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EARTHQUAKES AND HOUSING RENTAL PRICES IN URBAN INDONESIA: A HEDONIC PRICE ANALYSIS

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ABSTRACT

This paper examines the influence of earthquakes on housing rental prices in the urban areas of Indonesia. We employ the household and community data from the Indonesian Family Life Surveys (IFLS) 4 and 5 and estimate a hedonic price model of housing rental prices. We also add a set of variables representing housing attributes and a set of variables related to the community attributes. We find that current earthquakes have had a statistically significant impact on the housing rental prices, confirming the short-term impact of the earthquakes. There is no evidence that earthquakes have long-term impacts on housing rental prices. We find that earthquakes have a short-term effect on the housing rental prices for self-owned houses only. This finding confirms that different statuses of houses respond differently to earthquake disasters.

Keywords: Earthquakes; Housing rental prices; Hedonic price method; Urban.
JEL Classification: O18; Q32; Q54.

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I. INTRODUCTION

In this paper, we investigate the influence of earthquakes on housing prices in urban areas in Indonesia. The motivation is twofold. First, Indonesia's cities are amongst the fastest-growing cities in the world. By 2025, according to the World Population Prospect, Indonesia will have 68% of its population living in cities or urban communities. Therefore, natural hazard risks in urban areas are increasing due to the rising exposure of the population and assets (see, Tipple 2005, Bilham 2009, Lall and Deichmann 2012). Second, many cities in Indonesia are vulnerable to earthquakes, one of the most dominant natural disasters in Indonesia. Several earthquakes in Indonesia, such as the Aceh earthquake and tsunami in 2004, the Yogyakarta earthquake in 2006, the Pangandaran earthquake in 2006, and the Padang earthquake in 2009, have been deadly and costly natural disasters.

Studies especially in developed countries show that earthquakes influence house prices. A meta-analysis study shows that geographical location is one of the key determinants of estimated coefficients (Sirmans *et al* 2006). This finding is consistent with the fact that an earthquake is an exogenous risk factor that is tied to a specific location as argued by Naoi *et al*. (2009) and it could be repeated, although its probability of occurrence is extremely low (Nakanishi 2017). Lall and Deichmann (2012) find that being in an earthquake zone significantly lowers office rents, but there are no significant correlations for floods and cyclones. Their study uses data for central business office rents and hazards risk information for 155 cities around the world in 2005, indicating that earthquakes tend to have a larger impact on property prices than flood and cyclone.

Murdoch *et al*. (1993) and Beron *et al*. (1997) study the impact of the 1989 Loma Prieta earthquake on property value in the San Francisco Bay area and find that the earthquake caused a reduction in the market value of the property. Cheung *et al*. (2018) examine the impact of induced earthquakes on residential property values using sales data from Oklahoma from 2006 to 2014 and find that prices decline after a home has experienced a moderate earthquake. They conclude that these findings are consistent with the experience of an earthquake—a new risk that is then capitalized into house values. Modica *et al*. (2021) evaluate housing market responses to the Northern Italy earthquake of May 2012 and find that earthquakes might increase the price differential between earthquake-resistant and non-resistant houses. Logan (2017) find support for the hypothesis that consumers' perception of risk became more acute after experiencing an extreme event based on his study on the impact of the 22 February 2011 Canterbury earthquake in New Zealand. Nakagawa *et al*. (2007) that use a more conventional hedonic approach conclude that housing rents in the Tokyo Metropolitan Area are substantially lower in risky areas than in safer areas, even after controlling for other possible effects. Naoi *et al*. (2009) find both housing rents and owner-occupied home values are significantly and negatively correlated with regional earthquake risk in post-quake periods. Seko (2019) also finds that the earthquake occurrence probability has a negative impact on housing rent among cities/counties in Japan.

