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The Impact of Earthquake Risk on Property Values: A Multi-Level Approach

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The Impact of Earthquake Risk on Property Values: A Multi-Level Approach

Report for Royal Institution of Chartered Surveyors

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Contents

List of Figures

List of Tables

Executive Summary

The Motivation for the Research

There is considerable interest from house buyers, estate agents, valuers, mortgage lenders, and policy makers in developing methods that accurately estimate the impact on house prices of the perceived risks of damage from environmental disasters, including earthquakes and floods. Typically analysts have approached this by designing event studies, where they look at the circumstances before and after an identifiable systemic 'shock'. A variety of methods can be employed to disentangle the effects of the event from other influences. Some event studies use attitudinal surveys to do this. Others explore the changes in the key parameters in hedonic models. This approach has the advantage of being cheaper than survey methods. The hedonic-based approach, however, also has important weaknesses. Arguably it is limited in that it provides only very basic evidence of spatial differentiation in the estimates of price impacts, despite the general expectation that spatial diffusion of impacts might be very fine grained.

The Research Aims

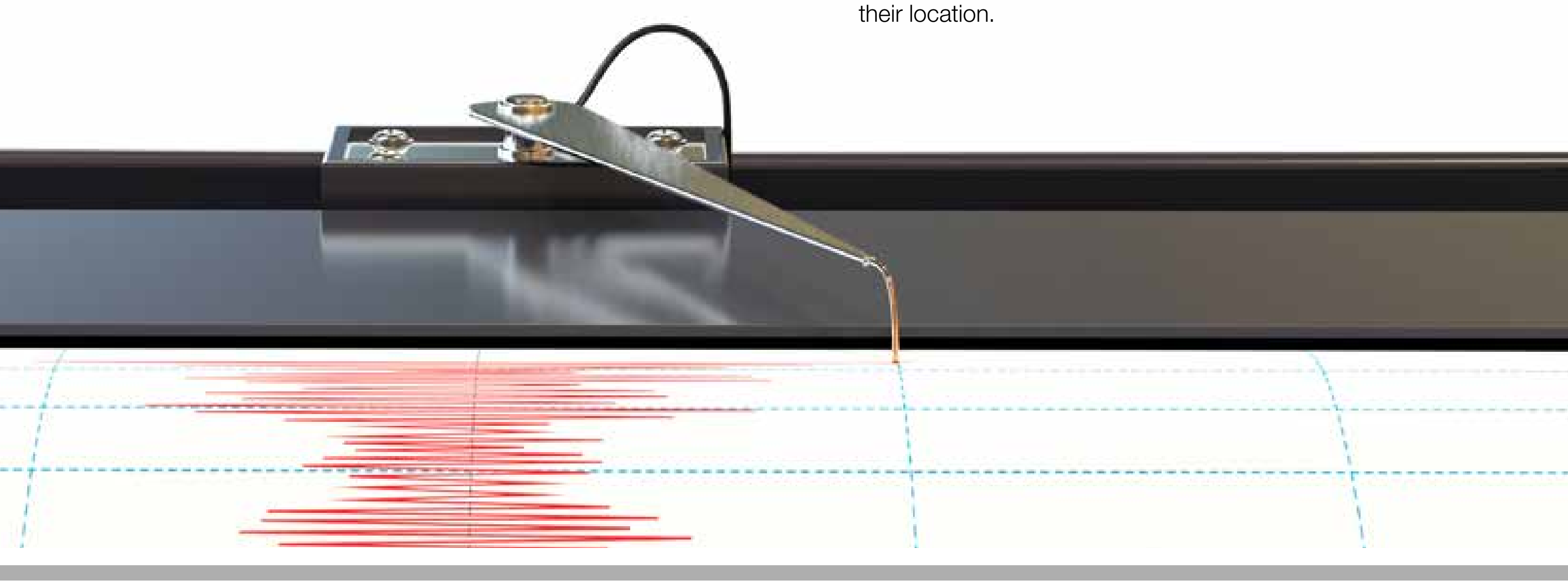
This research aims to address this weakness by applying multi-level modelling techniques to explore the impact of earthquake risk before and after an event within the study area. This technique has recently been shown to improve the accuracy of estimates of the spatial differences in house prices. The main contribution of the project is to establish an exemplar of how multi-level models might be used as an alternative to the econometric and survey techniques that currently dominate event studies of this type. It also provides new estimates of earthquake risk in the study area, Istanbul, which will be of immediate use to market actors and policy makers.

