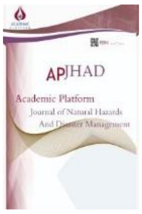

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Participation to Compulsory Earthquake Insurance System in the Southwestern Turkey After the 2023 Earthquake

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Abstract

Earthquake is one of the foremost natural disasters for Turkey with its potential of occurrence and frequency. The recent Kahramanmaraş earthquake that took place in the southeastern Turkey in 2023 was catastrophic. This catastrophe reminded the necessity of having awareness of and getting prepared for potential awaited earthquakes. With this research, it was aimed to measure the intention of the society to get prepared for earthquakes in the southwestern region of Turkey that pose significant earthquake risk. The probability of having compulsory earthquake insurance (CEI) was estimated in Finike and Demre towns of Antalya, Turkey in 2023 after Kahramanmaraş earthquake. It was understood that with rising education, awareness and age, the probability of having insured rises in the representative districts. Yet, with ageing residency/building and random information, the probability declines. This early response emphasized the importance of scientific information of the society and better promotion of precautionary actions in the region and in Turkey.

Key words: Earthquake, Risk, Insurance, Logistic probability, Turkey

1. Introduction

Natural catastrophes are mostly inevitable. However, it is important to take precautions against their potential physical, financial, and health-related effects. Turkey has been historically known as a centre of periodic earthquake experiences. More than 90 % of country's lands that inhabit 95 % of the national population bear earthquake risks and it is known that 98 % of industrial centres and 93 % of energy producing dams are under direct earthquake risk [1]. Since the beginning of recorded history, Turkey witnessed many earthquakes and some of them were specifically devastating. The number of fatal earthquakes has been almost 20 in the last 100 years.

The recent Kahramanmaraş earthquake that took place in the southeastern region of Turkey in February 2023 was devastating with its mortality effect. Two earthquakes took place centred in two towns of the city in the same day, 6th of February, with magnitudes between 7.6 and 7.7. The earthquakes affected 11 provinces and more than 50 thousand people died. In addition, almost 2 million buildings got damaged, of which more than 500,000 were either collapsed or detected to be demolished afterwards [2]. Unfortunately, the earthquake reminded importance of preparations considering many aspects as health emergency systems, building structure

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reinforcement and post-encounter actions as physical and social recovery and reconstruction activities.

The public authorities make potential risk assessments for earthquakes and other natural disasters at least occasionally. The society has been informed continuously using different tools and with both scientific and social approaches. However, whether the society understands the importance of precautionary actions for earthquakes and similar natural disasters is still a question almost everywhere in the world. Kahramanmaraş earthquake was huge with its geographical dispersion and mortality effect. There were two previous devastating earthquakes that took place in Marmara Region in 1999, the industrial centre of Turkey. The magnitudes of the earthquakes were 7.8 and 7.5 and they led to high mortality of more than 18000 people. The loss of building stock was also more than 100000. Due to these catastrophes a need to increase societal awareness and level of preparation for potential earthquakes aroused [3]. Turkish Catastrophe Insurance Pool (the TCIP) was established in 2000 after Marmara earthquakes, to coordinate preparations for potential catastrophes. A Compulsory Earthquake Insurance (CEI) was issued at the end of 1999 to cover at least the material losses of the earthquakes and TCIP was appointed as the coordinator of insurance system [4]. The recent insurance records were overviewed to understand effectiveness of the system. The number of insurance certificates has risen steadily from 2.4 million in 2001 to 11,66 million of 20 million buildings in 2023 [5]. The rise observed in 2023 was 6.5 % but it was seen that the number of insurance certificates is still slightly above half of the existing national building stock. On the other hand, the total amount accumulated in the compulsory earthquake insurance pool has been fluctuating since its issuance on 1999/2000 as demonstrated in Figure 1.

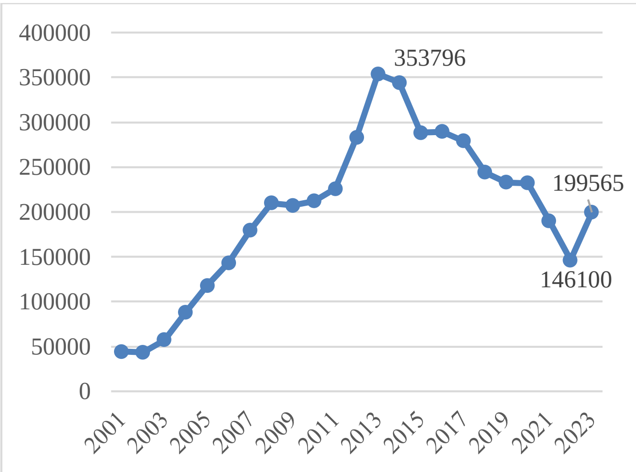

Figure 1. Value of certificates collected in TCIP – value in thousand $ (2001 – 2023)

While the total value was $ 44 million in 2001, the amount rose to almost $ 354 million in 2013 and reduced steadily afterwards. Following 2023 Kahramanmaraş earthquake, the total amount increased by 36 % from $ 146 to almost $ 200 million.

