The impact of flight noise on urban housing markets: Evidence from the new landing flight paths of Haneda Airport in Japan

Takeru Sugasawa* Yuta Kuroda† Kai Nomura‡ Shohei Yasuda§ Jun Yoshida¶

September 11, 2024

Abstract

The study focuses on the announcement and introduction of the new landing flight paths of Haneda Airport during south wind conditions and examines the impact of the newly generated flight noise on the directly below property markets. The new landing flight paths can be considered as a natural experiment because the flight paths fly straight along the runway extensions over urban areas that did not previously experience flight noise. Our analysis shows the considerably smaller impact of flight noise on housing values than the results suggested by previous studies. Our estimates indicate that a 1dB increase in flight noise decreases property prices directly below the new flight paths by approximately 0.1 percent. Additionally, the average impact of the new flight paths on property rents was either insignificant or negligible. We interpret these findings to mean that in urban areas already experiencing serious noise from other noise sources such as automobiles, the additional impact of flight noise is minimal. Furthermore, three years after the introduction of the new flight paths, the significant impacts on property price had disappeared. A possible explanation is that the progression of population selection in areas exposed to severe aircraft noise gradually increased the region's tolerance to noise over time. Previous studies have mainly focused on suburban areas, and their findings may be insufficient for examining the impact of flight noise in urban environments.

1 Introduction

The transportation of people and goods by airplanes is a crucial factor that influences the economic activities of urban areas. However, it is well-known that airports cause public nuisance such as flight

*Housing Research and Advancement Foundation of Japan. E-mail: sugasawa@hrf.or.jp.
†Osaka Metropolitan University. E-mail: kuroyu0725@gmail.com.
‡Yamanashi Eiwa College. E-mail: k.nomura@yamanashi-eiwa@ac.jp.
§Nihon University. E-mail: yasuda.shohei@nihon-u.ac.jp.
¶Tohoku Gakuin University. E-mail: junyoshida@mail.tohoku-gakuin.ac.jp.

noise pollution. Noise pollution poses health risks, such as headaches, particularly in areas with high aircraft traffic, and its economic impacts are significant (Boes et al., 2013; Beghelli et al., 2023).[1] Economists have analyzed the willingness to pay to avoid exposure to flight noise pollution through changes in housing prices and rents (McMillen, 2004; Pope, 2008; Boes and Nüesch, 2011).

However, there is the possibility that the results of the previous studies include some endogeneity. In concrete, arbitrary selection of flight paths or the issue of sample selection of surrounding residents and properties can introduce endogeneity to estimation results, making it challenging to strictly identify the impact of flight noise on housing transactions. If aircraft chooses paths that minimize the amount of damage from flight noise, the impact of noise occurs in relatively quiet areas and may be overestimated compared to the same level of noise in urban areas with larger noise from other noise sources such as roads with heavy traffic. Additionally, areas surrounding airports or flight paths that experience severe noise may be populated by individuals more tolerant of noise or have a higher concentration of properties with strong soundproofing. Therefore, it is debatable whether the estimation results obtained from such cases are representative of the general impact of aircraft noise.

To address these endogeneity issues and strictly identify the impact of flight noise pollution on urban housing markets, we conduct hedonic approach with focusing on the two new landing paths introduced at Haneda Airport in Japan on March 29, 2020. These two landing paths run straight over the metropolitan area of Tokyo towards the runways, and the areas newly exposed to aircraft noise due to the flight paths can be interpreted as areas that coincidentally lie along the extended paths of the runways. Additionally, the regions newly affected by flight noise due to these two landing paths were previously unaffected by aircraft departing from or arriving at Haneda Airport, thus addressing the potential selection biases of people and buildings adapting to flight noise. Furthermore, the areas directly beneath the landing paths are in the metropolitan area of Tokyo, one of the most developed urban areas in the world, providing an opportunity to examine the impact of flight noise in urban areas where noise pollution is a serious concern. For these reasons, the two landing paths of Haneda Airport serve as an ideal case study to investigate the impact of flight noise on the housing market in urban areas.

The study makes three key contributions. First, as mentioned above, we are the first to investigate the impact of aircraft noise on the peripheral housing market using a natural experiment approach.