Research Design and Methods

The empirical analysis focuses on the Istanbul housing market. Istanbul provides an excellent 'laboratory' for this project for several reasons. First, Istanbul is vulnerable to earthquake risk and, as such, the potential for damage has long been an important influence on housing transactions and on the behaviour of valuers, lenders and insurance companies. Second, although not directly affecting Istanbul, there has been recent earthquake activity on the wider geographic region. This activity provides a timely reminder of the risks posed and, we would contend, provides a useful opportunity to see if heightened awareness of risk has led to changes in the pattern of house prices within the city. Finally, Istanbul exemplifies the data problems that are often common in developing market contexts. In sum, this allows to apply a novel method to a study area where awareness of risk is high. The research also demonstrates that the method can be used in international contexts, including those where high quality micro-datasets are not widely available.

The modelling work is developed in three stages. First, a baseline multi-level model for a period (2007) prior to a shock to perceptions of the risk of earthquake damage in the Istanbul housing market was developed. Second, a model was established to explore the extent to which activity had recent earthquake activity in the wider geographic region raised awareness of risk damage within the Istanbul housing market. Third, the spatial patterns of earthquake risk in the study area before and after a significant potentially "perception altering" event were compared and contrasted.

The data was collected from collected from Estate Agent (Turyap and Remax) websites. The two samples were made up 2175 and 1190 observations from 2007 and 2012 respectively and included information on the asking price of homes on the market, their physical characteristics and their location.



Key Findings

The multi-level model allows us to isolate the impact of earthquake risk from the other factors, such as neighbourhood amenity quality or the physical features of the dwelling, that help explain the difference in dwelling prices. The model also differentiates between market-wide impacts and those felt within submarkets and at neighbourhood level.

The model results show that, in 2007, a 0.164% discount in house price is expected for a 1% increase in the likelihood that a building will be damaged by earthquake activity. As might be expected, the discount rate becomes larger and rises to 0.196% discount for every 1% increase in earthquake risk for the 2012 period. This impact is statistically significant.

The impact on the discount level is much more pronounced at neighbourhood level than at the market-wide level. The variation between neighbourhood effects is considerable. There is little impact on high price areas, where none of the priciest neighbourhoods experienced an earthquake risk discount in 2007 and only one did in 2012. The discount is much more visible in lower price neighbourhoods in both time periods. The five most expensive neighbourhoods exhibit discounts in each period and the size of these discounts has increased since recent earthquake activity in the region.

The Implications of the Research

This research introduces a new multi-level approach to exploring the impact of the perceived risk of damage from environmental events on house prices. The approach can be applied in a range of contexts, as long as basic data are available of house prices, housing attributes and the location of dwellings. The model enhances standard hedonic-based methods by providing estimates of price effects that are more spatially granular than would normally be the case. It helps differentiate between the market-wide effects and neighbourhood impacts without limiting degrees of freedom excessively. The results have potentially important implications for the valuations of buyers and for the work of professional valuers. The approach and the estimates generated could be used by those engaged by the public sector to assess the benefits of mitigation; those developing valuations for mortgage lenders; and those involved in marketing properties.

The specific results of this research show that, since the earthquake activity in the wider region in 2011, proximity to areas with a history of activity has had significant impacts on prices. This information should be of considerable use to house purchasers and ought to be into the decision-making processes of insurance agents and mortgage lenders.