Onder *et al*. (2004) study the 1999 Marmara activity has an impact on house prices in Istanbul. The finding is that distance from fault lines is an important factor in explaining house prices and its impact on house values increased after the 1999 Kocaeli earthquake. However, this study concludes that none of the measures of earthquake risk significantly affected the change in housing values in Istanbul. Alas and Ülger (2019) also examine the impact of earthquake risk on housing prices differs between high-risk and low-risk areas in riverbeds in Istanbul, related to the 1999 Kocaeli earthquake. The results show that the earthquake risk has a negative impact on both areas. They also find that the change in housing prices occurs depending on the housing submarkets in the riverbeds. Similarly, Willis and Asgary (1997) indicate housing market in Teheran is sensitive to the earthquake resistance feature of houses. In addition, Koster and Ommeren (2015) investigate the impact of earthquakes caused by natural gas extraction (human-induced earthquakes) on property prices in Groningen, Netherlands. They show that induced earthquakes that are noticeable to residents generate important negative impacts on house prices. Boelhouwer and van der Heijden (2018) also confirm that the general downturn in the housing market in the Netherlands, especially the Groningen housing market is also related to the earthquake problems, especially in the period after the earthquake in Huizinge in August 2012.

Based on the above discussion, our hypothesis is that earthquake risk has a negative influence on housing prices, at least in the short-term, in the urban areas in Indonesia by using hedonic price analysis as the most applied method of housing price evaluation (Xiao 2017). Housing comprises a product class differentiated by characteristics, then the housing value can be reflected a function of its characteristics. In other words, the hedonic housing models basically predict that housing price can be considered as willingness to pay for a bundle of characteristics. Xiao identifies four subsets of determining variables that have been used in empirical studies. First, the structural or internal attributes representing the physical characteristics of housing, such as numbers of room. Second, the attributes of location such as accessibility to major amenities and infrastructures, such as public facilities. Third, neighbourhood attributes indicating the quality of the economic and social characteristics of the neighbourhood, such as income status. And fourth is environmental attributes in which we can also include whether the house is in disaster prone area or not.

Therefore, aaccording to the hedonic framework, the impact of earthquakes or the risk of earthquakes will be reflected in a discount in housing prices indicating an earthquake experience or an earthquake risk is an environmental risk. People tend to negatively respond to earthquakes due to an earthquake is an event that cannot be controlled by the economic agents that participated in the affected housing markets. After experiencing an extreme event, such as an earthquake, consumers' perception of disaster risk became more acute (Logan 2017). This reflects how consumers use the previous earthquakes as a signal that future earthquakes may have larger damage (Koster and Ommeren 2015) and finally affect consumers' willingness to pay for housing.

Our study finds that earthquakes have a short-term impact on the housing rental prices in the urban area, indicating that earthquakes reduce the housing rental prices. However, earthquakes have no long-term impact on housing rental prices, probably because people revise their earthquake risk evaluation. Our study makes two contributions. First, the findings of this study add to the current literature on the relationship between earthquakes and housing rental prices, particularly in developing countries by implementing hedonic price analysis.

Second, we use data at the household level provided by the Indonesian Family Life Surveys (IFLS) covering a diverse region. Yusuf and Resosudarmo (2009) use the same data source, but they focus on the influence of clean air on housing rental prices, while Alvarez and Resosudarmo (2019) implement a hedonic prices analysis of the Jakarta housing market focusing on the cost of floods.

This paper proceeds as follows. Section II discusses data and methodology. We discuss our main findings in Section III. Section IV provides conclusions.

II. DATA AND METHODOLOGY

The main data source is the Indonesian Family Life Surveys (IFLS). It is a large-scale panel household survey in Indonesia representing about 83 per cent of the Indonesian population and has over 30,000 individuals and more than 10,000 households living in 13 of the 27 provinces in the country. IFLS has been conducted 5 waves, starting from IFLS-1 in 1993/94 and the newest wave (IFLS-5) was conducted in 2014/15.