[1] There is extensive research in the field of medicine on the impact of noise on human health. High levels of noise can directly increase the risk of hearing loss (Alberti, 1992). Additionally, the stress induced by noise exposure has been reported to elevate health risks for individuals without chronic illnesses (Babisch et al., 2003). These health risks associated with noise can act as a deterrent, and cause people to avoid residing in areas with serious noise exposure.

Our estimation results suggest that the introduction of the new landing flight paths led to a decrease in property prices directly below by approximately 0.10% per 1 dB increase in noise. This coefficient is significantly smaller compared to previous studies that examined the impact of flight noise on housing prices, e.g. approximately 1.7% decreases in housing prices per 1 dB increase in noise found by Winke (2017). Additionally, our analysis did not find significant effects on rental prices directly beneath the new flight paths. This result contrasts with previous research that discovered significant impacts of changes in aircraft noise levels due to variations in flight volume on surrounding housing rents (Boes and Nüesch, 2011). Those results imply that in urban areas already exposed to high noise levels, the additional impact of flight noise might be limited. By using data on automobile noise published by the Ministry of the Environment (ME), we found that the extent of the decline in housing prices decreases approximately by 64% within 50 meters of roads that are sources of high road noise level. These results suggest that the negative externalities of transportation noise may vary between urban and suburban or rural areas. Additionally, our results indicate that properties with lower prices or in older buildings, which are associated with lower soundproofing, experience a greater negative impact from noise exposure. Since living in lower prices or older properties correlate with lower income, the result suggests the presence of income disparities in noise damage within urban areas.

Second, this study compares the impact of flight noise on property sales prices and rents. Our estimation results indicate that while housing prices significantly decreased directly below the new landing flight paths, the impact on property rents is insignificant or negligible. This difference in the impact of noise on sales and rental markets remained robust across various robustness checks. These findings are consistent with previous research that suggests that in the housing market, the living environment is more highly valued in sales transactions than in rental transactions (Caplan et al., 2021; Kuroda and Sugasawa, 2023; Sugasawa et al., 2024). A possible explanation is that in urban areas, rental housing occupants are often young singles, such as university students, who are less likely to be at home during the day when the new flight paths are in use, thereby limiting their exposure to noise. An analysis limited to the subsample of properties with an area of 50 square meters or more revealed a decrease in rents for properties directly below the new flight paths after the flight paths were introduced.

Third, we discuss the progression of selection in population and property characteristics following the introduction of the new landing flight paths. Interestingly, the impact of Haneda Airport's new landing flight paths on property prices directly below the flight paths was no longer statistically significant about two years after the paths were introduced. A possible interpretation is that, following the introduction of the new flight paths, people who are sensitive to noise relocated away from areas directly under the new flight paths. An analysis focusing on different population groups showed that the proportion of the $25 - 34$ years old population with high mobility decreased in areas directly below the flight paths after the introduction. This change might reflect a progression in population selection, where people who are more sensitive to noise move from directly under the flight paths. On the other hand, the characteristics of transacted properties directly below the new landing flight paths were not significantly affected after the flight path's introduction. While previous studies (Boes et al., 2013; Huss et al., 2010; Von Graevenitz, 2018) have shown a bias in population and property characteristics in areas with high noise levels, our analysis suggests that the progression of population selection following the introduction of noise precedes changes in the selection of property characteristics.

The rest of the paper is structured as follows. In Section 2, we review previous studies focusing on the effects of flight noise on property values. Section 3 describes the background about the new flight paths of Haneda Airport. Section 4 outlines this study's empirical design, data sources, and variables. Section 5 shows the main results and robustness checks. Section 6 discusses the factors affecting the impacts of flight noise and generating small magnitudes of our estimation results. Finally, Section 7 concludes the paper.

2 Previous studies

The section overviews previous studies that examine the impact of airport noise on housing values using quasi-experimental methods, with focusing on the endogeneity that may be inherent in their findings. Focusing on quasi-experimental cases, prior research that estimates the impact of aircraft noise on housing values can be categorized into two types. The first type examines the exogenous occurrence, increase, or decrease of airport noise in a specific region (Boes and Nüesch, 2011; Winke, 2017; Zheng et al., 2020). The second type investigates the announcement effects of decisions that introduce additional noise to a region (Jud and Winkler, 2006; Mense and Kholodilin, 2014; Winke, 2017).[2]

[2]In the realm of quasi-natural experiments related to aircraft noise and housing prices, Pope (2008) stands out despite not fitting into the two mentioned categories. Pope (2008) examines the impact of reducing information asymmetry between buyers and sellers by publicizing aircraft noise levels peripheral areas of Raleigh-Durham International Airport. The study finds that making noise levels known led to an additional decrease in the prices of affected houses by up to approximately 2.9%. Pope (2008) provides crucial evidence on how information about flight noise impacts property transactions. However, because our study does not focus on scenarios where supplementary information about existing noise is introduced, we do not directly compare the research design of Pope (2008) with the design of the study.