Therefore, the unfortunate 2023 Kahramanmaraş earthquake emphasized the need for assessing public awareness and individual preparedness to possible earthquakes countrywide. Accordingly, it was aimed with this study to detect the factors that affect individuals' earthquake insurance decisions. The insurance acceptance was analysed and interpreted for the Mediterranean region of Turkey with a representative sample of two touristic towns residing in southwestern costs of Antalya, that are Demre and Finike.

2. The Earthquake Risk in Antalya and Possible Causes

The research was focused on two Antalya towns and this focus needs to be explained. Earthquakes with high magnitudes were recorded in the region close to the Lycian coast throughout history and felt in Finike and Demre. The epicentre of the earthquake known as the Lycian Earthquake, which occurred in 141 AD, was predicted by Guidoboni and friends [6] to be between Rhodes island and Marmaris town. It is known that the damage was significant in a wide area from Limyra to Patara in this earthquake, and some of these damaged structures (especially public buildings) were repaired by Opramoas, a rich and benevolent person from Rhodiapolis [7]. A severe earthquake occurred in Finike on November 14th, 1886, and although there was no life loss record, it caused the walls of some buildings to split and a few furnace chimneys to collapse. The people of Finike left their homes due to fear and anxiety and spent the night in tents as recorded in Prime Ministry Ottoman Archives [8].

The region experienced many earthquakes during the 20th century as well. An earthquake having Mw=6.1 magnitude occurred near Finike on April 30th, 1911. An earthquake with an epicentre of 32 km south of Finike, at a depth of 10 km and a magnitude of Mw = 6.5 occurred on March 18th, 1926. The earthquake resulted in physical damage to 364 buildings and loss of life in the region between Kumluca and Fethiye as recorded by Ayhan and his friends in 1981 [9]. A recent earthquake took place on January 14th, 1969. This earthquake with a 6.3 magnitude occurred near Megisti Island, and although there was no loss of life, over 1000 buildings were damaged between Kumluca and Fethiye towns of southwestern region of Turkey. It was reported that half of the houses in Kalkan settlement had become uninhabitable due to this earthquake [10].

Residing on this historical background, the current situation of the region with regards to earthquake risk needs to be overviewed. When the focal points of earthquakes around Antalya are analysed in 3D, the earthquakes can be divided into two groups as Crustal earthquakes and Subduction zone earthquakes. In the region eleven source zones were defined for crustal earthquakes [11]. Among the crustal seismic zones, the C1 seismic zone is sourced by tectonic structure which is shown as TT in Figure 2.

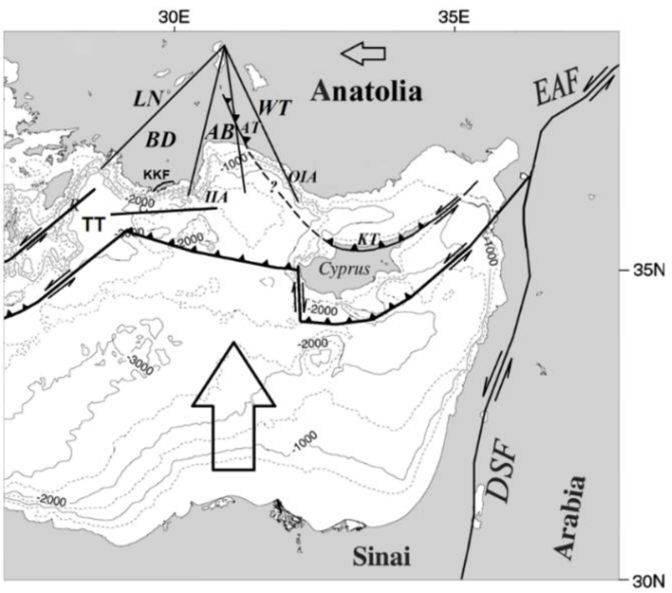

Figure 2. The earthquake sources of the region

This source zone demonstrated is particularly important as it is 25 km away from the current research area. In this region, there is a depression called Finike Trench, which is one of the deepest regions of the Mediterranean with a depth of 3064 meters [12]. Another tectonic structure among crustal resources is the Kekova and Kale faults (KKF) confirmed with different studies [13, 14]. These are two parallel faults between Demre and Kaş. These two faults demonstrated in Figure 2 have potential to produce an earthquake of magnitude Mw = 6.5.

