Preferences for Earthquake Risk–Mitigation Mechanisms: Experimental Evidence

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Preferences for the Earthquake Risk Mitigation Mechanisms: Experimental Evidence

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Abstract

This study aims to investigate two risk reduction mechanisms: self-insurance and market insurance. More specifically, it examines individuals' preferences and valuations for these mechanisms to mitigate the earthquake risk in Turkey. For this purpose, a paper-pencil experiment designed to test the Expected Utility Theory and previous theoretical framework was conducted to 78 subjects. The results indicate that self-insurance (retrofitting the house) and market insurance (earthquake insurance) are found to be substitutes. Further, self-insurance and market insurance are found to differ significantly with respect to individuals' valuations and buying decisions, and the subjects are found to prefer self-insurance to market insurance. This conclusion may provide some policy implications to assist Turkish government to take the necessary actions in mitigating disaster risk. As the results suggest, self-insurance mechanism described as urban renewal project should be invested more than market insurance mechanism described as the Turkish Compulsory Insurance Pool. Last, population characteristics are discussed according to their insurance preferences.

Key words: Earthquake; Self-Insurance; Market Insurance; Experiment; Risk Mitigation.

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Introduction

Natural hazards, such as earthquakes, are considered to be low probability, high consequence loss events, where the probability of occurrence of the hazard is low, but the loss size is extremely high. The precautionary mechanisms available to mitigate these events have been categorized as: *market insurance* (MI), *self-insurance* (SI) and *self-protection* (SP) (Ehrlich and Becker 1972). Market insurance is the insurance available for purchase in the market from the government or private vendors such as homeowners/renters insurance; self-insurance is a mechanism that reduces the size of loss such as an individual placing valuable items in a safety deposit box at the bank which reduces possible losses from a burglary; and self-protection is any precaution that decreases the probability of the loss occurrence such as installing a burglar alarm to prevent getting burgled.

According to Expected Utility Theory (EUT), all the three risk mitigation mechanisms (MI, SI and SP) should be valued same by the individuals, where they reduce the expected loss to zero. Thus, rational individuals give same value, and equally demand all these mechanisms. Ehrlich and Becker (1972), however, reveal that these risk mitigation mechanisms are not equally valued, and theoretically prove that SI and MI are substitutes, and SI and SP are complements (also supported by Courbage 2001). Further, other theoretical studies have found that risk-averse individuals tend to invest more on self-insurance, but not necessarily more on self-protection (Dionne and Eeckhoudt 1985; Briys and Schlesinger 1990; Briys et al. 1991). Although there exist many theoretical studies (e.g., Immordino 2000; Quiggin 2002; Lee 2005; Lohse et al. 2012), there are very few empirical studies that examine individual valuations for SI and SP (Shogren 1990; Di Mauro and Maffioletti 1996). Consistent with EUT, no significant differences between the preferences for these two risk mitigation tools have been found in the literature. For these studies, risk is taken in a general context without specifying the loss event, and they generally give particular probabilities and loss amounts. This study is unique in a sense that specifically earthquake risk is taken as the loss event since it asserts that individuals may value SI, MI, and SP differently depending on the risk they are exposed to. For example, a person that tries to prevent mad cow disease risk may choose to eat less beef as a precaution (SP), whereas a person that faces tornado risk may choose to build a safe room in the house (SI). The point is that there are some

risks where you have no control over the probability of the occurrence of the loss event. Therefore, the valuations of mitigation mechanisms should be examined for specific risks instead of a general risk context. Further, all previous empirical studies have compared SI and SP, however, there exists no study that takes into account MI. Therefore, this study is the first attempt to compare individuals' valuations and demands towards SI and MI. Self-insurance for this study is taken as retrofitting the house, and market insurance is taken as the Turkish Catastrophe Insurance Pool (TCIP), which is the available earthquake insurance in the market in Turkey. These risk mitigation tools are examined in an experimental setting.

The paper is organized as follows: Next section explains the earthquake risk mitigation alternatives available in Turkey followed by a brief summary of the literature review. Then, the experimental design and the sample selection of the study are explained. Finally, the results and the conclusion of the study are presented and discussed.