Studies that examine the impact of changes in airport noise on housing values include Boes and Nüesch (2011), and Zheng et al. (2020). Boes and Nüesch (2011) focused on changes in flight noise at peripheral areas of Zurich Airport, estimating the impact of changes in aircraft noise on property rents. They found that in areas where airport noise increased by more than 3 decibels, rental prices decreased by approximately 0.5% per decibel. In addition, Zheng et al. (2020) investigated the impact of the disappearance of aircraft noise following the relocation of Hong Kong's Kai Tak Airport on peripheral property prices. Their results suggest that the disappearance of airport noise due to the airport's relocation increased property prices around the former airport area approximately by 24.4% on average.

Research examining the impact of announcements related to new noise sources on surrounding housing prices includes Jud and Winkler (2006) and Mense and Kholodilin (2014). Jud and Winkler (2006) investigated the impact of the announcement of an aviation hub in the Greensboro/High Point/Winston-Salem metropolitan area on peripheral property prices. Their findings indicate that the announcement of the aviation hub's construction caused a decrease in property prices by approximately 9.2% within 2.5 miles of the expected site. Mense and Kholodilin (2014) estimated the impact of anticipated changes in noise exposure due to the expansion of Berlin Brandenburg International Airport on housing prices around the expected flight paths. Their results show that the predicted additional noise exposure decreased property prices below the planed flight paths by about 9.6% to 10.2%.

Winke (2017) is recent research focusing on both the announcement effect and actual new noise exposure. Winke (2017) focuses on the construction of a new runway at Frankfurt Airport and the impacts of the events on surrounding property prices. The study found a significant decrease in property prices by about 1.7% per 1 dB of noise exposure. On the other hands, no significant announcement effect was detected. This inconsistency in the results regarding the announcement effects within the quasi-experimental studies highlights a divergence in findings. However, there is a consensus among the previous studies that actual flight noise exposure negatively impacts surrounding property prices and rents.

These prior studies using quasi-natural experimental methods provide valuable insights into the impact of aircraft noise exposure and its announcement on housing transactions. However, a common challenge in these studies is that they do not completely eliminate the issue of endogeneity related to the sample exposed to flight noise.

The endogeneity issues in previous studies can be categorized into two main points. Firstly, the shocks focused by the previous research involve pre-existing variations in flight volumes or the introduction of new flight paths in areas already exposed to flight noise, the possibility of selection based on the existing population composition or property characteristics in response to the noise cannot be excluded. Von Graevenitz (2018) found that properties within 200 meters of major roads tend to be smaller and lower in price compared to other properties. Additionally, these areas have a higher concentration of residents who are students or single households. Boes et al. (2013) indicate that residents might select their locations with consideration for their health conditions when examining the health impacts of aircraft noise on surrounding residents. In addition, since aircraft noise tends to lower property prices, it could attract lower-income households, thereby influencing the demographic characteristics of the area (Hener, 2022). Furthermore, in areas with significant noise, there may be extensive soundproofing installations such as double-glazed windows, leading to property characteristics that differ from those in relatively quieter surrounding areas. The bias arising from these interregional differences in the impact of noise on housing transactions is generally addressed by including regional fixed effects, such as postal codes. However, if the noise present before the change induces selection, causing the impact of noise changes on housing prices to vary, the average estimated results might still contain bias even after considering regional fixed effects. In areas where population and property selection have adapted to pre-existing noise pollution, it is conceivable that these areas might be less affected by additional pollution exposure compared to cases where no such selection has occurred (Greenstone and Gayer, 2009). To address these potential selection biases and examine the impact of aircraft noise on property transactions, it is necessary to focus on cases of new aircraft noise exposure in areas previously not exposed to such noise. To our best knowledge, no prior research has focused on such cases.