All IFLS waves provide a rich micro database of individuals and households, and in the small geographical unit (enumeration area) or the village area. These surveys also cover housing and natural disasters information. We use the household and community data taken from IFLS-4 (2007) and IFLS-5 (2014) to investigate the impact of the earthquakes. Using these two IFLS waves we can evaluate not only the short-run (within 5 years) but also the long-run (within 10 years) impact of the earthquake. As the focus of our study is urban areas, we only use data from urban households. The final sample consists of 3,010 observations that has been extracted from more than 10,000 observations. Table 1 provides a short description about variables used in the study.

To assess the influence of earthquakes on housing prices we will employ a hedonic price method. The left-hand-side variable is the monthly rent of the house per m^2, notated as *HR* (in log). IFLS does not provide housing prices, but this has information about housing rent. The same approach has been used in Yusuf and Resosudarmo (2009) and Alvarez and Resosudarmo (2019). We then use this housing rent data from IFLS 5, regardless of the status of the house (self-owned, occupied, or rented/contracted).

For the purpose of our study, we choose to use earthquake experience at the community level. The IFLS does not provide sufficient data on the earthquake indicators, therefore we create a relatively simple measure based on information about earthquakes in the last 5 years. This binary variable is notated as *CEC* representing the current earthquake, taking the value of 1 for households whose village experienced an earthquake in the last 5 years, and 0 otherwise. For the past earthquake, we take the data from IFLS 4 to create a dummy variable of the past earthquake, annotated as *PEC*. The IFLS 4 is conducted in 2007, then 'the last 5 years' in this wave can be treated as the past earthquake for the IFLS-5. The maximum time distance between the past earthquake and the current earthquake is 10 years (2012-2002). This allows us to interpret the impact of the earthquake indicator that is taken from the IFLS 4 as the long-run impact of the earthquake. It is expected that *CEC* and *PEC* will have a negative coefficient indicating the negative impact of the earthquake.

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Table 1.
Data Description

This table reports descriptive statistics of variables used in our estimations. IFLS4 and IFLS5 refer to the Indonesian Family Life Surveys waves 4 and 5, respectively. We report the means and standard deviations for continues variables (labelled as Avg. and Std.Dev., respectively), but for dummy variables, we only report the ratios (labelled as ratio) in parentheses.

Variable	Description	Source	No. of Obs.	Avg. (ratio)	Std. Dev.
	Housing rent prices indicator				
HR	House rent per month per m^2 (in log)	IFLS5	3,010	8.33	1.15
	Earthquake indicators (EC)				
CEC	The value of 1 for households whose village experienced an earthquake in the last 5 years, and 0 otherwise	IFLS5	3,010	(0.12)	
PEC	The value of 1 for households whose village experienced an earthquake in the last 5 years, and 0 otherwise	IFLS4	3,010	(0.30)	
	Housing attributes (HA)				
HS	House size in m^2 (in log)	IFLS5	3,010	4.12	0.79
HRM	Number of rooms (in log)	IFLS5	3,010	1.66	0.48
HRF	The value of 1 for households whose house roof is concrete, and 0 otherwise	IFLS5	3,010	(0.02)	
HOW	The value of 1 for households whose house outer wall is cement/bricks, and 0 otherwise	IFLS5	3,010	(0.89)	
HSU	The value of 1 for households whose house is a single unit, and 0 otherwise	IFLS5	3,010	(0.81)	
HWD	The value of 1 for households whose source of water for drinking is inside, and 0 otherwise	IFLS5	3,010	(0.74)	
HYA	The value of 1 for households whose house has a moderately-sized yard, and 0 otherwise	IFLS5	3,010	(0.65)	
HVE	The value of 1 for households whose house ventilation is sufficient, and 0 otherwise	IFLS5	3,010	(0.88)	
HCS	The value of 1 for households whose cooking room and sleeping rooms are the same, and 0 otherwise	IFLS5	3,010	(0.03)	
	Community attributes (CA)				
CES	The value of 1 for households whose village current condition of education services is adequate, and 0 otherwise	IFLS5	3,010	(0.95)	
CHS	The value of 1 for households whose village current condition of health services is adequate, and 0 otherwise	IFLS5	3,010	(0.93)	
CCF	The value of 1 for households whose village condition of condition/terrain of the village/township is flat, and 0 otherwise	IFLS5	3,010	(0.70)	
CAIR	The value of 1 for households whose village air condition is generally polluted, and 0 otherwise	IFLS5	3,010	(0.20)	
CPOOR	Poor households/total households at the village/township level (%)	IFLS5	3,010	28.07	17.15
CPD	Population density per km^2 at the village/township level (in log)	IFLS5	3,010	7.23	1.60