Earthquake Mitigation Alternatives in Turkey

Turkey is located on a highly earthquake risk-prone geographical area. The cost of damage from earthquake events can be amplified by unplanned urbanization, poor construction in high risk areas, and inadequate financial mechanisms to fund the recovery. To date, the 1999 Marmara Earthquake has been the most significant loss event to place significant burdens on the Government's budget, which caused a dramatic loss of life and property. The number of fatalities was reported as above 18,000, and economic loss resulted from this earthquake was estimated above 20 billion USD (Gulkan 2002). In order to compensate the financial losses, the Turkish government enforced an earthquake insurance program called the Turkish Catastrophe Insurance Pool (TCIP), something that had been planned since the 1992 Erzincan Earthquake, 1995 Dinar Earthquake, and especially after 1998 Adana Ceyhan Earthquake. It was the first public-private insurance partnership in a developing country on the nationwide with the aim of transferring the national risk to the international basis through sharing pools under the management of international reinsurance companies and capital markets (Deniz and Yucemen 2009; Erkan and Yilmaz 2015).

The TCIP has become an important market insurance mechanism in Turkey. Prior to 1999, the government was responsible for compensation and paying for all economic losses in the aftermath of disasters. The penetration rate for residential earthquake insurance at the time of the Marmara event was around 3%. The main goal of the TCIP is to transfer the national risk to the global reinsurance markets (Erkan and Yilmaz 2015). Also, the TCIP aims to share the burden, increase insurance awareness, enhance an insurance culture, enforce earthquake resistant construction and pool the remaining earthquake risk. Thus, the TCIP functions as a market insurance mechanism and covers financial losses caused by earthquakes, fires following earthquakes, explosions, landslides and tsunamis triggered by earthquakes (Erkan and Yilmaz 2015). The TCIP transfers this risk to A or A+ rated global reinsurance companies.

Between 2000 and 2012, Decree Law (No.587) was in effect. According to this decree law, although earthquake insurance was compulsory, no penalties were imposed if a household did not purchase earthquake insurance. On May 9, 2012, Law No. 6305 -- the 'Disaster Insurance Law' -- was passed by the Turkish Grand National Assembly. Under this new law, a household not purchasing an earthquake insurance policy is not permitted to subscribe to utility services such as gas, electricity and water.

As of April 2017, the TCIP has:

- Total number of policies: 7.7 million
- Total premium collected: 251 million USD
- Number of earthquakes to have generated claims: 502
- Number of claims: 16,867
- Total paid claims: 13 million USD
- Penetration Rate: 44.1 per cent
- Total payment capacity: 4.2 billion USD

Another important market insurance mechanism is so called catastrophe bonds and other alternative risk transfer instruments that transfer catastrophe risks to the capital markets. The Turkish Treasury has implemented some cat bonds.

Government disaster funding might also be considered as a market insurance mechanism. Every year, the Ministry of Development allocates certain amount from its budget as a precaution in case a disaster occurs in any part of the country. If these types of events do not occur within that budget year, that amount is not accumulated and used for to pay for other budgetary needs. The disaster fund is renewed each year. This money needs to be dispensed wisely if it is not to reduce the incentives of building owners to take out insurance either from the TCIP, private sector insurance companies or both. If a housing unit is worth more than the maximum coverage of the TCIP (approximately 50,000USD in 2016), then the owner can purchase private property insurance to cover the difference. This is similar to the situation pertaining in New Zealand with its Earthquake Commission (McAneney et al. 2016) which covers a first-loss up to 100,000NZD.

In Turkey, homeowners can choose to employ various risk management tools to improve their resilience against earthquakes. One way to do so is called 'self-insurance', investing ex-ante (before event) to reduce the losses incurred during an earthquake event. Urban renewal is one of the examples of self-insurance, which is recently preferred by individuals in earthquake-prone areas. Government officials foresee the demolition of around 6.5 million building within the scope of the urban renewal project in the 30 year-period (Ministry of Environment and Urbanization 2016). As well as building demolition, capacity improvement of buildings is another way of self-insurance. In this paper, self-insurance is taken as retrofitting to improve the capacity of buildings to resist seismic ground motions.

Homeowners wanting to learn about the seismic capacity of their building can get it assessed by authorized engineers. If the risk of building collapse is high, it can be reconstructed. In many parts of Turkey towards the end of 2012, an 'urban transformation-renewal' has begun following the passing of Law No. 6306. This urban transformation will take many years to complete.

Literature Review

Expected Utility Theory (EUT) asserts that both self-insurance and market insurance mechanisms should be equally preferred by individuals when both mitigation tools reduce the risk to zero (either by lowering the damage or compensating the monetary loss). Therefore, rational individuals are expected to give same value to these mechanisms. However, some theoretical studies have found different results. For example, Ehrlich and Becker's (1972) theoretical work shows that market insurance and self-insurance are "substitutes" for each other. Under some assumptions, in particular that the price of market insurance is independent of the amount of self- insurance, the authors find that the "shadow price" of self-insurance is equal to the price of market insurance. In other words, if the cost of market insurance increases and the probability of a loss is unchanged, Ehrlich and Becker (1972) show that demand for market insurance will decrease, and the demand for self-insurance will increase. Further, Dione and Eeckhoudt (1985) indicate that more risk-averse individuals are likely to invest in more in self-insurance, but not necessarily more in self-protection. In addition, Briys and Schlesinger (1990) state that as the degree of risk aversion increases, the level of self-insurance activity increases, but this does not guarantee for self-protection (also supported by Immordino 2000; Quiggin 2002; Lee 2005; Lohse et al. 2007).