The second issue is that the location of aviation hubs or flight paths might be determined in such a way that the noise impact on surrounding areas is minimized. For instance, Winke (2017) treats the additional noise exposure due to the new runway at Frankfurt Airport as an exogenous change of the amount of flight noise. The areas newly exposed to noise levels of 55 decibels or more due to the new flight path are limited to regions outside the city center. Similarly, Boes and Nüesch (2011) and Boes et al. (2013) focused on the changes in noise levels due to alterations in flight volume around Zurich Airport in Switzerland. Still, areas with average daytime noise levels exceeding 50 dB are concentrated in regions far from the city center. If such selection exists in the analyzed cases, the observed treatments cannot be considered as randomly occurring, leading to potential bias in the estimated results. Suburban and rural areas are likely to have fewer alternative noise sources, such as traffic noise and urban hustle, compared to urban areas. Therefore, there is room for doubt regarding the generalizability of findings on the impact of additional noise in such regions (Greenstone and Gayer, 2009). To address this issue, it is necessary to focus on areas where flight paths are determined exogenously and investigate the impact of noise on the region. However, no such studies have been reported to date.

Related to the second problem mentioned above, is the scarcity of studies that identify the impact of additional noise on housing prices and economic activities within urban areas due to the endogenous nature of noise source location selection. Noise is widely discussed as a major urban pollution issue, and accumulating rigorous evidence on the impact of noise on the living environment and economic activities in urban areas is an important topic in urban economics. When additional traffic noise occurs in a city, it is expected that the negative externalities of agglomeration will increase, and selection of population and property characteristics would progress. However, due to the aforementioned reasons, there are no studies examining cases where additional flight noise has exogenously occurred in urban areas.

We address the endogeneity issues that previous studies were unable to resolve due to the limitations of their cases by focusing on the announcement and introduction of the new landing flight paths of Haneda Airport. The new landing flight paths can be interpreted as a case that new flight noise exogenously occurred in a highly developed urban area. The characteristics of the flight paths allow us to investigate the impact of noise on the surrounding environment while overcoming the aforementioned endogeneity issues that prior research could not address.

3 New flight paths of Haneda Airport

Haneda Airport, located in Ota Ward, Tokyo, is the largest airport in Japan, serving approximately 78.7 million passengers in 2023. [3] According to Airports Council International (ACI) , Haneda Airport ranked fifth globally in terms of annual passenger volume in 2023, making it one of the world's busiest airports.[4] Haneda Airport is situated about 15 km southeast of central Tokyo. Tokyo itself is ranked as the fourth most developed city in the world according to the Global Cities Index published by

[3] The breakdown includes 60.8 million domestic passengers and 17.9 million international passengers, respectively.

[4] `https://airportindustry-news.com/aci-world-reveals-top-10-busiest-airports-in-2023/`, retrieved 5 July 2024

Oxford Economics, highlighting Haneda's significant proximity to a major urban area.[5]

Haneda Airport has four runways (Runways A, B, C, and D), and eight runway surfaces are utilized depending on whether it is for takeoff or landing, the wind direction (north or south), and weather conditions. Figure 1 shows the locations of Haneda Airport's runways, runway surfaces, and terminal buildings.

[Figure 1 around here]

Among these, Runway B began operations in March 2000, and no changes in the number of runways have been made since then. On August 8, 2019, there was the announcement about that the new flight paths of Haneda Airport would be introduced on March 29, 2020. Before the new flight paths were implemented, the flight paths either passed over Tokyo Bay or took alternative paths that avoided flying directly over the central Tokyo area. There were no flight paths that passed directly over central Tokyo.

The new flight paths involve six of the eight runway surfaces and is to be used in conjunction with the existing paths. According to the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), this change will allow for an increase of 39,000 international flights annually.

The blue lines of Appendix Figure A1 shows the records of flights using the new landing flight paths of Haneda Airport.[6] Under the new flight paths, the paths for landing on Runways A and C during southerly winds traverse Saitama Prefecture, and then fly directly over central Tokyo to reach the runways during the daytime.[7] These landing paths pass over some of Tokyo's most developed areas, including Minato Ward, Shinagawa Ward, and Shibuya Ward. As mentioned earlier, prior to the implementation of these new paths, no flight paths passed directly over these regions. Therefore, the introduction of the new Haneda Airport paths can be interpreted as introducing new noise exposure to the areas underneath the two southerly landing paths. Additionally, the directness of these new flight paths suggests that the areas experiencing new noise exposure were determined by their alignment with the extended lines of Runways A or C.