1.0 Introduction

There is a voluminous international literature that explores the impact of earthquake risk on housing prices. This research agenda has been motivated by the need for a variety of stakeholders including valuers, estate agents, policy makers and mortgage lenders to be able to accurately estimate the way in which changing perceptions to the risk of damage could alter property values over space and time (Onder et al, 2004).

There have been two main methods used to derive estimates of the impact of risk damage on property values. The first, which has parallels with the mass appraisal literature, uses hedonic house price models to isolate the impact of earthquake risk from the effects of other physical, neighbourhoods and locational determinants of property values (Nakagawa et al, 2007; Naoi et al, 2009). The second method uses survey methods to capture revealed preferences or to identify the willingness to pay to reduce risk (Palm, 1981; Willis and Asgary, 1997). Irrespective of the approach, the majority of the empirical estimates have been derived from event studies, where current (or recent) estimated values are compared with those derived prior to some significant shock that might have altered perceptions of risk to property (Beron et al, 1997).

This project seeks to develop a new approach to estimating the impact of environmental change on the housing market. It uses multi-level modelling methods. Multi-level methods have been around for some time but it is only in the last few years that they have become much more commonly used in real estate research (see Costello et al, 2013; Leishman, 2009). The novelty of this project comes from using these methods as a means of undertaking the comparative analysis of a housing market at two discrete time periods. Arguably this approach is superior to the use of hedonics in event studies because in this case it allows a more granular understanding of the spatial dimensions of the impact of environmental risk.

The approach is applied to data from the Istanbul housing market. Istanbul provides a useful case study for the exploration of the impact of earthquake risk because of its recent history of earthquake activity. Notable events include the 1999 Marmara earthquake which has been shown to distort house price values within the city (Onder et al, 2004) and earthquake activity in Eastern Turkey in 2011, which although it was not sufficiently proximate to cause direct property damage, appeared to heighten concerns within the study area about the risk of damage.

Thus, the overall aim of this project is to apply multi-level modelling techniques to the estimation of the impact of earthquake risk in different spatial submarkets and in different time periods. This is done in three stages. First, a baseline multi-level model was developed for a period (2007) prior to a shock to perceptions of the risk of earthquake damage in the Istanbul housing market. Second, a model was developed to explore the extent to which activity had recent earthquake activity in the wider geographic region might have changed the impact of risk on prices within the Istanbul housing market. Third, the spatial patterns of earthquake risk in the study area before and after a significant potentially “perception altering” event were compared and contrasted. This allows to provide estimates of the changing spatial impact of risk in a form that is accessible to market actors and policy makers in the study area.

The report has four further sections. Section two provides an overview of the existing literature. It sets out the conceptual basis for the modelling and illustrates how this approach enhances the methods that have been used to explore the impact of environmental changes. Section three explains the research design. It provides an overview of the study area, describes the data used in the project and explains the methods of estimation used to calibrate the models. Section four summarises the results. Finally, the paper ends with some concluding remarks about the findings and the utility of the method used in this study. In addition, areas for future research are briefly highlighted.

2.0 Measuring the impact of earthquake risk on property values

Hedonic models have been employed for nearly five decades as a means of exploring the determinants of house prices. One of the earliest applications, by Ridker and Henning (1968), used hedonics to separate out the negative influence of air pollution from other factors. This was the forerunner to a voluminous literature that applies hedonic techniques to the assessment of a variety of environmental factors including noise pollution, water contamination and proximity to hazardous waste sites or overhead powerlines (see Boyle and Kiel, 2001 for a review thirty papers of this type). This method has also been used to explore the effects of natural disasters (see Willis and Asgary, 1997). The basic proposition encapsulated in these studies is that it should be possible to discern a discount in real estate prices that reflects the impact (or risk) of a negative external event.