Few empirical studies have tested the results of Ehrlich and Becker (1972). For example, Shogren (1990) examines the effect of self-protection and self-insurance on individual responses to risk and finds evidence that the both mechanisms are effective in reducing risk. The results also show that individuals act to reduce risk when the potential severity of an event is high and self-protection is preferred to self-insurance. The author also concludes that private mechanisms are valued significantly more than collective mechanisms for both self-protection and self-insurance. In another study, Di Mauro and Maffioletti (1996) investigate how individuals value self-protection and self-insurance. Consistent with the EUT, the findings of their study reveal that there is no significant difference between the SI and SP. An experimental study (Ozdemir 2016) also examines individuals' valuations of self-insurance and self-protection for risky and ambiguous situations when the probability of occurrence is known but the size

of the loss is not. The author finds no significant difference between the individual valuations for SI and SP for risky events; also no significant difference between ambiguous and risky situations.

The current study aims to contribute to the existing literature since it is the first attempt to investigate SI and MI for a specific risk, earthquake. Thus, market insurance is taken as buying the earthquake insurance in the market, namely the TCIP, and self-insurance is taken as retrofitting to improve the capacity of buildings to resist seismic ground motions (urban renewal). For a specific earthquake risk, where individuals cannot do anything to reduce the probability of occurrence, market insurance compensates only for the monetary loss and does not cover other intangible costs, and it is expected that the individuals' demand for self-insurance may be significantly different from market insurance.

Methodology

Experimental Design

The current experiment consisted of some scenario type questions that asked the subjects their decisions for buying risk reduction mechanisms. The design of each scenario was based on the theoretical framework explained in the previous sections, and real monetary incentives were induced to elicit subjects' insurance decisions. At the very beginning of the experiment, the subjects were shown a picture of a house valued at 300,000TL (Turkish Lira), and they were told that the house belonged to them. Then, the subjects were given options of two risk reduction mechanisms, buying the TCIP (MI) and retrofitting the house (SI) to decrease the monetary loss of their houses from a possible earthquake. They were also provided with information about these protective mechanisms, and they could choose to take precautions to protect their houses against seismic ground shaking. Thereafter, the subjects were asked hypothetical earthquake scenarios for different probability of occurrences of a possible earthquake, and for different prices. If the subjects purchased these risk reduction mechanisms (either MI, either SI, or both), they were able to protect their houses in case of occurrence of an earthquake. If they did not purchase any of these mechanisms and an earthquake happens, then they would lose their houses, so the loss size would be 300.000TL.

The experiment consisted of three parts. In the first part of the experiment, the subjects were asked their maximum willingness to pay (WTP) for each mechanism for three different levels of the average annual

probability of earthquake occurrence (0.01, 0.50 and 0.80) without giving any price of the precautionary mechanisms (SI and MI). Thus, anchoring effect were tried to be eliminated by not giving a certain price before the subjects were asked their willingness to pay. Also, the sample was divided into two, and the questions' order in itself was different for the two sessions, which enabled to be avoided by ordering effect. In the second part of the experiment, the subjects were asked to indicate whether they were willing to purchase each risk reduction mechanism at given prices (3,000TL, 150,000TL and 240,000TL), where the prices for the risk reduction mechanisms were equal to the expected value of the possible losses for each given earthquake risk. At the third stage of the experiment, the subjects were asked to state their preferences of having both mechanisms together. The subjects were given options: They could choose to buy two risk reduction mechanisms, one of them or none. Their relative preferences were measured by the changing the prices of mechanisms and the probability of occurrence of that scenario (sample instructions for the experiment are available in the appendix).

The Becker, DeGroot, Marschak (BDM 1964) mechanism used in the current study has also been used in many other studies to elicit individual valuations (Starmer and Sugden 1991; Hey and Lee 2005; Drehmann et al. 2007). BDM mechanism ensures an economic incentive for decision makers to demonstrate their true value of assets, and the mechanism is the optimal strategy that decision makers can reveal their true price of assets (Keller et al. 1993). Whether the subjects would get protective mechanism is based on the value of their bids compared to a random number. If their bids are greater than the random number, they can buy the insurance; otherwise, they cannot buy it. After all decisions are made in every scenario, one of the scenarios is randomly selected and played for real. The payment is given to the subject according to the scenario drawn at the end of the experiment. One of the most critical features of the experiment is that while asking the scenarios, probabilities are shown as ratios; in other words, both the numerator and denominator of probability are multiplied by a constant; for example, instead of 1% or 1 in 100, 10 in 1000 is used in order to attract people's attention to the event (Slovic et al. 2000).