From the above, it can be interpreted that the two southerly landing paths of Haneda Airport introduced new aircraft noise exogenously to central Tokyo. Due to the characteristics of the Haneda

[5] `https://www.oxfordeconomics.com/global-cities-index/`, retrieved 5 July 2024

[6] The flight paths was recorded on 28 May 2024, and retrieved on 24 July 2024.

[7] The use of Haneda Airport's new flight path during southerly winds is restricted to the hours between PM 3:00 and PM 7:00.

Airport landing paths, we are able to address the endogeneity issues outlined in Section 2 and examine the impact of aircraft noise on the urban housing market.

4 Study area, data, and empirical strategy

4.1 Study area

To examine the exogenous impact of new flight noise on the housing market directly beneath the new landing paths of Haneda Airport, this study focuses on the areas surrounding the linear part of the flight paths over Tokyo. Specifically, the analysis targets the area from approximately 17 kilometers from Haneda Airport along the new straight flight path to Runway A. The straight part of the flight path for Runway C is longer than that for Runway A; however, to simplify the selection of treatment and control groups, we analyze the area where both flight paths are straight.

Limiting the analysis to the straight flight paths is crucial for the identification strategy, as deviating from the runway's extension could lead to selecting flight paths over areas where the impact of noise on residents' well-being is minimized. While there are other new paths at Haneda Airport besides the two southerly landing paths, these are excluded from this study due to factors such as flying over Tokyo Bay shortly after takeoff or having too few residences directly below them.

The municipalities included in the areas directly beneath the new straight flight paths to the runways in this study are Minato Ward, Shinagawa Ward, Shinjuku Ward, Meguro Ward, Shibuya Ward, and Nakano Ward. These areas are among the most densely populated within Tokyo's 23 wards, allowing for the observation of noise impacts in highly developed urban areas.

4.2 Property transaction data

We adopt property transaction data supplied by the Real Estate Transaction Promotion Center (RETPC), an association of realtors. The RETPC provides Multiple Listing Service (MLS) data set, called as the Real Estate Information Network System (REINS). REINS data contains information of the property transactions recorded by each member real estate agent. This dataset includes both sales and rental transactions of the properties in apartments for residential purposes. Each record in the dataset contains information about the transacted price or rent, transaction date, address, and a range of characteristics of the transacted property and its building, such as room count, floor area, floor level, building age. We convert addresses of apartment buildings into longitude and latitude coordinates, and merge the property data with the other variables based on the location information.

To adjust our estimation period to the timing that the new flight paths of Haneda Airport begun to be used (29 March, 2020), we adopt the properties transacted between 29 March, 2017 and 28 March, 2023. In the period, REINS dataset records approximately 110,000 sales and 680,000 leases property transactions in our study area. We construct our analytical sample by restricting the property transaction records to those properties estimated to experience severe noise pollution from Haneda Airport's new landing paths and those in the surrounding areas.

4.3 Noise data

Detailed distribution data on aircraft noise around Haneda Airport is not publicly available. Therefore, we estimate the noise levels under the new flight paths based on the noise measurement results published by MLIT. For our noise estimation, we use the data from 29 noise measurement devices located within 1 km directly below the straight portions of the new landing flight paths for southward winds. The detailed calculation process and the distribution of the noise measurement devices are described in Appendix A.

As a result of the calculations, it was estimated that the noise exposure levels exceed 70dB, which is the environmental standard for serious daytime noise set by the Tokyo Metropolitan Government, within approximately 10 km from Haneda Airport and within 500 meters of the new flight paths. Properties located within this range are interpreted as the treatment group significantly affected by noise due to the new flight paths of Haneda Airport.

