The Impact of Flooding on Real Estate Transactions in Densely Populated Areas: Evidence from the 2019 Typhoon Hagibis in Japan*

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Abstract

We examine the impact of flooding on real estate transactions in an urban area, using as a natural experiment the flooding caused by Typhoon Hagibis, which hit Japan in October 2019. Applying the difference-in-differences method, we find that the properties located in the inundated areas experienced significant declines in contract and offer prices by about 6.4% and 5.9% on average, respectively, indicating that discount rate, defined as a percentage change from offer to contract prices, became larger by about 0.5 percentage points. Focusing on transactions of apartments, we show that the negative effects are significant for higher floors, whereas insignificant for lower floors. This suggests a possibility of buyers becoming more aware that higher floors are also vulnerable to flooding because of the risks of power and water outages. It is also revealed that the negative effects on detached houses are more serious and appear more slowly than those on apartments.

Keywords: flood, typhoon, real estate, apartments, bargaining power

JEL classification: Q54, R11, R31

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1 Introduction

Climate change may increase the threat of natural disasters in the near future. In fact, the intensity of tropical cyclones has increased over the past few decades and the most intense cyclones are predicted to become more frequent by the end of the twenty-first century (Emanuel, 2005; Knutson et al., 2010). Furthermore, an increase in precipitation can result in making more people and properties face the risk of flooding (Intergovernmental Panel on Climate Change, 2012; Wing et al., 2022). Under these circumstances, it becomes more and more important to grasp how floods affect our lives and properties, particularly in urban areas with a large population and many economic activities.[1]

Densely-populated urban areas are often characterized by a lot of high-rise buildings. Compared with lower floors, higher floors are seemingly safe even if a flood occurs because such floors would not be flooded above the floor level. However, flooding may bring about power and water outages around the flooded areas due to damages on electrical power facilities, harming not only lower but also higher floors. This implies that higher floors are also not free from the flood risk as long as the building is located in a flood-prone area. As pointed out by Gourevitch et al. (2023), residential properties at flood risks tend to be overvalued. Here in the context of populous cities, a question is whether the housing market adequately reflects the risk of higher floors in case of flooding.

To examine whether flood risks are perceived and capitalized into the market prices, it is useful to study what happened to the housing market when floods actually occurred because natural disasters can update people's risk perception (Carbone et al., 2006). Thus, the present study evaluates the impact of flooding on the housing market in an urban area with a large population, using as a natural experiment the flood in Tokyo metropolitan area induced by the 2019 Typhoon Hagibis, one of the costliest typhoons that ever hit Japan.

A notable feature of this flood is that it brought about power and water outages in apartment buildings due to flooding of electric equipment, forcing residents in such buildings to live an inconvenient life until recovery, even on high floors without direct damages of the inundation. For example, in one tower block residence, the rising water level caused power outages in electrical and mechanical facilities, shutting down the water supply and elevators. It took one week to restore power and two weeks to restore water (NIKKEI, 2020). Thus, this flood is considered to have updated people's perception of flood risks in apartment buildings and suitable for our research purposes.

As an estimation strategy, we employ the difference-in-differences approach. Along with the literature, we take the contract price of a property as the outcome variable. In addition, the data that we use in the present study lets us know not only contract prices but also prices initially offered by sellers. Note that a feature of real estate transaction is that properties are often discounted during the process of transaction. Thus, the availability of the data on offer

[1] Kocornik-Mina et al. (2020) point out that economic activities are more concentrated on low-elevation urban areas, although these areas are flooded more frequently. They also document that economic activities do not move out of these areas in response to floods.

prices enables us to see the effects on discount rates, from which we can obtain an insight into how bargaining powers of sellers and buyers are affected by disasters.

We first conduct the regression combining both apartments and detached houses into a single sample. The results suggest a significantly negative impact of flooding. Specifically, the contract and offer prices of properties located in the flooded areas declined by about 6.4% and 5.9% on average, respectively, compared with those located outside the inundated areas. Consistent with these observations, it is also shown that the discount rates were significantly larger in the flooded areas by about 0.5 percentage points. These results indicate that the flood not only had a negative impact on the transaction price itself, but also made the bargaining power of buyers stronger and that of sellers weaker. Stated differently, the decline in contract prices in the flooded areas can be partly attributed to changes in bargaining powers of sellers and buyers.

We then examine transaction of apartments. Dividing the sample into properties located on higher and lower floors, we find that the effects were insignificant for lower floors and significantly negative for higher floors. Because the flooding induced by Typhoon Hagibis brought about power and water outages in apartment buildings due to flooding of electric equipment, it can be thought that buyers updated their risk perception and became more aware that not only lower but also higher floors are vulnerable to flooding. On the other hand, the flood risk of lower floors, such as inundation above the floor level, had long been recognized among buyers and had already been capitalized into the prices. From these, the results exhibit significantly negative impacts on higher floors, whereas not on lower floors.

Focusing on transaction of detached houses, we find that the quantitative impacts on detached houses are larger than those on apartments, regarding both prices and discount rates. A possible explanation for this observation is that most of detached houses are made of wood, more vulnerable to flooding than reinforced concrete or steel, resulting in more serious impacts.

Furthermore, we also investigate the dynamic effects of flooding, applying the event study design. The results indicate that the effects on apartments appeared rather immediately, about a year after the typhoon hit, whereas those on detached houses appeared more slowly, about three years after the hit. There are three possible reasons for these observations. First, the liquidity of detached houses is lower than that of apartments. Second, owners of the flooded houses postponed putting up for sale to restore the parts damaged by the flood. Third, it became difficult for the damaged houses to be sold until the prices are largely discounted, resulting in the longer time-on-market.

The present study is related to the ones that investigated the effects of flooding on real estate markets. It is mostly agreed by many extant studies that housing markets are negatively affected by flood events: for example, the 1992 Hurricane Andrew (Hallstrom and Smith, 2005); the 1993 flood on the Missouri and Mississippi rivers (Kousky, 2010); the 1994 flood in Dougherty County, Georgia (Atreya et al., 2013); the 1999 Hurricane Floyd (Bin and Polasky, 2004; Bin and Landry, 2013); the 2005 Hurricane Katrina (Vigdor, 2008); the great Iowa flood in 2008 (Yi and Choi, 2020); and the 2012 Hurricane Sandy (Ortega and Taşpınar, 2018; Cohen et al., 2021).[2] In line with these studies, we also find that prices of properties located in the areas flooded by Typhoon Hagibis declined. A unique point of our study is that we focus on not only contract prices but also offer prices. We reveal that contract prices were affected significantly more than offer prices, implying that properties located in the inundated areas became more likely to be discounted during the process of transaction.

Among the studies focusing on the impact of flooding due to hurricanes, Atreya et al. (2013), Bin and Landry (2013) and Cohen et al. (2021) found that housing prices in the flood plains declined immediately after the flood, although these effects became smaller and eventually disappeared within several years, indicating that the negative effects of flooding are temporary. Conversely, Ortega and Taṣpınar (2018) suggested an evidence on the persistence of negative impacts. They studied the case of Hurricane Sandy and found that damaged properties experienced a large drop in prices immediately after the storm, and then the prices partially recovered, but did not come back to the pre-flood level. In the present study, it is difficult to provide a conclusive evidence on whether the negative impacts of flooding are temporary or persistent, partly because we can observe only four years after the typhoon hit. On the other hand, our study can give an insight into the timing at which the negative impacts appear.

Some studies also pointed out heterogeneity in the effects of flooding. For instance, Zhang (2016) revealed that lower-priced houses are affected more than higher-priced ones, based on a quantile regression analysis. Our study contributes to the literature by showing another kind of heterogeneity in the negative impact of flooding. We find that, regarding transactions of apartments, the effect is different depending on floors on which the property is located: properties on higher floors are more affected than those on lower floors. Accounting for this "vertical heterogeneity" is crucial, particularly when managing the flood risk in large urban areas with a dense population and many high-rise buildings.