The earthquake sources of the region are the Cyprus Arc and the Isparta Angle (Figure 2). The Cyprus Arc tectonic structure is a subduction fault between Cyprus and Rhodes, south of Antalya. This segment of the Cyprus Arc plunges northward, causing the Mediterranean Sea floor to subduct beneath Antalya region (Figure 3).

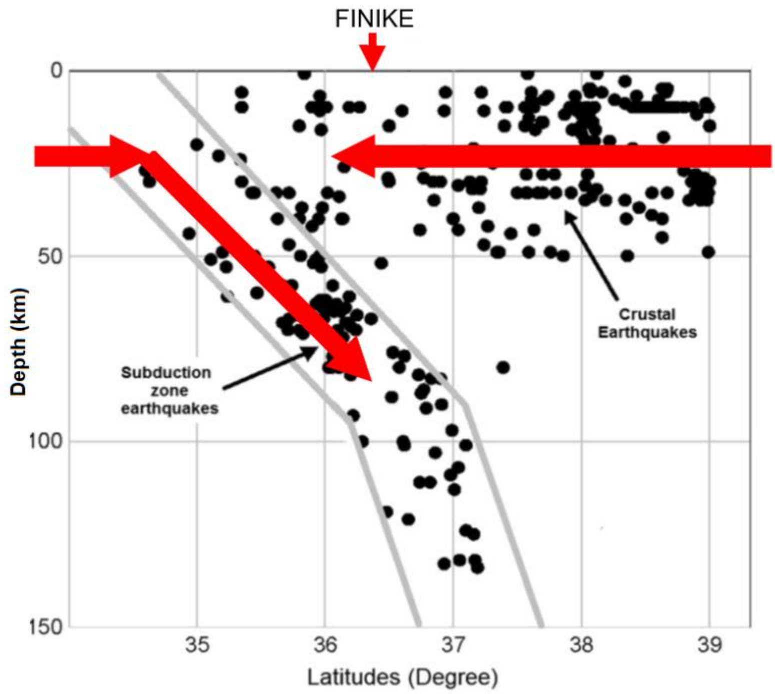

Figure 3. Northward subduction between Cyprus and Rhodes, beneath the Antalya region

When we look at the current research area, there are 3 active faults recognized within 50 km sphere of Finike and Demre towns. These faults have produced earthquakes up to Mw = 6.5 since 1900. It is predicted that the region should be prepared for an earthquake of Mw = 7 magnitude and a horizontal acceleration of 0.37g-0.42g in the future.

Finike and Demre soils are sand, and silt dominated alluvium, formed by the material transported via the streams reaching the coast filling the old bays. The groundwater table is approximately 2 m deep. There is susceptibility to liquefaction in the fine sand-dominated layers in the ground profile. In the liquefaction potential calculations made for Mw = 7 in these layers, the ground was found to be liquefiable. These records indicate that there is the possibility of witnessing earthquakes with high magnitudes and structures and endurability of current building stock in the region do pose mortality risk in contrast to the existent close history.

Accordingly, the awareness and preparation of the society in the targeted towns of Antalya province was considered as representative for the southwestern coasts of Turkey. The region and targeted towns are also important in terms of contribution to tourism and agricultural income of Turkey. These multidimensional characteristics of the region constituted the scientific and socio-economic bases of this research.

3. Materials and Method

The research objective was to estimate and interpret the tendency of individuals to have/purchase Compulsory Earthquake Insurance for earthquake preparation and factors affecting this decision within a logistic regression framework. Accordingly, primary data was retrieved via face-to-face surveys from 471 individuals, 232 in Demre and 239 in Finike towns of Antalya in June/July 2023.