In addition to aircraft noise, road traffic noise and railway noise can also affect property prices (Ossokina and Verweij, 2015; Von Graevenitz, 2018; Diao et al., 2023). Von Graevenitz (2018) examined the impact of road traffic noise on housing prices in Copenhagen, while also considering the levels of aircraft noise and railway noise. We obtained road traffic noise information published by the Ministry of the Environment (ME: 2017, 2018, 2019, 2020, 2021, 2022, and 2023). The road traffic noise data records noise levels at observation points along major roads. We matched emergency transport roads for each year with the nearest noise observation point to create road traffic noise information. Emergency transport roads, designated by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), are key roads comprising major roads such as national roads and roads connecting national roads. Furthermore, we matched each property with the nearest emergency transport road. We use the distance from each property to the nearest major road with recorded noise information as an explaining variable. Additionally, highways might be a significant source of noise pollution. We calculated the straight-line distance from each property to the nearest highway. Unfortunately, we could not obtain noise information related to railways in Tokyo. As an alternative, we calculated the distance from each property to the nearest railway track and used this as a variable.

Since the Ministry of the Environment's road traffic noise information is not recorded for all emergency transport roads, there are properties for which road traffic noise information is missing when matched to the nearest emergency transport road. Considering the potential reduction in sample size, we conduct analyses that both include and exclude noise information other than aircraft noise.

4.4 Other control variables

We control for a variety of characteristics that can affect property values. We referred various government statistics and obtained GIS data regarding the locations of stations, busstops, entrances of highways, urban parks, post offices, hospitals, schools, police stations, fire departments, culture departments (museums and libraries), attraction facilities (sports fields, martial arts facilities, and swimming pools), welfare facilities, general waste disposal sites, industrial waste disposal sites, heliport, the Haneda Airport terminal building, and we calculated the distances from each property to the closest instance of each type of amenity.

4.5 Identification strategy

Our baseline DiD model, constructed based on the hedonic price model (Rosen, 1974), is as follows:

$$\begin{aligned} \ln price_{isymd} = \alpha + \beta AfterNFP_{ymd} + \sum_{b=1}^{3} \gamma_b Distband_{bi} + \sum_{b=1}^{3} \delta_b AfterNFP_{ymd} * Distband_{bi} \\ + \boldsymbol{\phi X_{isym}} + \mu_s + \tau_{ym} + \sigma_{sy} + \epsilon_{isymd}, \end{aligned} \tag{1}$$

where the dependent variable, $\ln price_{isym}$, is the natural logarithm of the nominal price or rent of property i in street (*cho-cho*, called in Japanese) s, transacted on day d month m, year y. $AfterNFP_{ymd}$ indicate property transactions occurring after the commencement of the new flight paths of Haneda Airport on March 29, 2020. The variable takes the value of one for transacted date ymd is after this date. In addition to analyzing the impact of the new paths starting from March 29, 2020, we also estimation treating the announcement date of the new flight paths, August 8, 2019, as the treatment.

For identifying the effect of the announcement, the dummy variable $AfterNFP_{ymd}$ is adjusted to take the value of 1 for transactions made on or after August 8, 2019. Additionally, for this analysis, the sample is restricted to transactions occurring up to March 28, 2020, the day before the new paths were actually implemented.

$Distband_{bi}$ represents that property i is located within the b-th buffer from directly below the new landing flight paths of Haneda Airport. The coefficient γ_b measures the value of locating within the b-th buffer. The cross-term between $AfterNFP_{ymd}$ and $Distband_{bi}$ identify the properties transacted after the new flight paths of Haneda Airport begun to be used by their proximity to the landing flight paths. We interpret δ_b as the treatment effects of new flight paths of Haneda Airport on directly below real estate markets. $\boldsymbol{X_{isym}}$ controls for various characteristics, such as property characteristics, accessibility characteristics. μ_s is the street (*cho-cho*) fixed effects controlling for unobserved and time invariant characteristics, such as the culture and residential environment common to each street. τ_{ym} is the fixed effect of the transacted year and month that controls for property market variations caused by economic tendencies and other events in each year and month. σ_{sy} is the fixed effect controlling for property market variations base on each street in each year. For instance, the impact of COVID-19 epidemic on real estate markets could differ among both of street and year. This specification allows us to estimate the impact of the new flight paths of Haneda Airport within the same street, controlling for property market trends. We estimate model (1) using two separate datasets on sales and rental properties.