We also add a set of variables representing interior attributes of the house, notated as *HA*; and a set of variables related to the external aspects of the house notated as *CA*. All these variables are also selected by considering data availability and by referring to studies on hedonic housing prices. *HA* consists of house size in m^2 (*HS*), the number of rooms (*HRM*), house roof (*HRF*), house outer wall (*HOW*), type of house (*HSU*), source of water for drinking (*HWD*), house yard (*HYA*), house ventilation (*HVE*), cooking room and sleeping room in the same room or not (*HCS*). All these variables, except the size of the house, the type of house, and the cooking-sleeping room, are expected to have positive relationships with monthly house rent. We expect the size of the house has a negative influence on house rent as we use monthly house rent per m^2. In other words, if the size of the house increases, then the unit price of this house decreases. As for the type of house, the expectation is that this variable has a negative implication on monthly house rent since people in urban areas tend to prefer a multilevel house due to limited land settlement.

Meanwhile, *CA* represents variables at the community level. They are the current condition of education (*CES*) and health services (*CHS*), the condition or terrain of the village (*CCF*), air quality air in the village (*CAIR*), the percentage of poor households in the village (*CPOOR*), and population density per km^2 (*CPD*). These variables reflect amenities at the village level. We may expect that the rents of houses that are located in a village with good amenities tend to have higher monthly house rent. For instance, people tend to discount the price of the house if this house is in a village that is generally polluted. Three of six community attributes are expected to have positive relationships with monthly house rent: education services, health services, and the condition of the village. The rest is expected to show negative correlations with monthly house rent: poverty rate, air pollution, and population density.

As indicated in Table 1, we use a log-log specification to estimate the influence of earthquake on housing rental prices based on the available functional forms of hedonic model, the commonly applied methods of housing price evaluation (Xiao, 2017). We first estimate the baseline model which includes all observations. We then also conduct further estimation, in which we split the sample into three groups based on the status of houses. Following Naoi *et al*. (2009), the aim of this additional estimation is to find out whether the different status of the house has different implication on the housing rental prices. To account for potential spatial autocorrelation of the error term, we cluster standard errors at the community level. We also include province fixed effects in our estimations.

III. RESULTS AND DISCUSSION

A. Baseline Regressions

The baseline estimation results are provided in Table 2. We start our estimation with a regression in which the current earthquake indicators are the only independent variables (estimation-1). The result shows that *CEC* has a statistically significant negative coefficients, but *PEC* does not have any statistically significant coefficients. The result of *CEC* confirms that earthquakes had a temporary impact only on the house rents in the urban area in Indonesia. At first, earthquakes reduce house rents, because of a large price discount to the houses. This large discount probably reflects the fact that agents overestimated the earthquake risk in their location. However, in the long run, agents might revise their earthquake risk evaluation that could be responsible for the loss of statistical significance of past earthquakes. Another possible explanation is that there was effective disaster prevention that increases the safety of housing.

Adding housing attributes does not change the impact of the earthquake indicator as *CEC* still has a statistically significant coefficient (estimation -2). The results of these three estimations suggest that earthquakes negatively affect house rental prices in the short run. Six out of nine housing attributes have a statistically significant coefficient. These attributes are housing size (*HS*), the number of rooms (*HRM*), quality of wall (*HOW*), type of house (*HSU*), water source (*HWD*), and the cooking and sleeping room (*HCE*). As expected, the size of the house, the house type, and the cooking-sleeping room variables show negative correlation with housing rent prices/m^2.