With this primary data the probability of having Compulsory Earthquake Insurance (CEI) was estimated for the houseowners. There are many uninsured buildings, even if the insurance was announced as compulsory. The age and district of the building and having not changed the owner recently might be considered as effects of this limited insurance rate. However, the response - based evaluation was expected to provide more insights. Accordingly, the attitude related probability was estimated with logistic regression which was suggested by Berkson [15] in 1944. The probability function can be briefly reported as below.

$$log[Pr(Y=1|x)] = \ln\left[\frac{Pr(Y=1|x)}{1-\Pr(Y=1|x)}\right] = \sum \beta_i x_i + \sum \alpha_i D_i + u_i$$

The probability up to 100 % was estimated in a dichotomous framework and the positive and negative factors were detected with this methodology suggested by McFadden [16]. Therefore, the variable to be estimated (Y) referred to whether the house owner has CEI for his property (1) or not (0). The pre-detected potential factors, either continuous/discrete (x) or dummy (dichotomous/polytomous) were enlisted below.

Independent Variables

- **Age:** Age of the individual – scale (1: below 30 years old, 2:31-50 years old, 3:51+)
- **Edu:** Level of education – scale (1: elementary; 2: secondary; 3: BA/BSc; 4: MSc+)
- **PI:** Personal Income – scale (1: below minimum wage; 2: minimum wage; 3: 11.402-20000, 4: 2001-50000, 5: 50000+, 6: not mentioned, 7: no-income)
- **HHSE:** number of people employed in the household – discrete
- **A_B:** Age of the building & **A_R:** Years of residency – scale (1: 0-5 years. 2: 6-10 years, 3: 11-15 years, 4:15-20 years, 5: 21 years +
- **PRF:** The most important factor in apartment/house purchases is price – binary (1: Yes, 0: otherwise)
- **EQF:** The most important factor in apartment/house purchases is resistance to quakes– binary (1: Yes, 0: otherwise)
- **Info_CEI:** Knowledge on Insurance – binary (1: Yes, 0: No)
- **Info_OIV:** Knowledge on Private Communication Tax (OIV) and its relation to earthquake– binary (1: Yes, 0: No)
- **Prep_EQ:** Evaluation on public preparedness level – scale (1: completely ready, 2: ready, 3: no idea, 4: not ready, 5: definitely not ready)
- **Info_EQ:** Acceptance after proper information on reasons and results of earthquakes– scale (1: complete, 2: have idea, 3: no idea, 4: not ready, 5: definitely not ready)
- **Use_OIV:** Belief on Proper Use of Private Communication Tax – binary (1: Yes, 0: No)

- **Accept_CEI:** Insurance acceptance after proper information– scale (1: completely ready, 2: ready, 3: no idea, 4: not ready, 5: definitely not ready)
- **FD:** Residency – binary (1: Finike, 0: Demre)

Departing from this aggregate variable list, the probability was estimated via Python and using machine learning methodology of training and testing the data. After statistical fit tests the probability of odds or occurrence were determined from estimates of independent variables [17, 18].

4. Estimation of the Tendency to Have CEI

4.1. Estimation Results

A priory, it is important to mention that 105 individuals out of surveyed sample of 471 declared that they have CEI. This signed less than 25 % of insured buildings/apartments and very limited awareness for the target area that has earthquake risks. The number of insured individuals or buildings was 46 in Demre and 59 in Finike towns, with a slightly higher share in Finike. Existent awareness on CEI was portrayed with 127 out of 128 individuals' understanding of the Private Communication Tax (OIV) and its relevance to earthquake preparation. Therefore, the awareness and acceptance of the audience seemed to be closely related and low. Following this brief sample presentation, the reasoning behind this low level of insurance holding and factors that can be used to induce insurance capacity were detected and evaluated for the sample.

Afore mentioned independent list were estimated initially and checked with pseudo R^2 that refer to degree of explanation. As there were many potential determinants, there might be a multicollinear significance indicating correlation of the determinants. This collinearity level was checked with Variance Inflation Factor of each variable. The factors were demonstrated in the Table 1.

Table 1. Variance inflation factors of tendency to have CEI insurance

Estimator	VIF	Estimator	VIF
Age	7.38	Earthquake Awareness Preference	1.69
Education	9.13	CEI Knowledge	1.47
Personal Income	4.39	OIV Knowledge	1.57
HH Employment	4.35	Rising Public Preparation for Earthquakes	9.14
Age of Building	10.27	OIV Use	2.39
Years of Residency	6.27	Rising Information on Earthquakes	1.41
Price Preference	1.44	CEI Acceptance with Information	2.36
		Residency – F/D	3.23

The VIF score equal to 1 refers to inexistence of independent correlation between the relevant variable and other indicators. The value between 1 and 5 refers to low, 6 and 10 to moderate/high and above 10 extreme correlation levels. Depending on this information the number of variables were reduced, and three alternative models were estimated and evaluated. The model outputs were statistically evaluated with Likelihood Ratio [19] and Log-likelihood providing accurate inference on logistic estimation methodology [20].