The present study is also related to the literature of bargaining in housing markets (Han and Strange, 2015). In this literature, Harding et al. (2003b) is a seminal paper that accounted for bargaining powers of buyers and sellers in an empirical model. Their approach revealed that bargaining powers were influenced by household wealth, gender, and other demographic traits, and is followed by a lot of studies.[3] Merlo and Ortalo-Magné (2004) is also an innovative study in that they looked into the bargaining process in housing markets by analyzing the records of listing price changes and sales agreements. They found that listing price revisions were caused by a lack of offers, and the size of the reduction in the listing price tended to be larger when the property had been on the market longer. The present study contributes to this strand of research by showing a possibility that natural disasters affect the balance of sellers' and buyers'

[2]Other studies also examined the impacts of hurricanes or typhoons on, for example, business activities (Elliott et al., 2019; Indaco et al., 2021; Okubo and Strobl, 2021; Meltzer et al., 2021), local labor markets (Belasen and Polachek, 2008; McIntosh, 2008; Deryugina et al., 2018; Groen et al., 2020), fiscal costs (Deryugina, 2017; Jerch et al., 2023; Capuno et al., 2024), homeowners' behavior (Gallagher, 2014; McCoy and Zhao, 2018), and residential sorting (Smith et al., 2006; Varela, 2023).

[3]Applications in early years include Harding et al. (2003a) and Colwell and Munneke (2006). More recently, their framework is applied in, for instance, Steegmans and Hassink (2017), Ling et al. (2018), and Hayunga and Munneke (2021).

bargaining powers in the damaged areas.

In Japanese context, our study is also related to Zhai et al. (2003), who investigated the case of the flood caused by a heavy rain in Aichi Prefecture, containing the central part of the third largest metropolitan area in Japan. Their study is similar to ours in that they examined flooding in densely-populated urban areas, but different in that their focus was on the effects on appraised land values. We rather focus on the impacts on transaction prices and elucidate how the impacts are different between apartments and detached houses. To the best of our knowledge, the present study is the first to quantify the impact of Typhoon Hagibis on the real estate market.

The remainder of the paper is organized as follows. Section 2 briefly explains the background on Typhoon Hagibis. Section 3 describes the data that we use. Section 4 provides the econometric framework. Section 5 shows the regression results. Section 6 examines the dynamic effects. Finally, Section 7 concludes the paper and provides some implications derived from the present study.

2 Background

On October 6th, 2019, a tropical storm grew into a typhoon in east of the Mariana Islands and was named Hagibis. It rapidly intensified and reached a central pressure of 915 hPa on October 7th. Heading north, Typhoon Hagibis made landfall on October 12th at the Izu Peninsula, southwest of the Tokyo metropolitan area, Japan, with a central pressure of 955 hPa and a maximum wind speed of 40 m/s (Japan Meteorological Agency, 2019). Heavy rains, wind storms, tidal waves, and storm surges were caused by this extremely strong typhoon. The damage was extensive throughout Japan, affecting 33 of the 47 prefectures. In particular, many areas where the typhoon passed through experienced the largest amount of precipitation ever recorded. This extreme rainfall caused rivers to overflow and landslides in many areas. After passing over Japan, the typhoon became an extratropical low in northeast of Japan on October 13th.

According to the available sources, more than 100 lives were lost, over 100,000 homes were damaged, and flood damage was estimated at JPY 1.88 trillion. It was the largest amount of damage since 1961, the start of Japanese flood statistics (Ministry of Land, Infrastructure, Transportation and Tourism, 2019, 2021; Fire and Disaster Management Agency, 2019). For example, the flooding of the Chikuma River in Nagano Prefecture caused the submergence of a Shinkansen rail yard. In Fukushima and Miyagi Prefectures, the Abukuma River overflowed, killing more than 50 people, about a half of the total deaths due to this typhoon. Because this typhoon caused extensive damages over a wide area in eastern Japan, it is also known as the "East Japan Typhoon" in Japan.

The Tokyo metropolitan area, where the population is concentrated, also suffered distinctive damage. Concentrated precipitation in Tokyo and Kanagawa Prefectures caused internal flooding in the lower reaches of the Tama River, where many high-rise residential buildings are located.

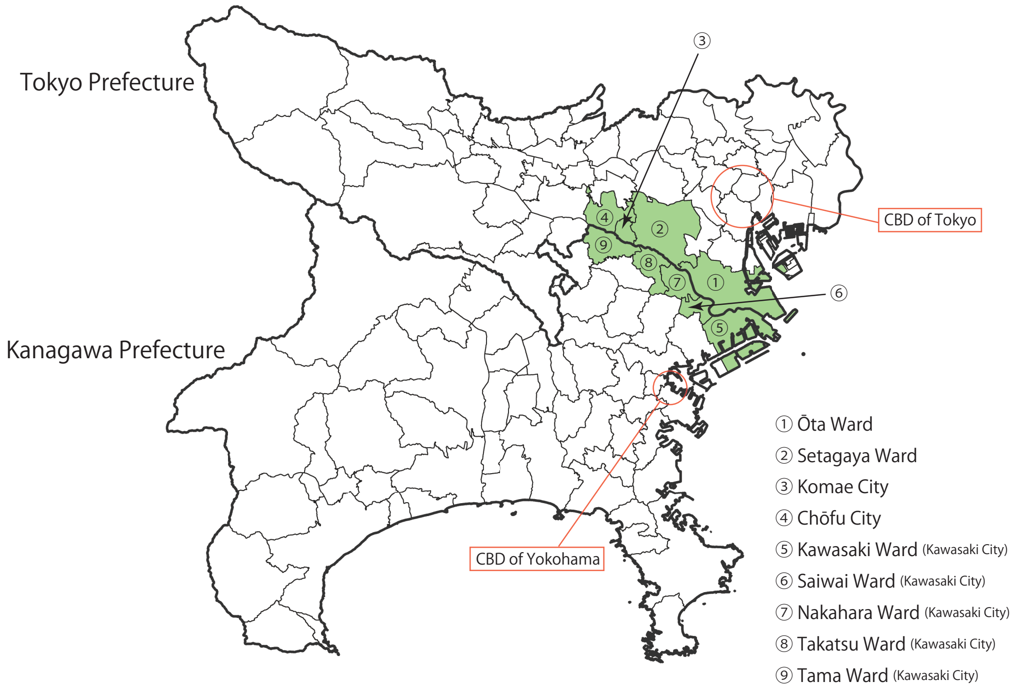


Figure 1: Locations of the municipalities.

Notes: The figure shows the map of Tokyo and Kanagawa Prefectures. The thick and thin lines represent prefectural and municipal boundaries, respectively. The colored municipalities with numbers are the ones of our focus.

The heavy rain made it difficult to remove rainwater from sewers to rivers, causing water from the river to flow back through drainpipes and making some areas along the river flooded. This results in power outages and water supply disruptions in these areas.

3 Data

In the present study, we focus on nine municipalities located in the lower reaches of the Tama River. In these areas, the Tama River coincides with the prefectural border: that is, the left and right banks belong to Tokyo and Kanagawa Prefectures, respectively. The locations of the municipalities are shown in Figure 1. The colored municipalities with numbers are the ones on which we focus in the present study. The municipalities labeled with one through four — Ōta Ward, Setagaya Ward, Komae City, and Chōfu City — are located on the left bank of the Tama river and belong to Tokyo Prefecture. The municipalities labeled with five through nine are Kawasaki Ward, Saiwai Ward, Nakahara Ward, Takatsu Ward, and Tama Ward, all of which are sub-municipal districts of Kawasaki City. These municipalities are located on the right bank of the Tama River and belong to Kanagawa Prefecture.

Tokyo Prefecture contains the capital of Japan, Tokyo, and the location of its central business district (CBD) is also shown in Figure 1. Kanagawa Prefecture is the second most populous prefecture of Japan after Tokyo. Although a large part of Kanagawa Prefecture is regarded as the suburban areas of the Greater Tokyo, the capital city, Yokohama, hosts one of the greatest ports in Japan and has large business and commercial districts. In Figure 1, we also show the location of Yokohama's CBD.