There are two weaknesses associated with this approach. The first is that it assumes that the impact will be constant over time. In the case of natural disasters, this assumption is only valid if market actors factor this into the information sets that inform bidding and selling strategies perfectly over time. It does not easily allow perceptions of the potential of a disaster to vary. Nor does it allow this to feed through into house price patterns. There have been some attempts to solve this problem. Case *et al* (2006) use a hybrid hedonic/repeat sales model to explore the changes in the impact of environmental contamination annually over an eighteen-year period. This approach has been used elsewhere by Lamond *et al* (2010) to explore the impact of flood risk on prices. More typically, however, studies simply compare cross-section from before and after an event.

The second problem, and one that is also evident in the hybrid hedonic/repeat sales approach, is that the spatial diffusion of price impacts cannot be captured in a very granular way. In other words, it is not possible to demonstrate the incremental differences in impacts as the distance from the parts of the market most at risk increases.

One way to overcome the latter (but not the former) problem is to employ multi-level methods within an event study design. Multi-level models are a variant on standard hedonic methods (Orford, 1999; Leishman, 2009). Use of multi-level methods is advised when the observations being analysed are clustered and correlated, the causal processes underlying the relationships operate simultaneously at multiple spatial scales and there is value in seeking to disentangle the spatial and temporal effects of different variables (Subramanian, 2010). Their use has begun to expand within the quantitative human geography literature where the technique has been used to explore a range of complex spatial impacts and interactions including in the measurement of social well-being (see Ballas and Tranmer, 2008).

The complexity of this challenge resonates with the issues associated with modelling housing markets more generally. Indeed, as Costello *et al* (2013) demonstrate in their comparison of alternative modelling strategies, multi-level models are superior to standard hedonic techniques in that they provide models that have greater predictive accuracy and provide estimates of coefficients that are disaggregated to more finely grained units of geography. As Keskin (2010) has shown in a previous study of earthquake risk, this can provide a more accurate reading of the spatial pattern of risk than alternative methods. Thus, this approach addresses the standard criticism that both hedonic and willingness to pay methods are too crude in delineating the differences in the spatial impact of risk.

3.0 Research Design

3.1 Study Area

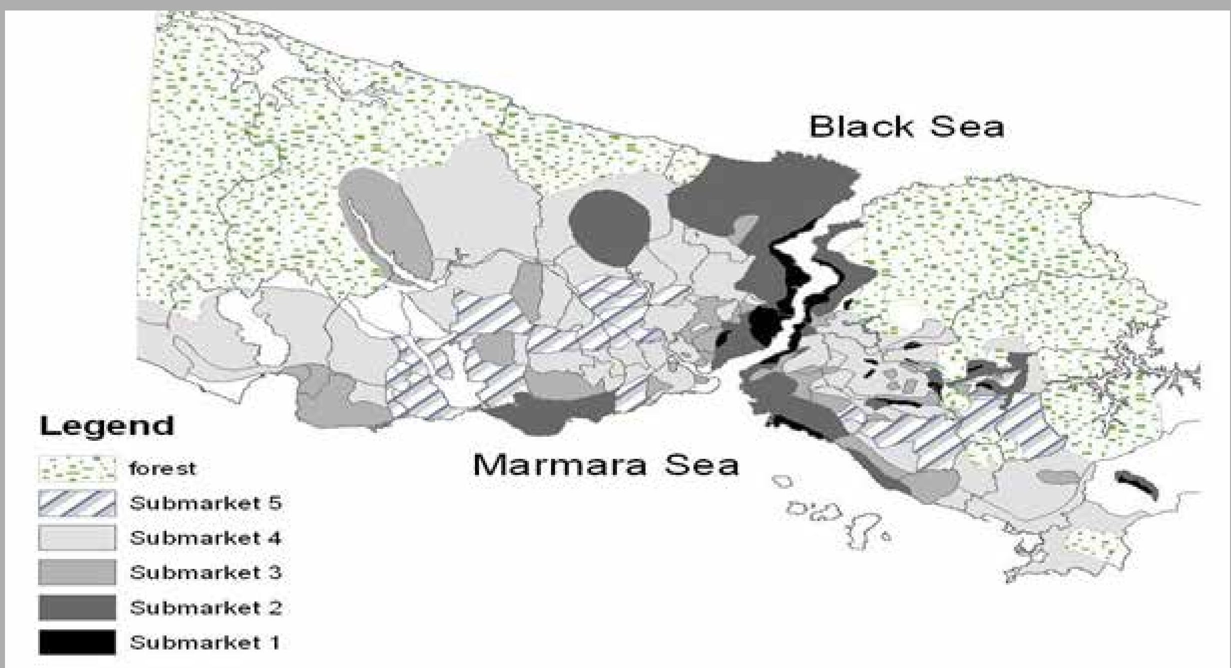
The empirical analysis in this paper focuses on Istanbul, the largest city in Turkey and home to almost fifteen per cent of the population of the country. Istanbul's housing sector is dominated by market dwellings but this tenure is extremely heterogeneous. The majority of housing is located in high density, inner urban neighbourhoods where much of the stock dates from the early twentieth century. This contrasts markedly with the newer dwellings that are found in a number of planned housing areas promoted by government since the start of the century.