At the end of the experiment, they were paid 25TL as a participation fee. Then, one of the scenarios was randomly selected and played for real, and the selected subject was paid certain amount of money

(150TL) according to that subject's decision in the selected scenario. Since an earthquake happened in the selected scenario, and the selected subject purchased an insurance mechanism before the earthquake occurrence, the subject was given certain amount of money calculated by extracting the insurance amount from the value of the house. It is important to note that the subjects were paid real money to see their true preferences with a randomly selected scenario (Starmer and Sugden 1991).

Sample Selection

78 subjects from Middle East Technical University participated in the paper-pencil experiment designed to measure the subjects' earthquake risk mitigation preferences. The distribution of the students' demographic characteristics (such as age, gender and income) were quite similar to the students of the university's general profile. The recruitment process was designed by announcing the experiment through hanging posters to the walls of all departments and cafeterias. On the poster, an e-mail address was provided that the students could return if they wanted to participate in the experiment. The subjects' recruitment process might have caused some selection biases. First of all, the poster announcement was only for the university students. Second, although the participation is voluntary, the majority of the subjects participating in the study were from the Faculty of Economics and Administrative Science. This might be because these students are probably more aware of economic experiments and these kinds of studies. Last, the participation fee and the possibility of winning monetary award at the end of the experiment might have encouraged certain type of students that were in need of money to participate. At this point, Lindell and Perry (2000) emphasize that researchers are often advised to assess sample bias by determining if the respondents' demographic characteristics are similar to census data for that location. The authors further suggest that sample bias has occurred only if demographic categories are significantly correlated with questionnaire response. In the current study, the poster announcement has been made to the university students whose demographic profiles are very similar in terms of age, gender, and income level. Also, the demographic characteristics of the subjects do not have any significant impact on insurance preference and willingness to pay amounts. Thus, selection bias in the sampling process might reduce in a certain extent.

Results

Table 1 describes each variable explanation and measurement used in the study. Accordingly, the preferences to the mitigation mechanisms are measured by three types of scenario-based questions. The questions are asked to elicit maximum willingness to pay to buy SI and MI, individuals' buying decisions for SI and MI, and the comparison between SI and MI.

TABLE 1 ABOUT HERE

Table 2 states the number of subjects that purchase market insurance and self-insurance mechanism for three different prices and the probability levels. In general, self-insurance is found to be preferable to market insurance. As the prices of insurance mechanisms decrease and the probability of occurrences increase, the number of the subjects purchasing both mechanisms increase. Further, the current study examines whether any significant differences exists between the two insurance mechanisms with respect to buy or not decisions. The individuals' demands for SI and MI are also calculated for the two mechanisms. As the Wilcoxon Signed Rank Test results suggested, the two risk reduction mechanisms differ from each other ($p=0.002$) with respect to individual buy or not decision, and SI is more preferred over MI (also reached same conclusion with paired-samples t-test).

TABLE 2 ABOUT HERE

Table 3 demonstrates the descriptive statistics of the maximum willingness to pay amounts for self-insurance and market insurance mechanisms at three different probability levels (0.01, 0.50 and 0.80). As expected, when the annual probability of the occurrence increases, the subjects are willing to pay more for loss reduction. Also, when self-insurance and market insurance mechanisms are compared with respect to WTP amounts, the subjects are found to pay more for self-insurance than market insurance for each probability level.

TABLE 3 ABOUT HERE

Further, Wilcoxon Signed Rank Test is conducted to investigate the difference of maximum willingness to pays between self-insurance and market insurance mechanisms. As the results suggest, the maximum willingness to pay amounts of individuals are statistically different from each other for SI and MI ($p=0.00$), and SI is preferred to MI (also supported by the paired-samples t-test).

Given that SI and MI are statistically different from each other, next the cross-price elasticities are calculated. The cross-price elasticity of demand measures the change in demand for one good in response to a change in price of another good. In the present study, demand is presented as the number of subjects that are willing to purchase each mechanism. In this experimental setting, the price of self-insurance is held constant as the price of market insurance is increased. To determine whether SI and MI are substitutes, the cross-price elasticities are calculated measuring the sensitiveness of the quantity demanded for SI to a change in the price of MI. Thus, the cross-price elasticities are found to be all positive for all probability levels, which indicates that self-insurance and market insurance mechanisms are substitutes for each other (Table 4).