Located between two large cities, our study areas host a large population.[4] About two million people live in the four municipalities of Tokyo Prefecture, and about one million people reside in the five municipalities of Kanagawa Prefecture. In total, there are more than three million people living in our study areas.

3.1 Real Estate Transaction Data

The data for real estate transactions is derived from Real Estate Information Network Systems (REINS), which has a large administrative transaction dataset. From this dataset, we extract the data on apartments and detached houses that are located in the municipalities shown in Figure 1 and transacted between January 2016 and August 2023.[5]

The data provides not only contract prices, but also the prices initially proposed by a seller, which we refer to as offer prices. The availability of these two kinds of prices enables us to calculate how much a property was discounted during the process of transaction. Thus, we define the discount rate as follows:

$$\text{(discount rate)} = 100 \times \frac{\text{(contract price)} - \text{(offer price)}}{\text{(offer price)}}.$$

Besides the prices, the data also contains a large set of information about characteristics of properties, which we can use as control variables in a regression. For example, the information on the walking time to the nearest train station and the age of a structure is available for both apartments and detached houses. In the sample of apartments, we can also use the information on the exclusive area of an apartment and the floor where an apartment is located. On the other hand, the sample of detached houses provides us of the information on the area of land, the width of a road faced by the house, and the floor-area ratio. The details of all other control variables are provided in Appendix A.

3.2 Treatment and Control Groups

Although we use the data on transactions of real estates located in the municipalities illustrated in Figure 1, ex ante risks of flooding are different across locations even within these areas. Since the flooded areas were thought to face a risk of flooding even before the typhoon hit, we should

[4]According to the 2020 Census, the number of population is 748,081 in Ōta Ward, 943,664 in Setagaya Ward, 84,772 in Komae City, 242,614 in Chōfu City, 232,965 in Kawasaki Ward, 171,119 in Saiwai Ward, 263,683 in Nakahara Ward, 234,328 in Takatsu Ward, and 221,734 in Tama Ward. The total population of these municipalities adds up to 3,142,960.

[5]In our full sample, observations for apartments account for about 78%, while the other 22% is for detached houses.

Table 1: Summary statistics.

Variable	N	Mean	Sd	Median	Min	Max
Common to apartments and detached houses						
contract price (ten thousand yen)	28330	4499	2492	4230	9	52800
offer price (ten thousand yen)	28330	4608	2561	4300	12	53800
discount rate (%)	28330	-2.611	4.279	-1.389	-72.5	0
flooded by Typhoon Hagibis (dummy)	28330	0.02993	0.1704	0	0	1
after flooding (dummy)	28330	0.4999	0.5	0	0	1
walking time to the nearest station (minutes)	26891	8.751	4.785	8	1	35
age of structure (years)	27442	18.92	13.01	16	0	96
Only for apartments						
exclusive area (m^2)	21966	62.62	21.45	66.33	7.99	330.6
floor	21490	5.603	6.283	4	1	57
Only for detached houses						
land area (m^2)	6364	89.32	47.25	79.38	21.2	704.8
width of facing road (m)	5578	5.194	2.429	4.5	0.8	36
floor-area ratio	5971	154.6	58.97	160	40	500

Notes: In the column labeled with "N," we report the number of observations that are not missing. Sd, Min, and Max represent standard deviation, minimum value, and maximum value, respectively.

focus on the properties located in the areas that were also considered to have a similar risk, in order to uncover the causal impacts of the 2019 flooding. For this purpose, we refer to flood hazard maps provided by the Digital National Land Information System and use the one for flooding from rivers.[6] Then, we extract the data on transactions of real estates located in these expected flooded zones.

In the subsequent analysis, we take the difference-in-differences approach. Since our focus is on the effects of flooding caused by the typhoon, the properties located in the flooded areas are classified as the treatment group; whereas those which are located within the expected flooded zones but did not experience the flooding are classified as the control group. The polygon data of the inundated areas is provided by Ministry of Land, Infrastructure, Transportation and Tourism.

In preparation for the analysis, we construct two dummy variables. One is a variable that takes one if a property under transaction is located in the areas flooded by the typhoon, and the other is a variable that takes one if the date of contract is after the typhoon strike.[7]

3.3 Summary Statistics

Table 1 shows summary statistics for main variables used in the analysis.[8] It indicates that properties are often discounted to some extent during the process of transaction. The mean of the discount rates is about −2.6%, and the median is about −1.4%.

[6]The hazard maps are the ones in 2022 and available at the webpage of the Digital National Land Information System: https://nlftp.mlit.go.jp/ksj/ (last accessed on April 22, 2024).

[7]Specifically, the after-typhoon dummy takes one if the date of contract is October 14th, 2019 and beyond, because the typhoon passed over Japan and became an extratropical low on October 13th.

[8]Summary statistics for other categorical variables are also shown in Appendix A.

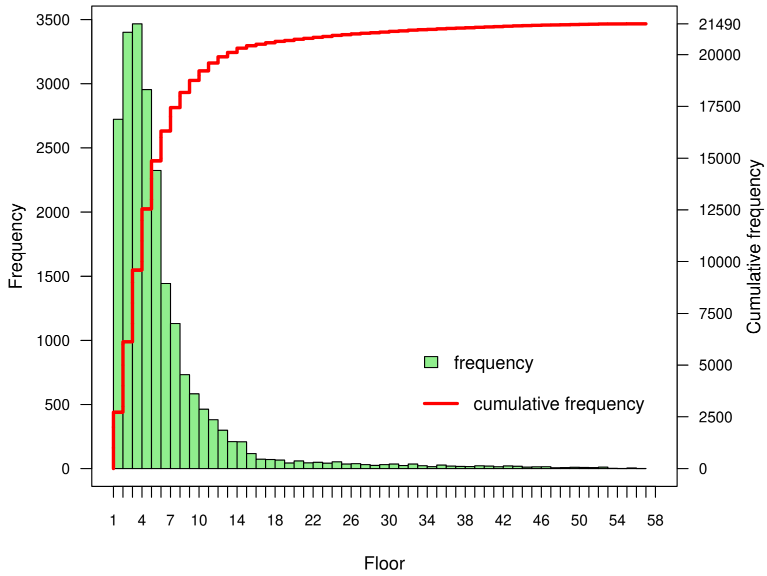


Figure 2: The number of observations for apartments by floor.

Notes: The horizontal axis represents floor. The vertical axis on the left side and green bars show the frequency of each floor, while the vertical axis on the right side and the red line show the cumulative frequency.

As the properties in our sample are located in densely populated areas, we have a rich set of observations for apartments. Figure 2 gives the distribution of floors on which the properties are located, showing that about 40% of the apartments in our sample are located on fifth or higher floors. This enables us to examine whether the impacts of the flooding are different between higher and lower floors.

We also have about six thousand observations for detached houses, although relatively fewer than those for apartments. Thus, it is possible to investigate the difference in the quantitative impacts between apartments and detached houses.

4 Empirical Framework

To examine the impact of the flooding caused by Typhoon Hagibis, we employ the difference-in-differences approach and specify the estimation equation as follows:

$$y_{irt} = \alpha + \beta_1 \times hagibis_i + \beta_2 \times after_t + \gamma \times hagibis_i \times after_t + z_{irt}^{\top}\delta + \mu_r + \tau_t + \varepsilon_{irt}, \quad (1)$$

where y_{irt} is an outcome variable for property i located in municipality r and sold on date t; $hagibis_i$ is a dummy variable that takes one if i is in the area flooded by the typhoon; $after_t$ is a dummy variable that takes one if t is after the typhoon strike; z_{irt} is the vector of control variables; μ_r is the municipality fixed effect; τ_t is the contract year fixed effect; and ε_{irt} is the error term. The coefficient of our focus is γ, which captures the treatment effect.

As the outcomes, we mainly consider three kinds of variables. One is the logarithm of the

Table 2: Baseline results.