These areas emerged as a result of a concerted effort from policy makers to transform Istanbul from a monocentric to a polycentric city. Public investment was used to make infrastructural improvements and to pump prime industrial development in suburban locales. The private sector's development activity responded to the resultant changes in employment patterns and the transport network. Many of the properties in these non-traditional areas occupy the mid – and higher end of the price scale. They are marketed in a way that reflects the growth in popularity of gated and semi-gated communities with good links to transport infrastructure, employment centres and high quality public amenities (Alkay, 2011).

At the lower end of the market, there are significant numbers of unplanned dwellings, estimated by some to be over fifty per cent of the total, located within squatter settlements, known as 'Gecekondu' (see Gokmen et al, 2006). These neighborhoods are occupied by lower income groups and consist of dwellings in poor physical condition and with limited sales values. Several of these areas have been subject to land market speculation and are starting to be transformed.

As Keskin (2010) explains, although property values have been moving upwards, there has been evidence of increasing differentiation between submarket at the cheaper end of the price spectrum and those at the top. Figure 1 below illustrates the degree of spatial disaggregation within the market. Keskin argues that these submarkets act as quasi-independent entities and offer a useful framework for the analysis of market change. The most expensive areas are in submarket 1 while the cheapest are in submarket 5, which also happen to be the neighbourhoods traditionally perceived to be most likely to suffer earthquake damage. She shows that the factors house prices generally vary in relative importance at the neighbourhood levels. These differences are taken into account by selecting a modelling approach that allows these differential impacts to be revealed

Figure 1 **Istanbul's Housing Submarkets**



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3.2 Data

The house price and housing attributes data used for 2007 year analysis are drawn from two internet listing services of two leading realtors, Turyap and Remax. The price and attribute data have been combined with socio-economic, neighborhood quality and locational characteristics obtained from a household survey undertaken by the Istanbul Greater Municipality (IGM) in 2006. Data on earthquake risk, which has been shown to be significant in the past was obtained from the Japanese International Cooperation Agency (JICA) report (JICA, 2002).

The database for 2012 analysis is generated by using three data sets. The first dataset was gathered from estate agents' websites, Remax. This dataset comprises 1190 observations from 278 neighbourhoods in 39 districts which is combined with household survey undertaken by Istanbul Greater Municipality and earthquake risk data from the JICA report. Table 1 provides a list of the main variables used and associated descriptive statistics

3.3 Methods

Multi-level modelling can be considered a modified version of hedonic price modelling since it has the same general structure, consisting of fixed and random effects. In comparison to hedonic price modelling, multi-level modelling is a more sophisticated version; the use of dummy variables in a hedonic function allows that function to obtain place parameters, each of which is viewed as consisting of an average value plus a random component (Fotheringham et al, 2007).