TABLE 4 ABOUT HERE

Conclusion

The current study is the first attempt to empirically examine individuals' valuations for two risk reduction mechanisms, self-insurance and market insurance, for a specific risk situation in Turkey. The

earthquake risk is taken as the loss event, where individuals cannot take precaution to decrease the probability of the occurrence of the event, but they can reduce the loss size. Further, self-insurance is taken as retrofitting the house, specifically as the urban renewal, while market insurance is the available earthquake insurance in the market, called the Turkish Catastrophe Insurance Pool.

The results suggest that self-insurance and market insurance are substitutes, consistent with the results of Ehrlich and Becker's (1972) theoretical work which contradicts with the Expected Utility Theory. In addition, self-insurance and market insurance are found to differ significantly with respect to individuals' willingness to pay and buying decisions. The subjects are found to prefer self-insurance to market insurance. One possible reason for this might be that most individuals probably consider retrofitting as a precaution that also reduces risk to life in addition to monetary loss. They might also consider that retrofitting increases the real estate value of the houses.

When it comes to managing the potential damage arising from natural disasters, Iwata et al. (2014) conclude that public investments in mitigation have the potential to make bigger difference than private investments. However, McAneney et al. (2016), in their review of various government pools providing catastrophe insurance in the US, France, New Zealand, Spain and the United Kingdom, find that many of these schemes primarily focus on insurance availability rather than risk reduction per se. Governments do have the capacity, however, to raise funds post-event to pay for the recovery, something that is not available to private sector insurers, who must retain capital and/or have reinsurance contracts in place to pay for future losses to policy holders when disaster strikes. Al-Nammari and Alzaghal (2015) contend that democratic participation and transparency are the main determinants of the strong governance required to improve disaster resilience for low and lower-middle income nations in respect to disaster risk reduction in Jordan.

While many suggest that public investments in risk reduction are more effective than private alternatives, the results for Turkey show that individuals prefer self-insurance (private mechanisms) to market insurance (government insurance pool). One possible explanation for this contradictory result can be that individuals give priority to health concerns above monetary loss and in the knowledge that poorly performing buildings may collapse in earthquakes. Also, homeowners might retrofit once to upgrade their houses, and they can reduce the probability of collapse.

This conclusion also suggests some implications for policy makers to be able to take necessary actions in mitigating disaster risk. Since individuals prefer self-insurance (urban renewal) to market insurance (the TCIP), and invest more on self-insurance than market insurance, Turkish government should start to provide more funding to urban renewal projects. Although Turkish government made some regulations in order to increase purchasing of the TCIP, the household participation rate increases only in a certain extent. Therefore, low rate of insurance purchasing has still been a major problem for the insurance system since households are obliged to have valid policy documentation only when they would like to buy or sell a house or to get new account for gas, water and electricity services. Thus, this policy motivates homeowners to purchase the TCIP only when they need to renew their accounts, and they do not have to renew their policies again annually. For that, to what extent the TCIP insurance policy is compulsory remains to be questionable. Further, there might be some other possible reasons that individuals do not prefer the TCIP. The low purchasing rate of the TCIP might be associated with its coverage. It does not cover the removal of rubble expenses, business downtime losses, bankruptcy, stoppage of rent revenue, alternative residence, and business premises expenses. Most importantly, it does not compensate injuries and deaths, or possible losses arising from the earthquake that are not specified in the insurance policy (Erkan and Yilmaz 2015).

Urban renewal (UR) project, on the other hand, an alternative scheme in disaster risk mitigation, considers health concern of individuals, which might be a major reason of choosing self-insurance mechanism (urban renewal) rather than market insurance (the TCIP). This conclusion offers some important suggestions to policy makers by showing that people prefer UR to the TCIP, and the Turkish government should take the necessary actions to promote UR practices that include incentives, discounts, long term payments, and transportation supports by allocating more funding.