	(1) log(contract price)	(2) log(offer price)	(3) discount rate (%)
intercept	18.094***	18.117***	−2.179***
	(0.032)	(0.032)	(0.288)
hagibis × after	−0.066***	−0.061**	−0.471**
	(0.024)	(0.024)	(0.220)
hagibis	0.040	0.036	0.261**
	(0.085)	(0.085)	(0.104)
after	0.011	0.013	−0.211***
	(0.008)	(0.008)	(0.076)
Num.Obs.	23 813	23 813	23 813
R2	0.595	0.590	0.103
R2 Adj.	0.594	0.589	0.101

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. Standard errors in parentheses are clustered in the municipalities.

contract price of a property, which is widely used as an outcome variable in many extant studies with a hedonic approach; another is the logarithm of the offer price that was initially proposed by a seller; and the other is the discount rate. Thus, if we take the contract or offer prices as the outcome variables, the prices of the properties flooded by the typhoon differ by $100 \times (e^{\gamma} - 1)\%$ compared with those outside the flooded areas. On the other hand, if we take the discount rate as the outcome, the discount rates of the properties in the flooded areas differ by γ percentage points compared with those outside the flooded areas. Therefore, if the flooding caused by the typhoon has a negative impact on the properties located within the inundated areas, γ is expected to be significantly negative.

As a baseline analysis, we first estimate (1) using the sample with both apartments and detached houses. In this analysis, we only use control variables available for both apartments and detached houses: walking time to the nearest station, age of structure, building structure, zoning of areas, land right, and current status. In addition to these common covariates, we also include a dummy variable that takes one if the property is a detached house, in order to control the type of a property.

We also estimate (1) using only with the sample for either apartments or detached houses. In the analysis with the sample for apartments, we control exclusive area, floor, and the direction of a balcony, besides the common covariates described above. In the analysis with the sample for detached houses, we control land area, floor-area ratio, width of facing road, the number and directions of sides facing roads, and terrain features, in addition to the common covariates.

Table 3: Effects on apartments.

	(1) log(contract price)	(2) log(offer price)	(3) discount rate (%)
intercept	15.847***	15.855***	−0.708
	(0.073)	(0.060)	(1.678)
hagibis × after	−0.036	−0.032	−0.453**
	(0.027)	(0.026)	(0.210)
hagibis	−0.018	−0.019	0.066
	(0.035)	(0.034)	(0.223)
after	−0.009	−0.004	−0.484***
	(0.006)	(0.006)	(0.045)
Num.Obs.	18 295	18 295	18 295
R2	0.872	0.876	0.098
R2 Adj.	0.871	0.876	0.095

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. Standard errors in parentheses are clustered in the municipalities.

5 Results

We first provide the results for our baseline regression, in which both apartments and detached houses are integrated into a unified sample. In Table 2, the first, second and third columns show the results for the cases where the outcome variables are the log of contract price, the log of offer price, and discount rate, respectively. The estimate of the coefficient of our focus, γ, is reported in the row labeled with "hagibis × after."

In columns (1) and (2), the estimates of γ are −0.066 and −0.061, implying that the contract and offer prices of properties located in the inundated areas declined by about 6.4% and 5.9% on average, respectively. Note that the quantitative impact is larger for the contract prices by about 0.5 percentage points. Consistent with this observation, the regression result shown in column (3) indicates that the discount rates are larger in the flooded areas by about 0.47 percentage points.

These results imply that the flood caused a transfer of bargaining power from sellers to buyers, resulting in larger discount rates in the flooded area. That is, it can be considered that the negative effects of flooding on contract prices are partly attributed to changes in bargaining powers of sellers and buyers.

5.1 Apartments

We next provide the results for analyses only with the sample for apartments. In Table 3, columns (1) and (2) show the results for the cases where the outcome variables are the log of contract price and offer price, respectively. Contrary to the baseline results, we do not find statistically significant impacts on these prices. On the other hand, the effects on discount rate, reported in column (3), are significantly negative, in line with the baseline results.

Table 4: Effects on apartments by floor.

	≥ 5th floor			< 5th floor		
	(1) log(contract price)	(2) log(offer price)	(3) discount rate (%)	(4) log(contract price)	(5) log(offer price)	(6) discount rate (%)
intercept	16.500***	16.554***	−4.572***	15.721***	15.731***	−0.869
	(0.070)	(0.067)	(0.661)	(0.081)	(0.072)	(1.796)
hagibis × after	−0.076***	−0.068***	−0.724**	0.009	0.011	−0.160
	(0.011)	(0.011)	(0.336)	(0.029)	(0.028)	(0.245)
hagibis	0.006	0.004	0.187	−0.037	−0.037	−0.005
	(0.032)	(0.029)	(0.256)	(0.028)	(0.029)	(0.163)
after	−0.010	−0.005	−0.484	−0.003	0.002	−0.478*
	(0.008)	(0.008)	(0.363)	(0.008)	(0.007)	(0.253)
Num.Obs.	7695	7695	7695	10 600	10 600	10 600
R2	0.879	0.883	0.093	0.870	0.874	0.103
R2 Adj.	0.878	0.882	0.087	0.869	0.874	0.099

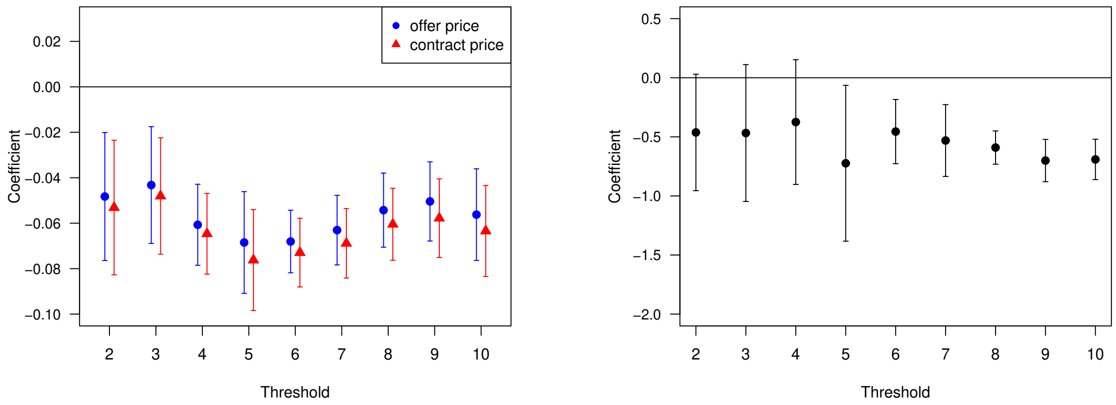
Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. Standard errors in parentheses are clustered in the municipalities.

A possible reason for this mixed observation is that the impact of flooding is different depending on floors on which the properties are located. To confirm this point, we divide the sample into two groups: apartments located on floors lower than fifth (lower-floor group), and ones located on fifth floor or floors higher than fifth (higher-floor group).

The results are shown in Table 4. In columns (1)-(3) and (4)-(6), we report those for higher- and lower-floor groups, respectively. In both groups, the first, second and third columns correspond to the cases where the outcome variables are the log of contract price, the log of offer price, and discount rate, respectively. Focusing on the higher-floor group, we find significantly negative impacts for all outcomes. Columns (1) and (2) indicate that the quantitative impacts on contract and offer prices are, on average, about −7.3% and −6.6%, respectively. In line with these estimates, column (3) reports that the discount rates are larger for properties in the inundated areas by about 0.72 percentage points. Conversely, the results shown in columns (4)-(6) indicate that the flooding had no statistically significant impacts on any outcome for the lower-floor group. From these observations, we can infer that the negative effects are significant for higher floors, whereas insignificant for lower floors.