To identify the attenuation of noise impact with increasing distance from the new landing flight paths of Haneda Airport, we divide the sample into distance buffers of 500 meters each from the new flight paths. The first distance band is 0-500 meters, the second band is 500-1000 meters, and the third band is 1000-1500 meters. The properties locate within these buffers are used as the treatment group in model (1). The sample is restricted to properties within 5000 meters of the new paths, with those located 1500-5000 meters from the new paths serving as the baseline. Our hypothesis is that the impact of the new flight paths on property prices and rents will be greatest in the buffer closest to the new paths. Figure 2 shows the distribution of our estimation sample and the new landing flight paths of Haneda Airport.

[Figure 2 around here]

In addition to Model 1, we estimate the impact of a 1dB increase in aircraft noise (Lden) on property prices. As discussed in the Appendix Appendix A, since noise monitoring devices are only located directly below the new flight paths, it is not feasible to estimate noise exposure levels for areas outside directly below the flight paths. The estimation model is as follows:

$$\begin{aligned} \ln price_{isymd} &= \alpha + \beta AfterNFP_{ymd} + \sum_{b=1}^{3} \gamma_b Distband_{bi} + \sum_{b=1}^{3} \gamma_b Distband_{bi} * Lden_{iym} \\ &+ \sum_{b=1}^{3} \delta_b AfterNFP_{ymd} * Distband_{bi} * Lden_{iym} + \boldsymbol{\phi X_{isym}} + \mu_s + \tau_{ym} + \sigma_{sy} + \epsilon_{isymd}, \end{aligned} \tag{2}$$

where, $Lden_{iym}$ represents estimated noise level (Lden) that property i exposed in month m, year y.

The top panel of Table 1 describes summary statistics of the variables used in the estimation, and the bottom panel shows statistics for the overall transaction sample before selection. To eliminate outliers from the estimation sample, we exclude properties with prices and rents within the top and bottom 1% of the sample. In the estimation sample, the average property price is JPY 57.0 million (approximately USD 380 thousand, based on an exchange rate of JPY 150/USD 1), and the average monthly property rent is JPY 103.9 thousand (USD 693). Table 1 indicates that the properties in the analytical sample are more upscale compared to the overall sample. This can be interpreted as reflecting that our estimation sample is located in highly developed areas of Tokyo with higher housing demand. In addition, sales properties tend to be superior to rental properties in terms of property characteristics, reflecting the general socioeconomic difference between buyers and renters.[8]

[Table 1 around here]

5 Estimation results

This section presents the primary results on the impact of the announce and the introduction of the new landing flight paths on directly below property price. We begin by presenting the estimation and the interpretation of the baseline model (1) results, followed by introducing alternative estimations that use different samples and variables specifications to ensure the robustness of the findings.

[8]According to Housing and Land Survey (MIC, 2018), property owners generally have higher incomes than property renters in Japan.

5.1 Main results

Table 2 presents the results of DiD estimates for sales properties to observe the effects of beginning to be used and announcement of the new landing flight paths of Haneda Airport.

[Table 2 around here]

Columns (1)-(3) describes the results identifying the effect of new flight paths being used. Before the new flight paths began to be used, there are no statistically significant differences between the treatment and control groups in sales price, supporting the validity of the parallel trend assumption.

In column (1), we observe a decline in prices following that the new landing flight paths of Haneda Airport began to be used with statistical significance. The coefficient shows that the new landing flight paths decrease property price by approximately 4.5% in the directly below housing markets. This reduction equals to JPY 2.57 million (USD 17,100: assuming an exchange rate of JPY 150/USD 1) for a unit with the average price of our estimation sample. Column (2) shows that the new landing flight paths have negative effects on directly below housing price even with controlling for other noise sources. Column (3) describes the effect of the new landing flight paths on property price by per decibel (Lden) level. The estimation result reveals that an increase in 1 dB decreases property price by approximately 0.1% with five percent statistical significance.

Columns (4) and (5) present the estimation results identifying the effects of the announcement of the new flight paths and their commencement date of Haneda Airport. The sample for these estimations is restricted to transactions occurring before the actual commencement of the new flight paths on March 29, 2020. Unlike the results in columns (1)-(3), these results indicate that the announcement of the new flight paths did not significantly decrease housing prices in areas directly under the new flight paths compared to the control group. These findings align more closely with Winke (2017), who suggested that the price declines directly under the new flight paths were caused by the actual occurrence of noise rather than the announcement, in contrast to the results by Mense and Kholodilin (2014), which found that price declines occurred at the time of the announcement.