In a hedonic equation, a model is estimated that contains only fixed effects- the intercept and coefficients describes the sample as a whole. However, the spatial pattern of house price is not adequately captured by fixed effects/ regression models, which assumes that the same intercept and slopes characterizes all neighbourhoods in this analysis. An alternative way to model the tendency toward spatial distribution of housing prices in different parts of the city and reduce the spatial autocorrelation problem is to allow each of the neighbourhoods to have their own random intercept instead of the fixed effects regression model. The multi-level modelling approach allows the decomposition of residuals to expose random intercepts and hedonic slope parameters that are unique to each defined spatial area (Costello et al, 2013). By including a set of coefficients that represents the whole city and also a random intercept which varies from one neighbourhood to another, a multi-level equation can be obtained which is formulated as:

$$Y_{ij} = \alpha_j + \Sigma\, \beta_i X_{ij} + (\varepsilon_{ij} + \mu_j \alpha + \mu_j \beta X_{ij})$$

In this formulation, it can be assumed that, Y_{ij} represents the price of the house **i** in area **j**;α, β and μ are the parameters to be estimated, ε is the error term and X_{ij} is a set of explanatory variables which include housing attributes, socio-economic characteristics and earthquake risk of the house i in area j.

Table 1 Descriptive Statistics for 2007 and 2012 Samples

Variables	Description	N	Maximum	Mean	St. Deviation
TRANSACTION PRICE ($)	Transaction Price of the Housing Unit	2175	8,000,000	251,082.92	382,467.37
		1190	*32,954,550*	*383,159.00*	*269,787.40*
AREA (m²)	Living area in the Housing Unit	2171	1920	170.08	123.063
		1190	*18673*	*235.04*	*856.61*
AGE (year)	Age of the Dwelling	1962	150	12.22	14.57
		1183	*126*	*9.74*	*14.93*
RESIDENCE	Dummy that reflects the fact that housing unit is located within a residence				
		1190	*1*	*0.07*	*0.26*
LOW (dummy)	Dummy that indicated a low-rise building (less than 5 storey)	2106	1	0.38	0.485
SITE (dummy)	Dummy that reflects the fact that housing unit is located within a gated or semi gated community	2132	1	0.17	0.38
		1190	*1*	*0.28*	*0.45*
GARDEN (dummy)	Dummy for presence of garden	2021	1	0.79	0.41
BALCONY (dummy)	Dummy for presence of balcony	2026	1	0.92	0.277
LIVPER (year)	Living Period in the city	2175	73	29.51	9.48
INCOME ($)	Average Income of the household	2113	6,000	1448.74	1095
		1163	*6,000*	*1338*	*1163*
HHSIZE (person)	Household size	2174	6.5	3.487	0.67
NEIGHSAT (1-7 likert scale)	the level of neighbor satisfaction revealed in the 2006 survey undertaken by the municipal authority	2175	7	5.79	0.79
		1169	*7*	*5.82*	*0.78*
SCHOOLSAT (1-7 likert scale)	is the survey-based estimate of school satisfaction 2006 survey undertaken by the municipal authority	2175	7	4.35	1.29
		1169	*7*	*4.63*	*1.14*
HEALTHSAT (1-7 likert scale)	is the survey-based estimate of health services satisfaction 2006 survey undertaken by the municipal authority	2175	7	4.103	1.375
CULTURESAT (1-7 likert scale)	is the survery-based estimate of cultural facilities 2006 survey undertaken by the municipal authority				
		1169	*7*	*3.44*	*1.61*
TTW (minutes)	is the travel time to local employement and education hub 2006 survey undretaken by the municipal authority	2034	95	28.67	15.19
		1081	*95*	*30.1*	*17.4*
QUAKE (%)	is the estimated risk of an earthquake and is computed as the %of buildings that will be highly damaged by an earthquake (based on JICA, 2002)	1980	18.27	5.34	4.1
		1168	*6.18*	*24.8*	*4.06*
CONTINENT (dummy)	indicates whether the dwelling is in the European zone	2175	1	0.45	0.497
		1190	*1*	*0.3*	*0.46*

Note: 2012 data is shown in italics

4.0 Findings

The multilevel model results, shown in Table 2, provide fixed effects and model fit statistics for a period (2007) prior to a shock to perceptions of the risk of earthquake damage and also for a period (2012) after recent earthquake activity in the wider geography region. The coefficients shown in Table 2 are analogous to hedonic coefficients from a regression model. The model solves this problem. It operates like a hedonic in that it isolate the earthquake risk from other price determinants. It also allow the differentiation between market-wide effects (-0.19% discounts) and random neighbourhoods effects (which can be + where risk is below the market average or – where risk is above the average).