To look into this point more, we additionally conduct similar analyses by changing the threshold floor. In Figure 3, we plot the estimates of γ obtained by regressions in which the sample is restricted to properties located on relatively higher floors. The horizontal axis represents the threshold floor. For instance, if the value on the horizontal axis is five, it means that the plotted estimate is the one obtained by defining the higher-floor group as properties located on fifth floor or floors higher than fifth. Panel (a) shows the estimates in the cases where the outcomes are the log of contract and offer prices. The estimates are significantly negative for any threshold between two and ten. Panel (b) plots the estimates under taking the discount rate as the outcome variable. We do not find statistical significance when the threshold floors are between two and four. However, if the threshold floor is made higher, the estimates are significantly negative and the 95% confidence interval becomes narrower.

In Figure 4, we plot the estimates of γ obtained by regressions using the sample only with properties located on relatively lower floors. Again, the horizontal axis represents the threshold



(a) Prices

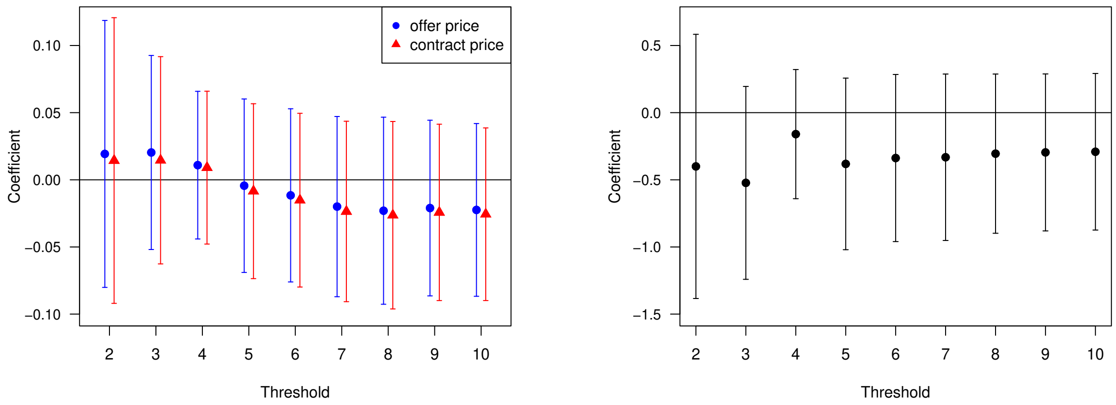
(b) Discount rate

Figure 3: Effects on relatively higher floors.

Notes: The horizontal axis shows the threshold floor. For example, if the value on the horizontal axis is five, the plotted estimates are the ones obtained when we define the higher-floor group as properties located on fifth or higher floors. Panel (a) plots the estimates obtained by taking the log of contract and offer prices as the outcome variables. Panel (b) plots the estimates obtained by taking the discount rate as the outcome variable. The vertical bars extending up and down from each point represent 95% confidence intervals.

floor. For example, if the value on the horizontal axis is four, it means that the plotted estimate is the one obtained by defining the lower-floor group as properties located on fourth floor or floors lower than fourth. Panel (a) shows the estimates in the cases where the outcomes are the log of contract and offer prices, while panel (b) plots the ones obtained by taking the discount rate as the outcome. In both panels, we do not find statistical significance for any threshold between two and ten. Recall that the distribution of floors on which the properties are located is quite right-skewed and about 60% of the sample are located on fourth or lower floors (see Figure 2 in Section 3), implying that the estimation results for the lower-floor group are likely to be driven by the properties on these floors. Thus, the estimates are insignificant even with "high" threshold values, such as nine or ten. In Appendix B.1, we also estimate equation (1) using the sample only with properties located on the first floor. As expected, we do not find statistical significance for the estimate of γ, supporting the robustness of the observation that the flood event had no impact on lower floors.

It might be counter-intuitive that the negative effects are significant for higher floors but insignificant for lower floors, because higher floors seem not to be directly affected by the inundation. However, a remarkable characteristic of the flooding induced by Typhoon Hagibis is that it brought about power and water outages in apartment buildings due to flooding of electric equipment, which is often located on low or underground floors. Because of this, residents in such buildings were forced to live an inconvenient life until recovery, even on higher floors that were not directly damaged by the inundation. Thus, it can be thought that buyers became more aware that not only lower floors but also higher floors are vulnerable to flooding, whereas the risks of lower floors in case of flooding, such as inundation above the floor level, had long been recognized among them. This is why we observe significantly negative effects on higher floors,



(a) Prices

(b) Discount rate

Figure 4: Effects on relatively lower floors.

Notes: The horizontal axis shows the threshold floor. For example, if the value on the horizontal axis is five, the plotted estimates are the ones obtained when we define the lower-floor group as properties located on fifth or lower floors. Panel (a) plots the estimates obtained by taking the log of contract and offer prices as the outcome variables. Panel (b) plots the estimates obtained by taking the discount rate as the outcome variable. The vertical bars extending up and down from each point represent 95% confidence intervals.

while not on lower floors.

As an additional test, Appendix B.2 gives an investigation on how the flood event affected properties located on relatively higher floors in the areas that were not flooded by the typhoon. Specifically, we focus on apartments in the entire area of the nine municipalities mentioned in Section 3, except for the areas flooded by the typhoon, and regard properties located in the expected flooded zones as the treatment group and those located outside the expected flooded zones as the control group. Then, we find negative impacts on the prices of properties located in the expected flooded zones, albeit milder compared with the effects on the properties in the inundated areas. This implies that the flood event also updated buyers' perception of the risk of high floors even outside the inundated areas, resulting in a decline in prices. On the other hand, the impact on discount rates is insignificant, indicating that a transfer of bargaining power from sellers to buyers was specific to the areas that actually experienced the flooding.

5.2 Detached Houses

Table 5 gives the results for regressions with the sample for detached houses. Again, columns (1), (2), and (3) show the results for the cases where the outcome variables are the log of contract price, the log of offer price, and discount rate, respectively. The results indicate that the contract and offer prices of detached houses located in the flooded areas declined by, on average, about 11.0% and 9.7%, respectively, compared with the ones located outside the inundated areas. Consistent with these observations, the discount rates are larger by about 1.2 percentage points in the flooded areas.

Note that the quantitative impacts on detached houses are larger than those on apartments.

Table 5: Effects on detached houses.

	(1) log(contract price)	(2) log(offer price)	(3) discount rate (%)
intercept	17.160***	17.175***	−1.446***
	(0.050)	(0.052)	(0.535)
hagibis × after	−0.116***	−0.102***	−1.224***
	(0.031)	(0.030)	(0.373)
hagibis	0.001	−0.015	1.350***
	(0.039)	(0.037)	(0.332)
after	0.060*	0.054*	0.525*
	(0.031)	(0.030)	(0.301)
Num.Obs.	3135	3135	3135
R2	0.753	0.761	0.170
R2 Adj.	0.749	0.756	0.154

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. Standard errors in parentheses are clustered in the municipalities.

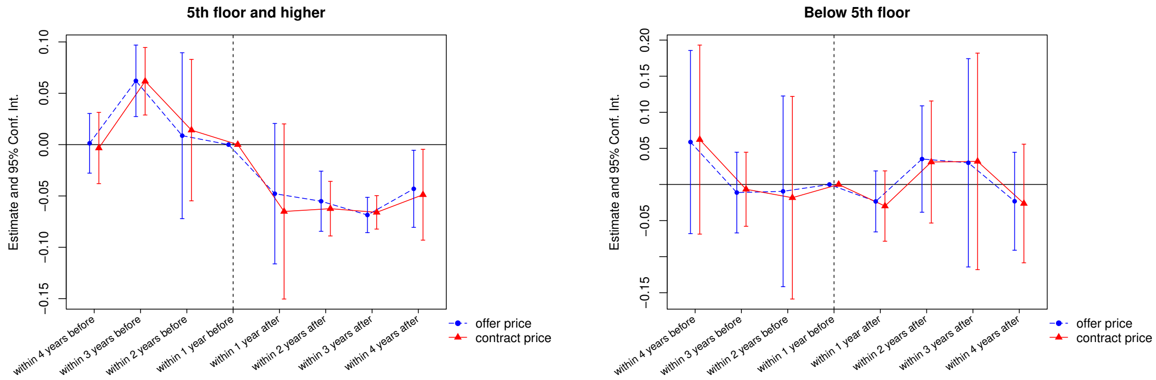
This implies that the negative effects of the flooding are more serious for detached houses than apartments. Different from apartments, most of detached houses are made of wood, more vulnerable to flooding than reinforced concrete or steel.[9] Thus, the damage of flooding is thought to be more serious for detached houses, resulting in the quantitatively larger impacts.