In addition to the likelihood of the estimates, AIC [21] and BIC [22] statistics were used to compare models and the model with minimum values is suggested. Models including relevant independent variables and preferential statistics were demonstrated in Table 2.

Table 2. Alternative models that determine tendency to have CEI insurance

Model 1 – 15 independents	Model 2 – 11 independents	Model 3 – 10 independents
• Age &Edu &PI & HHSE • A_B & A_R & PRF & EQF • Info_OIV&Info_EQ • Prep_EQ&Use_OIV • Info_CEI&Accept_CEI • FD Residency	• Age &Edu &PI • A_B & A_R & EQF • Info_OIV& Info_EQ • Info_CEI&Accept_CEI • FD Residency	• Age &Edu &PI • A_R & EQF • Info_OIV& Info_EQ • Accept_CEI Info_CEI& • FD Residency
AIC: 481.04 BIC: 547.52	AIC: 473.73 BIC: 523.59	AIC: 491.40 BIC: 537.10
Pseudo R2: 0.11	Pseudo R2: 0.11	Pseudo R2: 0.07
Log-Likelihood: -224.52 LLR p-value: .351e-06	Log-Likelihood: -224.87 LLR p-value: 7.655e-08	Log-Likelihood: -234.70 LLR p-value: 0.0001083

According to this classification, the third model was selected to explain the probability with its higher Log-Likelihood value in absolute terms. Even if the AIC and BIC selection criteria of second model is better, the VIF of age of the building was high with a value above 10. This sign of high multicollinearity or inflation of the variance refers to existence of a relationship between the building age and other factors obviously [23] and it led us to consider the fit of the third model.

Prior to evaluating the parameter estimates and their contribution to the probability of having CEI, the fit of the data should be evaluated. Therefore, the accuracy score and classification report were checked for these logit estimates with confusion matrix. The selected factors were detected to explain the probability by 78 % due to accuracy score and the average significance of the probability to have CEI with the relevant variables was 87 %. Therefore, the model and estimates were found to be explanatory for the insurance holding probabilities of the sample.

In the final step, inverse logarithms of the estimates were calculated, and odds ratios of the factors were retrieved. The odds ratios of parameters that explain the directions of the effects were demonstrated in Table 3. Accordingly, it can be noted that the factors that appreciate the probability of having earthquake insurance were age, level of education and income, awareness on CEI and Private Communication Tax (OIV).

Table 3. Odds of the factors affecting compulsory earthquake insurance

Factor	Odds	Factor	Odds
Constant	1.01	Info_CEI	1.52
Age	1.85	Info_OIV	1.86
Edu	1.45	Info_EQ	0.87
PI	1.17	Accept_CEI	0.70
A_R	0.95	FD Residency	0.95
PRF	1.36		

With the rising age of the residency building there seemed to be a descending trend in insurance acceptance. Rising information on earthquakes in general terms and rising acceptance of CEI seemed to reduce the probability of having insurance. This finding can be related to widespread existence of word-of-mouth or random information in the society or reliance of individuals to non-scientific information.

Yet, having resided in Finike town seemed to be negatively correlated with the insurance acceptance. However, it is not accurate to conclude that there is a significant difference between towns. Rather than removing the negative factors from the system, understanding the reasoning behind was considered as more contributory.

4.2. Results and Discussion

It is visible that with age, the need for security rises. Besides, probability of residency ownership is mostly higher for older individuals almost everywhere in the world. There was a positive relationship between ageing population and tendency for earthquake preparation with insurance in New Zealand. However, the society seemed not to be sure about full recovery under disaster conditions [24].

In an attitude evaluation survey in Erzincan province of Turkey, which had witnessed mortality involving earthquakes and has future risk, the relationship between awareness and preparation level of 400 individuals were assessed in 2016 [25]. It was understood that rising income is directive for taking precaution for the sample and the awareness level contributes acceptance of the compulsory insurance. Willingness to pay for earthquake insurance was measured in South Korea following a moderately severe earthquake and it was found out that risk perception or awareness, level of income and house ownership status induce insurance demand [26]. In a public survey conducted with almost 1000 individuals in Iran in 2019, significant relationships were detected between preparation level and education and homeownership [27]. Income and awareness on earthquake seemed to contribute individual insurance purchases in a sample of 78 individuals from Turkey [28]. The researchers concluded that self-insurance mechanisms should be empowered, and urban renewal projects should be supported rather than compulsory contribution to TCIP.