A broad survey study was conducted undertaken in Istanbul, which investigates the impacts of socioeconomic factors, namely, age, gender, household income level, education level, number of children, and marital status, on earthquake risk reduction preferences of individuals (Ozdemir and Yilmaz 2011). This study enables to deeply understand which population segments are more tend to purchase certain types of insurance. Two mitigation mechanisms (MI, SI) are presented to the

participants. First, past precautions described as self-insurance are presented including some activities such as building a safe room within the house; strengthening the walls, floor bearers, joints, roof, and other elements of the building; fixing furniture and utilities to the walls and/or to the ground; and building a fire ladder. Second, compulsory earthquake insurance described as market insurance is presented. The survey results indicate that household income, education level and age have positive significant impacts on compulsory earthquake insurance purchasing. Also, single respondents are more likely to buy compulsory earthquake insurance than married respondents. On the other hand, male respondents are found to have a higher propensity for purchasing past precautions, and household income is found to positively affect self-insurance preferences. The authors further find that number of children at home is a significant determinant of the monetary value of self-insurance. In addition, men have higher safety concerns than women, and male respondents invest more on self-insurance than female respondents. Male homeowners, those residing in high seismic risk areas, and those with higher levels of household income are more tend to invest in self-insurance. These survey results may assist policy makers to make a correct segmentation in the population according to their socioeconomic status in order to be able to present appropriate insurance mechanism. Accordingly, it is evident that individuals whose education level is higher and who are single prefer compulsory earthquake insurance as a precaution while male homeowners in high risk-area residents prefer self-insurance choices against a possible earthquake.

The study has some limitations that may provide suggestions for further research. First, the costs of the Turkish Catastrophe Insurance Pool (market insurance) and the urban renewable project (self-insurance) are not considered in the current study. Self-insurance often costs more in the short term, whereas the cost of market insurance is more in the long term. Yet, the main purpose of the current study is to test the theories where the costs of the mitigation mechanisms should be assumed equal. Therefore, the cost and benefit analysis may be considered for future research. Second, although small sample sizes are common for experimental studies, it may cause some problems in the analyses, so larger sample size should be preferable for future studies. Next, this study considers these risk reduction mechanisms only for a specific risk context, earthquake, and individuals' risk mitigation preferences may be valid only

for earthquake risk. Therefore, these mechanisms should also be compared for different types of risks such as flood, fire or hurricane. Last, this study takes into consideration two types of risk mitigation mechanisms, self-insurance and market insurance. However, there exist different types of mitigation mechanisms that could be considered. For example, certain disaster risk reduction tools are approached in literature. Kuroiwa (2002) asserts that a regional seismic scenario used for the Arequipa earthquake in Peru (June 23, 2001) is a useful tool in disaster reduction. Also, microzonation investigation and the resulting hazard maps are specified to be effective tools in disaster reduction. In another study, earthquake loss estimation methods of the HAZUS technology (referred to as HAZUS Earthquake) are discussed. Seismic hazard and the likelihood of various states of damage to buildings, lifelines, and other components of the built environment are specified, and the losses arise from these damages are estimated by using these disaster risk reduction methods (Kircher et al. 2006). Further, with the development of the earthquake early warning systems (EEWSs), it is possible to reduce the disaster risk (Asgary et al. 2007). Thus, these tools and methods can also be considered as risk mitigation mechanisms that may be investigated for further research.

Appendix

Sample Instructions and Scenarios for the Experiment

Sample Instructions

You are about to participate in an economic experiment to examine how individuals take precautions in different risk situations.

You are presented different scenarios about earthquake. You assume that you have a house whose value is 300,000TL and you will make some decisions to prevent your house against a possible earthquake. In each scenario, you will make a decision to protect your house.

There are two precautions for earthquake:

1. Retrofitting the house: When you choose retrofitting your house, you cannot affect the probability of occurrence of earthquake, but if an earthquake happens, you do not have any loss.
2. To purchase market insurance: When you purchase market insurance, you cannot affect the probability of occurrence of earthquake. If an earthquake happens, your house can damage, but market insurance will compensate your monetary loss.

When your decisions are completed, you will get a participation fee (25TL).

According to the decisions that you give in the scenarios, you can get additional gain as well as the participation fee. Thus, after all scenarios finish, one person will be selected among all subjects. Then, for the selected subject, one of the scenarios will be selected and played for real. Then, a random mechanism determines whether the earthquake would occur or not, and according to the decision of the selected subject, loss or gain amount will be determined, and if a gain occurs, the selected subjects will get additional money as well as participation fee.

Sample Scenarios

The probability of occurrence of an earthquake is 500/1000. If earthquake occurs, a monetary loss occurs valued at 300,000TL. If you retrofit your house, your monetary loss will be zero. Please indicate your maximum willingness to pay for retrofitting.

_____ TL

The probability of occurrence of an earthquake is 10/1000. If earthquake occurs, a monetary loss occurs valued at 300,000TL. If you purchase market insurance, your monetary loss will be zero. You are given three different prices to purchase market insurance. Please indicate whether you would like to purchase the precautionary mechanism for each price level.