In Appendix B.3, we extend our baseline regression to a triple difference framework and test whether there exists a significant difference in the quantitative impacts on apartments and detached houses. The results show significant differences for prices, although we cannot reject the hypothesis that the effects on discount rates are the same across apartments and detached houses. Thus, it can be considered that the negative impacts of the flooding on detached houses' prices are significantly larger than those on apartments' prices, and the extent to which sellers' bargaining power became weaker is not quite different across apartments and detached houses.

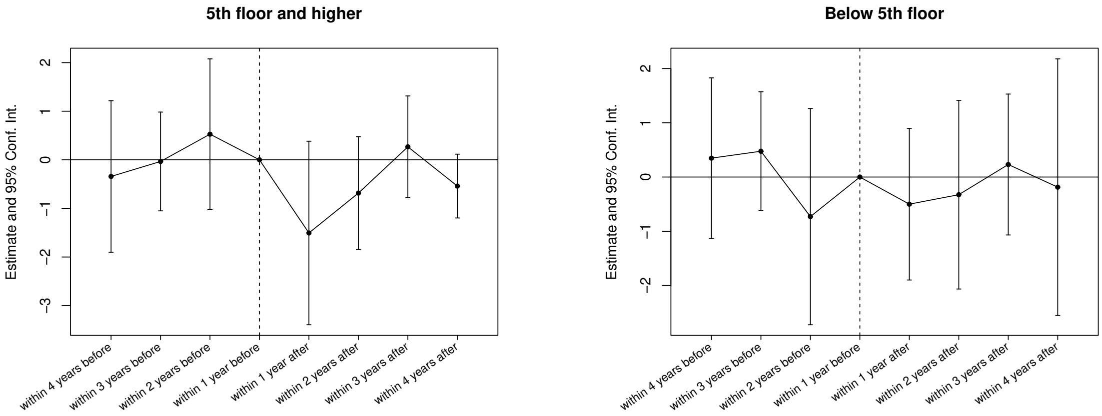
6 Dynamic Effects

Next, we examine the dynamic effects of the flooding, applying the event study design. Let Δ_s^{before} represent the set of dates that are more than $s-1$ years before the typhoon strike but not more than s years before. Similarly, we define Δ_s^{after} as the set of dates that are more than $s-1$ years after the typhoon strike but not more than s years after. Then, we estimate the following

[9]In our sample for detached houses, wooden ones account for about 87%.



(a) Prices



(b) Discount rate

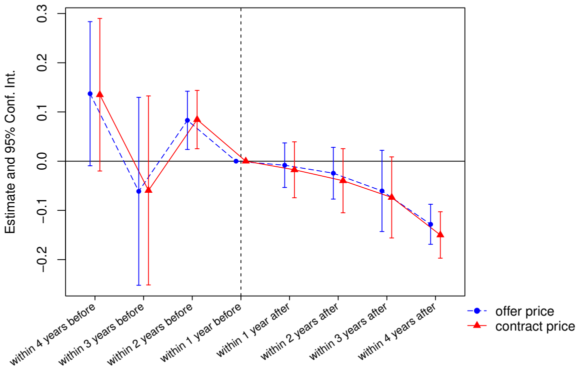
Figure 5: Dynamic effects on apartments.

Notes: In panel (a), we plot the estimates obtained by taking the log of contract and offer prices as the outcome variables, while in panel (b), we plot the estimates obtained by taking the discount rate as the outcome variable. In both panels, the left and right pictures show the estimates for the higher- and lower-floor groups, respectively. The vertical bars extending up and down from each point represent 95% confidence intervals.

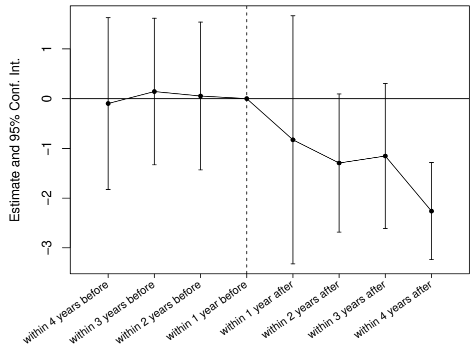
equation:

$$
\begin{aligned}
y_{irt} = \alpha + \beta \times hagibis_i + \sum_{s=2}^{4} \gamma_s^{\text{before}} \times hagibis_i \times \mathbb{1}\{t \in \Delta_s^{\text{before}}\} \\
+ \sum_{s=1}^{4} \gamma_s^{\text{after}} \times hagibis_i \times \mathbb{1}\{t \in \Delta_s^{\text{after}}\} + z_{irt}^{\top}\delta + \mu_r + \tau_t + \varepsilon_{irt},
\end{aligned}
\tag{2}
$$

where $\mathbb{1}\{t \in \Delta_s^{\text{before}}\}$ and $\mathbb{1}\{t \in \Delta_s^{\text{after}}\}$ are the indicator functions that take one if the contract date, t, is in Δ_s^{before} and Δ_s^{after}, respectively, and the definitions of $hagibis_i$, y_{irt}, μ_r, τ_t, z_{irt}, and ε_{irt} are the same as those in Section 4. Here, we do not estimate γ_1^{before} because we take Δ_1^{before} as the base period.



(a) Prices



(b) Discount rate

Figure 6: Dynamic effects on detached houses.

Notes: In panel (a), we plot the estimates obtained by taking the log of contract and offer prices as the outcome variables, while in panel (b), we plot the estimates obtained by taking the discount rate as the outcome variable. The vertical bars extending up and down from each point represent 95% confidence intervals.

6.1 Apartments

As already discussed, the effects on apartments are different depending on floors where the properties are located. Thus, we again divide the sample into two groups: floors below fifth (lower-floor group), and fifth and higher floors (higher-floor group).

The results of estimating (2) with each group's sample are plotted in Figure 5. In panel (a), we show the estimates of γ_s^{before} and γ_s^{after} when we take the log of contract and offer prices as the outcomes. The left and right pictures provide the effects on the higher- and lower-floor groups, respectively. For the higher-floor group, the estimates are significantly negative one year after the typhoon strike. On the other hand, the effects on the lower-floor group are consistently insignificant both before and after the typhoon hit. In panel (b), we plot the results of taking discount rate as the outcome. Again, the left and right pictures show the effects on the higher- and lower-floor groups, respectively. Although the point estimate for the higher-floor group sharply drops immediately after the typhoon strike, the 95% confidence interval is quite wide and we do not find statistical significance. For the lower-floor group, the estimates are consistently close to zero and statistically insignificant.

6.2 Detached Houses

The results of estimating (2) for detached houses are plotted in Figure 6. In panel (a), we show the estimates of γ_s^{before} and γ_s^{after} when the log of contract and offer prices are taken as the outcomes. After the hit of typhoon, the point estimates gradually decline and exhibit statistical significance more than three years after the strike. The effect on discount rate, shown in panel (b), also has a similar trend. Note that the quantitative impacts are larger than those on apartments, consistent with the results from the difference-in-differences analyses. These observations indicate that the negative effects of flooding on detached houses appear more slowly and quantitatively more serious than those on apartments.