Recalling the scope of OIV is also important to understand the relationship between the tax and insurance system. The Private Communication Tax (OIV) was introduced for Turkish society after the earthquakes of 1999 as a temporary funding tool. This tax is applied to cable TV, internet services and mobile use in minutes and messages. By the time, considerable shares of other permanent tax types as vehicle or housing taxes were devoted to recovery as well under the name of additive taxes. Those additive taxes were eliminated at the end of 2003, but OIV became permanent by 2003 [29]. The compulsory tax rate was 7.5 % until 2021 and rose to 10 % by then [30]. Yet, it was estimated that OIV collected from 1999 to 2022 had been around 39 billion Dollars in sum and 476 million Dollars in 2023 due to Ministry of Treasury and Finance records [31]. However, in contrast to its announcement objective, the tax revenues neither must be used solely for earthquake preparation due to tax regulations, nor were used for preparation [32]. For our research, the above 1 probability score inferred that with rising awareness on the earthquake tax and its uses, tendency to buy insurance plans would be affected positively.

Resistance of buildings to a potential earthquake is prioritized by some of the respondents in purchasing a house/apartment. For those people, the tendency of having their shelter insured seemed to be higher, signifying a correlation between awareness and preparation. However, rising information on earthquakes and acceptance of CEI after getting informed seemed to reduce the probability, in a contradictory way. The recent impacts may need further sociological evaluation. Over-information might be considered as a barrier against precautionary actions as well. In a phone survey with around 2000 individuals in California, the USA, it was seen that only 15 % of fully informed individuals seemed to have tendency to get prepared [33].

The detected factors affecting the probability of taking precautions against earthquakes with insurance in the sample towns were like earlier research findings. The factors related to the aggregate socio-economic awareness level like education, information on insurance and taxation tools and income appeared as probability rising factors. However, available random information on earthquakes and precautionary insurance/tax tools and derogations in residency structures seemed to deter the insurance ratio in the society.

5. Conclusion

There are many suggestions that can be derived from these findings. Rising insurance ratio due to rising education level is an expected outcome. But, even if there is endowed information in mass media or internet, the need for scientific information remains. Therefore, the first but not the least important suggestion is that the necessity of scientific information, its translation to daily wording and extension across society is still essential. However, considering the geological structure of the country, mass information and its detachment from earthquake experiences is also required. In other words, society should be kept awake continuously against earthquake risks.

Before concluding it is important to note that current research resides on personal responses of individuals in representative districts of a region of Turkey that pose important earthquake risk. Within the scope of limited sample and increased anxiety level after 2023 earthquake, intentions on getting insured in the future were higher. Accordingly, the mindset of people needs to be checked in normal condition. This rising interest and tendency was also observed in a sample that has higher education, income, total awareness than the national averages as the Mediterranean region and focused districts/towns has socio-economic endowments and advantages. This socio-economic inference solely is adequate to conclude on the need for informing larger audiences.

It is also important to note that follow-up of the awareness and preparation for earthquakes is essential for Turkey. Therefore, the audiences need to be surveyed and their preparation level should be evaluated by the public institutes and scientific organisations to form new precautionary actions in a persistent way. The detected rising insurance demand or tendency needs to be evaluated with different samples and followed up in time for policy and tool development to reach wider audiences. Besides, development of alternative insurance systems that would meet needs of individuals from different regions that have varied earthquake risk might be a persuasive act. The insurance companies or financial institutions that offer insurance plans can focus on new product development targeting audiences with different endowments and needs and may offer different payment plans. This sort of society-oriented policy making can be supported by national and regional public authorities. In this scope, scientific knowledge, financial evaluation and planning are expected to contribute to preparation for unwanted future occasions.

Conflict of Interest

Co-authors declare "no conflict of interest."

Author Contribution

R.F.C. and N.D designed the model and frame of the research together. N.D. guided the technical information sections on earthquake potential of the region and designed all technical questions of the survey. R.F.C. processed the socio-economic model. Co-authors contributed equally to the analysis and statistical interpretation. R.F.C. contributed socio-economic assessment of the findings. N.D. interpreted the findings to improve technical awareness and regional reflections of findings.

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