Price of Market Insurance	Buy	Not Buy
3,000 TL	_____	_____
150,000 TL	_____	_____
240,000 TL	_____	_____

The probability of occurrence of an earthquake is 800/1000. If earthquake occurs, a monetary loss occurs valued at 300,000TL. The price of retrofitting is 240,000TL. The price of market insurance is 240,000TL. Please indicate your choice.

I buy only market insurance _____

I buy only retrofitting _____

I buy both of them _____

I buy none of them _____

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References

Al-Nammari, F., and Alzaghal, M. (2015). "Towards local disaster risk reduction in developing countries: Challenges from Jordan." *International Journal of Disaster Risk Reduction,* 12, 34-41.

Asgary, A., Levy, J. K., and Mehregan, N. (2007). "Estimating willingness to pay for a hypothetical earthquake early warning systems." *Environmental Hazards*, 7(4), 312-320.

Becker, G. M., DeGroot, M. H., and Marschak, J. (1964). "Measuring utility by a single response sequential method." *Behavioral Science*, 9(3), 226-232.

Briys, E., and Schlesinger, H. (1990). "Risk aversion and the propensities for self-insurance and self-protection." *Southern Economic Journal*, 45(4), 458-467.

Briys, E., Schlesinger, H., and Schulenburg, J. M. (1991). "Reliability of risk management: Market insurance, self-insurance and self-protection reconsidered." *Geneva Papers on Risk and Insurance Theory*, 16(1), 45-59.

Courbage, C. (2001). "Market-insurance, self-insurance and self-protection within the dual theory of choice." *Geneva Papers on Risk and Insurance Theory*, 26(1), 43-56.

Deniz, A., and Yucemen, M. S. (2009). "Assessment of earthquake insurance rates for the Turkish Catastrophe Insurance Pool." *Georisk*, 3(2), 67-74.

Di Mauro, C., and Maffioletti, A. (1996). "An experimental investigation of the impact of ambiguity on the valuation of self-insurance and self-protection." *Journal of Risk and Uncertainty*, 13(1), 53-71.

Dionne, G., and Eeckhoudt, L. (1985). "Self-insurance, self-protection and increased risk aversion." *Economic Letters*, 17(1-2), 39-42.

Drehmann, M., Oechssler, J., and Roider, A. (2007). "Herding with and without payoff externalities-an internet experiment." *International Journal of Industrial Organization*, 25(2), 391-415.

Ehrlich, I., and Becker, G. S. (1972). "Market insurance, self-insurance and self-protection." *Journal of Political Economy*, 80(4), 623-648.

Erkan, B. B., and Yilmaz, O. (2015). "Success and failures of compulsory risk mitigation: Re-evaluating the Turkish Catastrophe Insurance Pool." *Disasters*, 39(4), 782-794.

Gulkan, P. (2002). "Setting the stage for urban risk mitigation: seismic risks and compulsory insurance policy issues in Turkey." Proc., the Second Annual IASA-DPRI Meeting, Integrated Disaster Risk Management: Megacity Vulnerability and Resilience. 29-31 July. Laxenburg, Austria.

Hey, J. D., and Lee, J. (2005). "Do subjects separate (or are they sophisticated)." *Experimental Economics*, 8(3), 233-265.

Immordino, G. (2000). "Self-protection, information and the precautionary principle." *Geneva Papers on Risk and Insurance Theory*, 25(2), 179-187.

Iwata, K., Ito, Y., and Managi, S. (2014). "Public and private mitigation for natural disasters in Japan." *International Journal of Disaster Risk Reduction*, 16, 192-199.

Keller, L. R., Segal, U., and Wang, T. (1993). "The Becker-DeGroot-Marschak mechanism and generalized utility theories: Theoretical predictions and empirical observations." *Theory and Decision*, 34(2), 83-97.

Kircher, C. A., Whitman, R. V., and Holmes, W. T. (2006). "HAZUS earthquake loss estimation methods." *Natural Hazards Review*, 0.1061/(ASCE)1527-6988(2006)7:2(45).

Kuroiwa, J. (2002). “Sustainable cities, a regional seismic scenario, and the 6-23-2001 Arequipa Peru earthquake.” *Natural Hazards Review,* 10.1061/(ASCE)1527-6988(2002)3:4(158).

Lee, K. (2005). “Wealth effects on self-insurance and self-protection against monetary and no monetary losses.” *Geneva Risk and Insurance Review,* 30(2), 147-59.

Lindell, M. K., and Perry, R. W. (2000). “Household adjustment to earthquake hazard: A review of research.” *Environment and Behavior*, 32(4), 461-501.