The coefficients of the earthquake indicators and housing attributes are stable when we also include community attributes (estimation-3). There is only one variable of the community attributes (quality of education services (*CES*)) that has a statistically significant coefficient. This variable has a positive coefficient, indicating that a house located in a village with adequate education services tends to have higher rental prices.

Table 2.
Baseline Results: Impact of Earthquakes on Housing Rental Prices

This table reports regression results for baseline models. In the first estimation, we included only earthquake indicators. Subsequently, housing attributes were added in the second estimation, and finally, community attributes were incorporated in the third estimation. Dependent variable: HR (Log of house rent per month per m^2). We cluster standard errors at the community level. Standard errors are in parentheses. * p<0.1, ** p<0.05, *** p<0.01

Variable	**(1) All Obs.**	**(2) All Obs.**	**(3) All Obs.**
Earthquake indicators:			
CEC	-0.585**	-0.462**	-0.495*
	(0.267)	(0.232)	(0.255)
PEC	0.048	-0.028	-0.107
	(0.145)	(0.144)	(0.181)
Housing attributes:			
HS		-0.792***	-0.786***
		(0.032)	(0.033)
HRM		0.282***	0.302***
		(0.068)	(0.063)
HRF		0.175	0.191
		(0.112)	(0.115)
HOW		0.280***	0.271***
		(0.068)	(0.064)
HSU		-0.282***	-0.270***
		(0.073)	(0.069)
HWD		0.189***	0.157***
		(0.048)	(0.050)

Table 2.
Baseline Results: Impact of Earthquakes on Housing Rental Prices (Continued)

Variable	(1) All Obs.	(2) All Obs.	(3) All Obs.
HYA		0.024	0.026
		(0.039)	(0.037)
HVE		0.075	0.077
		(0.054)	(0.050)
HCS		0.233**	0.206**
		(0.109)	(0.102)
Community attributes:			
CES			0.580**
			(0.250)
CHS			0.036
			(0.196)
CCF			0.079
			(0.102)
CAIR			0.055
			(0.092)
CPOOR			0.000
			(0.002)
CPD			0.007
			(0.022)
Province fixed effects (12)	Yes	Yes	Yes
N	3,010	3,010	3,010
Adj. R-sq	0.109	0.346	0.359

B. Regressions Based on the Status of the House

So far we have included all observations in estimating the impact of the earthquake. As already explained, the data cover self-owned, occupied, or rented/contracted houses. This implies that the actual rent price of the house is basically available for the rented or contracted houses, while the rest of housing rental prices are the prices provided by the owners or occupiers.

One may expect that owners and renters have different responses to a natural shock-like earthquakes. It is commonly known that housing availability is still a problem in urban Indonesia, and this rental housing may also reflect that low-income households face difficulty having a property in cities (Hoffman *et al*. 1991; see also Das 2017). This implies that renters have limited resources to rent a house in a safe area. In turn, we may expect that those renters would not consider earthquake risk in renting a house. We then expect that earthquake has no influence on the housing rents for the renters' group, but this may influence housing rents for the self-owned group.

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Table 3.
Grouped Results: Impact of Earthquakes on Housing Rental Prices

This table reports regression results for models categorized by three types of housing ownership: self owned, occupied, and rented. In these models, we not only incorporated earthquake indicators, but also housing and community attributes. Dependent variable: HR (Log of house rent per month per m^2). We cluster standard errors at the community level. Standard errors are in parentheses. * p<0.1, ** p<0.05, *** p<0.01