The possible reasons for the slow appearance of the effects on detached houses are as follows. First, detached houses have lower liquidity than apartments. In Japan, as pointed out by Ministry of Land, Infrastructure, Transportation and Tourism (2020a), the number of housing starts are larger for detached houses than for apartments, whereas the number of transactions in the existing housing market is larger for apartments, implying higher liquidity of apartments. Second, owners of the damaged houses postponed putting up for sale to restore the parts damaged by the flood. Third, it became difficult for the damaged houses to be sold until the prices are largely discounted, resulting in the longer time-on-market. Unfortunately, it is hard to confirm these two predictions because we do not have the accurate information about the date on which a property was put up for sale and cannot calculate the time-on-market. However, the mechanism described as the third possibility is implied by the results plotted in Figure 6. This explanation is also in line with Merlo and Ortalo-Magné (2004), who showed that the longer a property had been on the market, the larger the discount on it.

7 Concluding Remarks

In the near future, climate change may increase the intensity of hurricanes or typhoons, making more people and properties face the risk of flooding. This would make it more important for both policy makers and developers to assess such a risk adequately, particularly in urban areas with a large population and concentrated economic activities. The present study examined whether properties in densely populated areas reflected the flood risk by analyzing what happened to the real estate market after an actual flood. Specifically, we used as a natural experiment the flooding induced by Typhoon Hagibis, which hit Tokyo metropolitan area in October 2019, and applied the difference-in-differences method to evaluate the impact of flooding on the properties in the inundated areas.

We found that the contract and offer prices of properties located in the flooded areas declined by about 6.4% and 5.9% on average, respectively, compared with those located outside the inundated areas. Consistent with these observations, we also revealed that the discount rates were significantly larger in the flooded areas by about 0.5 percentage points, implying that the bargaining power of buyers became stronger and that of sellers became weaker. That is, the decline in contract prices in the flooded areas can be partly attributed to a transfer of bargaining power from sellers to buyers.

Focusing on transactions of apartments, we showed that the negative impact of flooding was insignificant for lower floors, whereas significant for higher floors. These results indicate that, although the flood risk of properties located on lower floors had already been capitalized into prices even before the flooding occurred, the risk of those located on higher floors was not fully reflected in prices. Thus, it can be thought that buyers became more aware that higher floors are also vulnerable to flooding due to the risks of power and water outages, resulting in the decline in transaction prices. We also examined transactions of detached houses and found that the negative effects on detached houses were quantitatively more serious and appeared more slowly than those on apartments.

Our study can provide implications for both policy makers and developers. Policy makers need to establish a rule such that real estate agents precisely inform buyers of what kind of flood risks the property is subject to and what would happen to the property in case of flooding. In fact, in response to the flood, the Ministry of Land, Infrastructure, Transport and Tourism studied countermeasures and established guidelines for preventing buildings' power supply facilities from flooding (Ministry of Land, Infrastructure, Transportation and Tourism, 2020b). Taking appropriate precautions as pointed out in these guidelines and informing residents beforehand of what to do in case of flooding, developers can enhance the value of apartments that they sell even in areas with flood risks.

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Appendix

A Other Control Variables

A.1 For Both Apartments and Detached Houses

Categorical variables that can be observed for both apartments and detached houses are the following four: building structure, land right, current status, and zoning regulations. The types of zoning districts are defined by the City Planning Act and the details of each district are provided in the Article 9.[A.1] Each category's number of observations that are not missing is shown in Table A.1. For each category, we also report the number of every sub-category's observations.

A.2 Only for Apartments

For apartments, the direction of a balcony is available. If a property's balcony faces multiple directions, only the primary direction is reported. We show the number of each direction's observations in Table A.2.

A.3 Only for Detached Houses

Categorical variables that can be observed only for detached houses are the following three: the condition of sides facing roads, the direction facing a road, and terrain features. The first one contains the information about the number of sides facing a road, and the second one informs us of the direction that faces a road. If a property faces roads in multiple directions, only the primary direction is reported. Each category's number of observations that are not missing is shown in Table A.3. For each category, we also report the number of every sub-category's observations.

[A.1] The English translation of the City Planning Act is available at the following page: https://www.japaneselawtranslation.go.jp/ja/laws/view/3841#je_ch2sc1at5 (last accessed on June 23, 2024).

Table A.1: Categorical variables available for both apartments and detached houses.

Category	N	
building structure	27,425	
reinforced concrete		17,707 (65%)
wooden		5,561 (20%)
steel reinforced concrete		3,403 (12%)
steel		409 (1.5%)
light gauge steel		232 (0.8%)
others		103 (0.4%)
precast concrete		8 (<0.1%)
concrete block		2 (<0.1%)
zoning regulation	25,848	
category 1 medium-to-high-rise exclusive residential districts		4,932 (19%)
category 1 low-rise exclusive residential districts		4,242 (16%)
category 1 residential districts		3,599 (14%)
commercial districts		3,267 (13%)
quasi-industrial districts		3,197 (12%)
neighborhood commercial districts		2,272 (8.8%)
category 2 residential districts		1,541 (6.0%)
industrial districts		1,180 (4.6%)
quasi-residential districts		835 (3.2%)
category 2 medium-to-high-rise exclusive residential districts		649 (2.5%)
category 2 low-rise exclusive residential districts		129 (0.5%)
exclusive industrial districts		4 (<0.1%)
nothing		1 (<0.1%)
land right	27,338	
ownership		26,878 (98%)
old leasehold		299 (1.1%)
fixed-term leasehold		48 (0.2%)
ordinary leasehold		39 (0.1%)
old superficies		38 (0.1%)
fixed-term superficies		30 (0.1%)
ordinary superficies		6 (<0.1%)
current status	27,576	
with residents		13,211 (48%)
vacant		11,775 (43%)
for rent		2,007 (7.3%)
under construction		583 (2.1%)

Notes: For each category, we report the number of observations that are not missing and the number and share of observations for each sub-category.

Table A.2: Categorical variables available only for apartments.

Category	N	
the direction of a balcony	20,398	
south		6,149 (30%)
southwest		3,889 (19%)
southeast		3,399 (17%)
east		2,793 (14%)
west		2,439 (12%)
northeast		672 (3.3%)
northwest		547 (2.7%)
north		510 (2.5%)

Notes: For each category, we report the number of observations that are not missing and the number and share of observations for each sub-category.

Table A.3: Categorical variables available only for detached houses.

Category	N	
the condition of sides facing roads	5,538	
one side		4,570 (83%)
corner		788 (14%)
two sides		159 (2.9%)
three sides		20 (0.4%)
four sides		1 (<0.1%)
the direction facing a road	5,555	
south		963 (17%)
north		946 (17%)
east		805 (14%)
west		784 (14%)
northeast		533 (9.6%)
southwest		527 (9.5%)
southeast		514 (9.3%)
northwest		483 (8.7%)
terrain features	4,246	
flat		4,107 (97%)
hill		84 (2.0%)
slope		30 (0.7%)
tiered		18 (0.4%)
lowland		4 (<0.1%)
others		3 (<0.1%)

Notes: For each category, we report the number of observations that are not missing and the number and share of observations for each sub-category.

Table B.1: Effects on the first floor.

	dependent variable		
	log(contract price)	log(offer price)	discount rate (%)
intercept	15.928***	15.915***	1.433**
	(0.060)	(0.055)	(0.588)
hagibis × after	0.082	0.086	−0.339
	(0.065)	(0.065)	(0.553)
hagibis	−0.109***	−0.112***	0.187
	(0.033)	(0.033)	(0.456)
after	0.013	0.013	0.040
	(0.032)	(0.029)	(0.575)
Num.Obs.	2299	2299	2299
R2	0.863	0.867	0.095
R2 Adj.	0.860	0.864	0.074

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. Standard errors in parentheses are clustered in the municipalities.

B Additional Results

B.1 Effects on Properties Located on the First Floor

We estimate equation (1) using the sample only with apartments located on the first floor.[B.1] The results are shown in Table B.1. The first, second and third columns show the results for the cases where the outcome variables are the log of contract price, the log of offer price, and discount rate, respectively. Focusing on the coefficient of the cross term, we do not find statistical significance for any outcome variable, indicating that the flooding had no impact on apartments located on the first floor.

