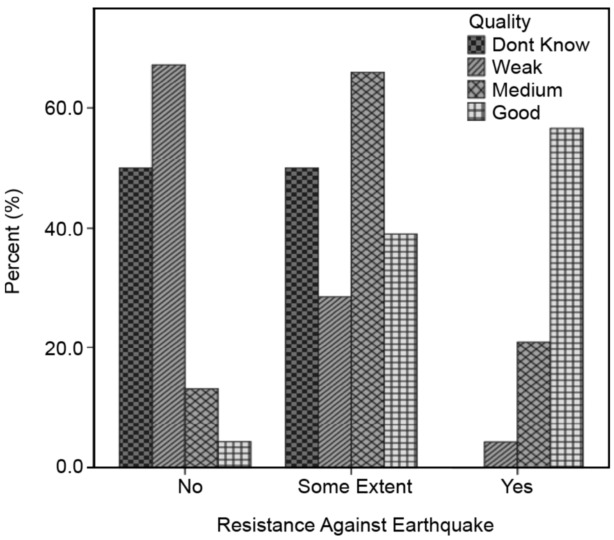



**Figure 17.** Structure resistance to earthquake.

that they believe 4% of buildings of poor quality are resistant, 28% are somewhat resistant, and 68% are not resistant.

## 6. Conclusion

The demand for earthquake insurance is directly or indirectly related to independent variables such as premiums, structure value, perception of risk, owner risk aversion level and expectation of government funding for disaster relief. This study found:

- The empirical analysis supports the hypothesis that an increase in premiums and building value significantly decreases the demand for earthquake insurance.
- Perception of risk significantly increases the demand for earthquake insurance. This implies that it is important to increase understanding of vulnerability and earthquake risk to induce hazard mitigation. An owner who feels more vulnerability is more likely to take mitigation measures and purchase more insurance.
- Relying on federal disaster relief for loss financing decreases the purchase of earthquake insurance. Citizens expect that the government should provide funding for disaster prevention and relief and are not motivated to purchase insurance.
- The results show that insurance demand is not significantly related to the seismic risk in a specific region. Homeowners living in high-risk areas, as measured by distance to an active fault or proximity to a relatively high intensity zone, tend to purchase more earthquake insurance than those living in areas of lower seismic risk. For example, owners in Gholhak (medium risk) purchase more than those living in Khak-e-sefid (high risk). People living in Khak-e-sefid are deprived compared with those in Gholhak.
- Income level does not have a significant effect on insurance demand. Poor householders do not have sufficient monthly income to afford insurance premiums and rich householders avoid purchasing earthquake insurance. Therefore, it has an effect on insurance demand.
- The demand for earthquake insurance is not significantly related to employment, trust in insurance companies, and age or education level of household head.
- Knowledge about faults, earthquake intensity and other facts about the earthquakes do not have a significant effect on demand for earthquake insurance.

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