Table 2 shows that the results are generally stable between these two periods. Many variables, including living area of the housing unit, being located at a semi gated or gated community, income of the household and earthquake risk have a significant impact on prices in both the 2007 and 2012 periods. The main difference between 2007 and 2012 is the influence of the age of the housing unit. This implies that there is an increasing tendency of preferring new buildings. In both periods the Wald chi-squared tests suggest strong explanatory power.

As theory would suggest, the influence of earthquake risk is also interesting. Our multilevel model results show that, in 2007, a 0.164% discount in house price would be expected for a 1% increase in the likelihood that a dwelling might be damaged. In 2012, the deflationary price effect becomes larger and rises to a 0.196% discount for every 1% increase in the earthquake risk. This impact is statistically significant in both time periods.

Table 2 Descriptive Statistics for 2007 and 2012 Samples

Variable	Coefficient (2007)	Coefficient (2012)
Constant	2.196529	2.159938
Area	1.045023*	0.93688*
Age	-0.0024381	-0.06287*
Residence	–	0.214118*
Garden	0.0347619*	–
Low	0.0096652	–
Site	0.113051*	0.0813993*
Income	0.195355*	0.48089*
Hhsize	-0.486838*	–
Schoolsat	0.0931491	0.09797
Neigsat	0.081995	-0.03098
Culturesat	–	0.571796
Livper	0.1556817	–
Ttwork	–	0.049677
Quake	-0.1642557*	-0.196622*
Continent	0.1085348*	-0.0417574
Wald chi(2)	2690.26*	1310.21*
Log restricted likelihood	632.96615*	147.98648*
Groups	270	278
N	1825	1070

Note: *indicates significant at the 5 per cent level
– Indicates that the variable is excluded due to multicollinearity

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The result of likelihood ratio test confirms that this random intercepts model offers significant improvement over a linear regression model with fixed effects only. A model with random intercepts for each neighbourhood can be predicted but random effects cannot be directly calculated from multilevel models. With further analysis, best linear unbiased predictions can be estimated (BLUPs) of random effects to create a new variable, containing the predicted random intercepts for each of the neighbourhoods.

Tables 4 and 5 provide examples of the impact of earthquake risk for the top five neighbourhoods with highest house price levels. They show that the neighbourhoods with highest prices have positive R effect values and the risk of earthquake is low both for 2007 and 2012 period.

Table 6 and Table 7 show the examples of the impact of earthquake risk for the five lowest price neighbourhoods. This shows that the cheapest neighbourhoods have mainly negative R effect values, implying price discounts, as a reflection of the high assessed risk of earthquake damage for the 2007 and 2012 periods.

Thus, it is clear that the impact of earthquake risk is most pronounced in lower price neighbourhoods. This was true both before and after the most recent activity. It is also clear that, since the recent activity, even though this has had a moderate general dampening impact on the market, there has been a markedly more pronounced effect in neighbourhoods at the bottom end of the market price spectrum.