Lohse, T., Robledo, J. R., and Schmidt, U. (2012). “Self-insurance and self-protection as public goods.” *Journal of Risk and Insurance,* 79(1), 57-76.

McAneney, J., McAneney, D., Musulin, R., Walker, G., and Crompton, R. (2016). “Government-sponsored natural disaster insurance pools: A view from down-under.” *International Journal of Disaster Risk Reduction,* 15, 1-9.

Ministry of Environment and Urbanization. (2016). “*Directorate general of infrastructure and urban transformation services.*”
‹http://www.csb.gov.tr/gm/altyapien/› (Apr. 2, 2017).

Ozdemir, O. (2016). “Impact of outcome ambiguity on self-insurance and self-protection: Experimental evidence.” *Bulletin of Economic Research,* 0307-3378.

Ozdemir, O., and Yilmaz, C. (2011). “Factors affecting risk mitigation revisited: the case of earthquake in Turkey.” *Journal of Risk Research,* 14(1), 17-46.

Quiggin, J. (2002). “Risk and self-protection: a state-contingent view.” *Journal of Risk and Uncertainty,* 25(2), 133-45.

Schlesinger, H. (1981). “The optimal level of deductibility in insurance contracts.” *Journal of Risk and Insurance,* 48(3), 465-481.

Shogren, J. F. (1990). “The impact of self-protection and self-insurance on individual response to risk.” *Journal of Risk and Uncertainty,* 3(2), 191-204.

Slovic, P., Monahan, J., and MacGregor, D. G. (2000). “Violence risk assessment and risk communication: The effects of using actual cases, providing instruction, and employing probability versus frequency formats.” *Law and Human Behavior*, 24(3), 271-296.

Starmer, C., and Sugden, R. (1991). “Does the random-lottery incentive system elicit true preferences? An experimental investigation.” *American Economic Review,* 81(4), 971-978.

Szpiro, G. G. (1985). “Optimal Insurance Coverage.” *Journal of Risk and Insurance*, 52(4), 705-710.

TCIP (The Turkish Catastrophe Insurance Pool). (2013).
‹http://www.dask.gov.tr/› (Mar. 10, 2017).

Tables

Table 1. Variable Explanation and Measurement

Scenario Type Questions	Examples
Maximum willingness to pay	please indicate how much do you want to pay for self-insurance mechanism when the probability of occurrence of an earthquake is 0.50

Buy or not decisions	please indicate whether do you want to buy market insurance mechanism when the price is 150,000TL and the probability of occurrence of an earthquake is 0.80
Pairwise comparisons	please indicate which risk mitigation mechanism do you want to buy (self-insurance or market insurance) when the price of the mechanisms are 3,000TL and the probability of occurrence of an earthquake is 0.01

Table 2. Number of Subjects and Percentages that are willing to Buy Each Mechanism

		Number of Subjects		Percentages (%)	
Probabilities	Prices (TL)	Self Insurance	Market Insurance	Self Insurance	Market Insurance
0.01	3,000	72	69	92	88
	150,000	14	7	18	9
	240,000	1	0	1	0
0.50	3,000	74	76	95	97
	150,000	62	54	79	69
	240,000	19	14	24	18
0.80	3,000	75	76	96	97
	150,000	71	66	91	85
	240,000	48	41	62	53

Note: Full Sample (N=78)

Table 3. Descriptive Statistics

Measures	Self-Insurance p=0.01	Self-Insurance p=0.50	Self-Insurance p=0.80	Market Insurance p=0.01	Market Insurance p=0.50	Market Insurance p=0.80
Mean	36,528.85	115,980.77	161,602.56	25,598.72	94,723.08	140,188.46
Median	10,000.00	100,000.00	177,500.00	6,000.00	95,000.00	135,000.00
Maximum	250,000	300,000	300,000	200,000	300,000	300,000
Minimum	0	0	0	0	0	0
Std. Dev.	52803.698	78,562.51	89,128.30	43,120.90	9,357.16	101,838.03
Skewness	2.04	0.485	-0.18	2.36	0.74	0.129
Kurtosis	4.129	-0.459	-1.202	5.178	-0.343	-1.401
Sum	2,849,250	9,046,500	12,605,000	1,996,700	7,388,400	10,934,700

Note: Full Sample (N=78)
Note: 300,000TL is the market value of the house, and also the monetary loss amount

Table 4. Cross Price Elasticities of Demand for SI and MI

Probabilities	Price Changes	Cross Price Elasticities
0.01	3,000-150,000	0.32%
	3,000-240,000	0.18%
0.50	150,000-3,000	34%
	150,000-240,000	27.80%

	240,000-3,000	0.39%
0.80	240,000-150,000	51.28%