B.2 Effects on Properties outside the Inundated Areas

We examine how the flood event affected properties located on relatively higher floors in the areas that were not flooded by Typhoon Hagibis. To do so, we focus on apartments in the entire area of the nine municipalities mentioned in Section 3, except for the areas flooded by the typhoon. We regard properties located in the expected flooded zones as the treatment group and those located outside the expected flooded zones as the control group. Then, we employ the difference-in-differences approach and estimate the following equation:

$$y_{irt} = \alpha + \beta_1 \times expected_i + \beta_2 \times after_t + \gamma \times expected_i \times after_t + z_{irt}^{\top}\delta + \mu_r + \tau_t + \varepsilon_{irt}, \quad \text{(B.1)}$$

[B.1] Different from the analyses conducted in the main text, we do not include the floor on which a property is located as a control variable, because we focus only on properties located on the first floor.

Table B.2: Effects on high-floor properties located outside the flooded areas.

	dependent variable		
	log(contract price)	log(offer price)	discount rate (%)
intercept	16.664***	16.689***	−2.319
	(0.111)	(0.088)	(2.670)
expected × after	−0.042**	−0.040*	−0.159
	(0.021)	(0.021)	(0.135)
expected	0.001	0.004	−0.237
	(0.040)	(0.041)	(0.163)
after	0.022	0.026	−0.371
	(0.016)	(0.019)	(0.393)
Num.Obs.	2623	2623	2623
R2	0.865	0.866	0.090
R2 Adj.	0.862	0.863	0.072

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. Standard errors in parentheses are clustered in the municipalities.

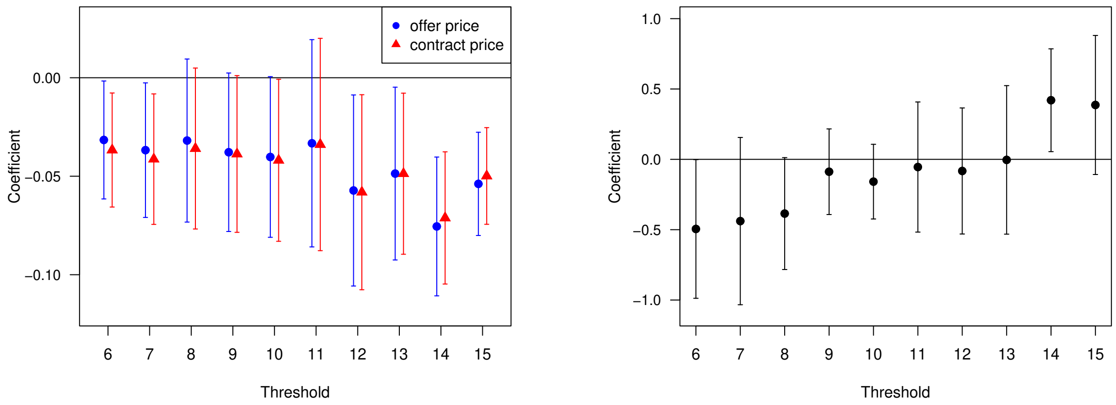
where $expected_i$ is a dummy variable that takes one if i is in the expected flooded zones. Again, the treatment effect is captured by γ.

We estimate equation (B.1) using the sample of apartments located on relatively higher floors.[B.2] Specifically, we focus on the properties located on tenth floor or higher. The estimation results are shown in Table B.2. The first, second and third columns provide the results for the cases where the outcome variables are the log of contract price, the log of offer price, and discount rate, respectively. We find negative impacts on the prices of properties located in the expected flooded zones, although the current sample does not contain the properties located in the areas flooded by the typhoon. The results shown in the first and second columns imply that both contract and offer prices of properties in the expected flooded zones declined by about 4%, compared with those outside the expected flooded zones. Note that the quantitative impacts on the prices of properties in the inundated areas, estimated in the main text, were around 7%. Thus, the negative impacts on higher floors were milder compared with the effects on the properties in the inundated areas. These results suggest a possibility that the flood event also updated the risk perception of buyers even outside the inundated areas, resulting in a decline in prices, albeit milder.

On the other hand, as shown in the third column of Table B.2, we find no significance of the impact on discount rates. This implies that a transfer of bargaining power from sellers to buyers was specific to the areas that actually experienced the flooding.

Although the results in Table B.2 are the ones obtained by defining "high floors" as tenth floor and higher, we can observe similar results even with other threshold floors. In Figure B.1, we plot the estimates of γ obtained by regressions in which the sample is restricted to

[B.2] Control variables are the same as those used in the main analyses.



(a) Prices (b) Discount rate

Figure B.1: Effects on higher floors under various thresholds.

Notes: The horizontal axis shows the threshold floor. For example, if the value on the horizontal axis is ten, the plotted estimates are the ones obtained when we define the higher-floor group as properties located on tenth or higher floors. Panel (a) plots the estimates obtained by taking the log of contract and offer prices as the outcome variables. Panel (b) plots the estimates obtained by taking the discount rate as the outcome variable. The vertical bars extending up and down from each point represent 95% confidence intervals.

properties located on relatively higher floors. The horizontal axis represents the threshold floor. For example, if the value on the horizontal axis is ten, it means that the plotted estimate is the one obtained by defining high floors as tenth floor and higher. Panel (a) shows the estimates in the cases where the outcomes are the log of contract and offer prices. In particular, the negative effects are more significant when the threshold floor is made higher. Panel (b) plots the estimates obtained by taking the discount rate as the outcome variable. In most cases, we do not find statistical significance of the impacts. If any, the significance is weak.

B.3 Triple Differences

To check whether there exists a significant difference between the quantitative impacts on apartments and detached houses, we extend our baseline regression to a triple difference framework. Specifically, we estimate the following equation using the full sample with both apartments and detached houses:

$$\begin{aligned} y_{irt} = {} & \alpha + \beta_1 \times hagibis_i + \beta_2 \times after_t + \beta_3 \times detached_i \\ & + \beta_4 \times hagibis_i \times after_t + \beta_5 \times hagibis_i \times detached_i + \beta_6 \times after_t \times detached_i \\ & + \gamma \times hagibis_i \times after_t \times detached_i + z_{irt}^{\top}\delta + \mu_r + \tau_t + \varepsilon_{irt}, \end{aligned} \tag{B.2}$$

where $detached_i$ is a dummy variable that takes one if i is a detached house. If the sign of γ is estimated to be significantly negative, it means that the quantitative impacts on detached houses are more serious than those on apartments.

The results of estimating equation (B.2) are provided in Table B.3. The first, second and

Table B.3: Difference in the quantitative impacts on apartments and detached houses.

	dependent variable		
	log(contract price)	log(offer price)	discount rate (%)
intercept	17.298***	17.302***	−0.461
	(0.051)	(0.050)	(0.333)
hagibis × after × detached	−0.139***	−0.135**	−0.261
	(0.052)	(0.056)	(0.644)
hagibis × after	−0.040**	−0.036*	−0.440**
	(0.020)	(0.019)	(0.200)
hagibis × detached	0.005	−0.005	0.804
	(0.069)	(0.066)	(0.549)
after × detached	−0.067***	−0.068***	0.007
	(0.005)	(0.005)	(0.089)
hagibis	0.040	0.039	0.120
	(0.095)	(0.094)	(0.170)
after	0.024***	0.026***	−0.209***
	(0.008)	(0.008)	(0.078)
detached	0.826***	0.846***	−1.737***
	(0.035)	(0.036)	(0.274)
Num.Obs.	23 813	23 813	23 813
R2	0.595	0.591	0.103
R2 Adj.	0.594	0.590	0.101

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses are clustered in the municipalities.

third columns show the results for the cases where the outcome variables are the log of contract price, the log of offer price, and discount rate, respectively. In the first and second columns, the estimates of γ are significantly negative, implying that the effects on prices of detached houses are more serious than those on prices of apartments. However, in the third column, we find no significance for the estimate of γ. Therefore, we cannot reject the hypothesis that the effects on discount rates are the same across apartments and detached houses.