Table 3 Multilevel model random effects

	2007		2012	
Variable	**Estimate**	**Std Error**	**Estimate**	**Std Error**
Constant	0.1254122	0.0260374	0.0008076	0.3247712
Residence			0.22841	0.0506395
Area			1.00E-01	8.72E-03
Income			0.0243879	0.0203682
Site			1.52E-01	0.0291819
Continent			1.54E-01	0.0482713
Neighsat	0.1405585	0.0508316		
Schoolsat	7.11E-08	0.0001425		
Quake	6.62E-11	7.82E-11	5.74E-02	0.1063757
Lr Test	chi2(4)=680.93		chi2(7)=531.02	
	prob>chi2=0000		prob>chi2=000	

Note: *indicates significant at the 5 per cent level – Indicates that the variable is excluded due to multicollinearity

Table 4 Impact of Earthquake Risk (The top 5 Neighbourhoods with highest transaction price-2007 Period)

Neighbourhood	R Effect Earthquake	Average Transaction Price $	Earthquake risk (% highly damaged buildings)
Kanlica	0.018	1,649,500	1.7
Cubuklu	0.076	1,289,320	1.7
Beylerbeyi	0.11	1,196,079	2.31
Alkent(Etiler)	0.061	1,068,550	4.06
Bebek	0.198	957,942	0.61

Table 5 Impact of Earthquake Risk (The top 5 Neighbourhoods with highest transaction price for period 2012)

Neighbourhood	R Effect Earthquake	Average Transaction Price $	Earthquake risk (% highly damaged buildings)
Bebek	0.00821964	19,184,750	4.1
Ruzgarlibahce	0.0031321	14,840,000	1.7
Levazim	0.00884852	8,692,000	4.1
Balmumcu	0.01491519	6,678,000	4.1
Atasehir	-0.00042594	6,000,000	2.3

Image source: Prometheus72/shutterstock.com

Table 6 Impact of Earthquake Risk (The top 5 Neighbourhoods with lowest transaction price- 2007 Period)

Neighbourhood	R Effect Earthquake	Average Transaction Price $	Earthquake risk (% highly damaged buildings)
Molla Serif	0.0008	47,619	16
Havaalani	-0.143	53,512	5.09
Nenehatun	-0.089	57,823	5.09
Birlik	-0.11	62,625	5.09
Gumuspala	-0.054	69,727	14.08

Table 7 Impact of Earthquake Risk (The top 5 Neighbourhoods with lowest transaction price period 2012)

Neighbourhood	R Effect Earthquake	Average Transaction Price $	Earthquake risk (% highly damaged buildings)
Avrupa Konutlari	-0.03177	29,545.45	9.4
Gumuspala	-0.013106	36,363.63	14.1
Yeni Bagcilar Yildiztepe	-0.07358	37,272.72	6.6
Albatros Mevkii	-0.01195	37,727.27	10.5
Kucukkoy	-0.005806	38,636.36	3.3

5.0 Conclusions

This project illustrates the use of a new method of estimating earthquake risk. It applies multi-level modelling techniques to data from Istanbul in Turkey to provide estimates of the impact of variations in the risk of earthquake damage between different spatial housing submarkets and in different time periods. The model enables to isolate the impact of changes in the perception earthquake risk from other determinants of the pattern of house prices, immediately after the seismic activity that took place in Eastern Turkey in late 2011, and to compare these with model estimates from the pre-event period.

The multilevel models operate like a hedonic regression equation in that they disentangle the influence of earthquake risk from other explanatory variables. The model also allows to differentiate between market-wide effects of earthquake risk (-0.16 to -0.19% discounts) and (random) effects that emerge at neighbourhood level (which can be + where risk is below the market average or – where risk is above the average). The model demonstrates that the recent earthquake activity led to a relatively modest overall increase in the price discount associated with earthquake risk. The neighbourhood level analysis shows that these effects vary considerably. The impact of changed perceptions is most visible and noticeably larger in neighbourhoods at the lower price end of the market.

The impacts estimated appear consistent with theory and previous studies. As is often the case, there may be omitted variable issues (as with hedonics) and it is possible that would anticipate more spatial differentiation might emerge with the addition of more levels (e.g. neighbourhood, submarket and market). This approach can be applied to other contexts including isolating the impacts of flood risk or regeneration investments. This approach has considerable potential to help unravel the impacts of recent flood activity on England and Wales.

Image source: Prometheus72/shutterstock.com

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