Variable	(1) Self owned	(2) Occupied	(3) Rented
Earthquake indicators:			
CEC	-0.531**	-0.452	-0.103
	(0.250)	(0.291)	(0.607)
PEC	-0.111	-0.087	-0.496
	(0.181)	(0.257)	(0.372)
Housing attributes:			
HS	-0.697***	-0.872***	-0.858***
	(0.044)	(0.055)	(0.083)
HRM	0.374***	0.299***	0.091
	(0.072)	(0.106)	(0.116)
HRF	0.065	0.047	0.632***
	(0.148)	(0.273	(0.136)
HOW	0.254***	0.118	0.496**
	(0.058)	(0.153)	(0.240)
HSU	-0.313***	-0.066	-0.091
	(0.083)	(0.132)	(0.138)
HWD	0.150**	0.144	0.086
	(0.064)	(0.096)	(0.140)
HYA	0.013	0.155*	-0.175*
	(0.049)	(0.088)	(0.089)
HVE	0.037	0.102	0.231
	(0.063)	(0.112)	(0.140)
HCS	0.190	0.236	-0.037
	(0.163)	(0.186)	(0.134)
Community attributes:			
CES	0.591***	0.247	0.907**
	(0.223)	(0.453)	(0.364)
CHS	0.096	0.235	-0.512*
	(0.178	(0.408)	(0.294)
CCF	-0.042	0.036	0.659***
	(0.103)	(0.130)	(0.203)
CAIR	-0.007	0.174	0.293
	(0.097)	(0.173)	(0.184)
CPOOR	-0.001	-0.002	0.003
	(0.003)	(0.005)	(0.004)
CPD	0.002	0.027	0.014
	(0.028)	(0.041)	(0.038)
Province fixed effects (12)	Yes	Yes	Yes
N	2,123	554	322
Adj. R-sq	0.257	0.424	0.552

To clarify that issue, we reestimate the impact of the earthquakes on the house rents of each group to assess whether the different status of the house has a different response to the earthquake. We do not estimate for the other group since the number of observations is insufficient (only 11 observations). Table 3 shows that *CEC* has a statistically significant influence on the housing rental prices for the self-owned group only. This indicates that house owners discounted the price of their houses in response to the earthquake that occurred in their village. Meanwhile, the occupiers and renters had no response to the recent earthquakes. One possible explanation for this behaviour is that the occupiers and renters had no ability to consider earthquake risk in their decision to occupy or rent a house due to lack of sufficient (financial) resources. This finding partially confirms that different statuses of houses had different responses to earthquake disasters. Another interesting finding is that the community attributes, especially the quality of education (*CES*) and physical condition of the village (*CCF*), play a positive role in determining the price of the house for the renter group. In contrast, the quality of health facilities shows a negative influence on the rent price of a house for this renter group.

Overall, this finding is consistent with the baseline results in Table 2, indicating that earthquakes tend to have a temporary influence on the housing rental prices for the self-owned houses. There is no indication that the past earthquake influences the housing rental prices. Other attributes show consistent relationships to housing rental prices in which community attributes are more important for the renters than for the two other groups.

IV. CONCLUSION

This paper examines the influence of earthquakes on housing prices in the urban areas in Indonesia using a hedonic price method. We employ two waves of the survey, which are IFLS 4 (2007) and IFLS 5 (2012). Given that empirical studies on the impacts of earthquakes on housing rental prices in urban Indonesia are rare, the findings of this study add to the current literature on the relationship between earthquakes and housing rental prices, particularly in developing countries.

This study finds that the current earthquakes (which occurred in the last 5 years) have a statistically significant impact on the house rental prices, confirming the short-term impact of the earthquakes (taken from IFLS 5) on the house rental prices. However, we do not find evidence that earthquakes have long-term impacts on housing rental prices. We use the past earthquake information (taken from IFLS 4) to assess the long-term impact of the earthquakes. These results indicate that earthquakes reduce the housing rental prices as agents offered a large price discount on their houses. However, in the long run, agents most likely revise their earthquake risk evaluation which may explain why the effect of earthquakes becomes statistically insignificant.

Further estimation based on the status of the house suggests that the earthquake variable only had a short-term effect on the housing rental prices for the self-owned houses, indicating that house owners discounted the price of their houses in response to the earthquake that occurred in their village. This finding confirms that different statuses of houses had different responses to earthquake disasters.

However, we show that the past earthquake did not influence the housing rental prices of all status of the houses.

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