The decision of the new flight paths for Haneda Airport was under discussion before the announcement of their commencement, suggesting that the selection process may have been ongoing prior to the actual announcement.[9] However, the estimates of the dummy variable representing areas directly

[9]The initial discussion regarding the decision for Haneda Airport's new flight paths was a proposal by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) in June 2014, aimed at enhancing the functionality of airports in the Tokyo metropolitan area.

under the new flight paths described in Columns (4) and (5) ($0 - 500m$ *from new flight paths*) are not significant, indicating no significant price difference between areas directly under the new flight paths and other areas before the announcement. To further observe differences in trends prior to the commencement of the new paths, we present the results of the placebo tests in Table 3.

[Table 3 around here]

Column (1) of Table 3 uses one year before the actual commencement of the new flight paths (March 29, 2019) as the placebo treatment date, while Column (2) uses two years before (March 29, 2018). Each sample includes only properties transacted before the actual commencement of the new flight paths. The results in Columns (1) and (2) of Table 3 both indicate that the placebo tests do not show a significant effect on areas directly under the new fight paths. These results suggest that the price decline observed in areas directly under the new flight paths, as revealed in Columns (1)-(3) of Table 2, was triggered by the actual noise generation after the commencement of the new flight paths. In other words, it can be interpreted that the parallel trends assumption between the treatment group and the control group is satisfied.

We find that property prices significantly declined in regions directly beneath the new flight paths after the commencement of the Haneda Airport new flight paths. However, the magnitude of this decline is substantially lower compared to results from previous studies. For instance, the impact of new flight paths on housing prices in Frankfurt showed a price decrease of 1.7% per 1 dB increase in noise level (Winke, 2017).

5.2 Robustness checks for the main finding

To confirm the robustness of our main results, we conduct additional estimations: (1) using a sample excluding the units with the top 5% and bottom 5% of prices instead of excluding the units with the top 1% and bottom 1%, (2) using a sample excluding the properties in apartments built after the commencement of the new flight paths, (3) using a sample excluding the properties with information showing reformed experience during the study period, (4) using the natural logarithm of per-floor-area price as the explained variable instead of the natural logarithm of price. In addition, we confirm the robustness of our main results for the changes in distance definition of our sample: (5) change the difference buffer defining our treatment groups, (6) using other borders limiting our control group, (7) using subsamples divided by distance from Haneda Airport.

The results for these robustness checks (1)–(4) are described in columns (1)–(4) of Appendix Table A2, respectively. By these estimations, we confirm that our main results remain robust and are unaffected by (1) different trimming levels of sample, (2) the possibility that the sample constructed after the treatment might have adapted to the noise, (3) the possibility that the existing sample might have adapted to the treatment, (4) changes in the form of the dependent variable.

As robustness check (5), we confirm the robustness of our main results by different distance definition of our treatment group and control group. Appendix Table A3 shows the estimation results when varying the buffer distances used to define the treatment group based on the distance from the new landing flight paths. The buffers are set at intervals of 50 meters, ranging from 400 meters to 600 meters, and columns (1)–(5) are numbered with shorter buffer distances defined in order. The buffer for the control group is uniformly set within 5000 meters from the new flight paths. The results of the 500-meter buffer shown in column (3) are the same as those in column (1) of Table 2, which are the main results. The results in Appendix Table A3 consistently indicate a decrease in property prices in the areas directly below the new flight paths after their use began, suggesting that the results described in Table 2 are robust to variations in the buffer distances.

As robustness check (6), we change the distance from the new landing flight paths of Haneda Airport to define the control group. Appendix Table A4 presents the results of the analysis by changing the distance limitations of properties from the new flight paths used in the sample. Columns (1)–(5) use samples divided at intervals of 1000 meters, ranging from 3000 meters to 7000 meters. The estimation for the sample constrained by the 5000-meter distance shown in column (3) corresponds to the estimation results in column (1) of Table 2. From Appendix Table A4, we find that significant property price declines occurred in the areas directly below the new flight paths after their use began. This suggests that our main results are robust to the definition of the control group.

Since the measured noise levels decrease with distance from Haneda Airport in Appendix A, the effect on property prices from the new flight paths is likely to vary based on the distance from the airport. As robustness check (7), Appendix Table A5 presents the results of an analysis using subsamples divided by distance from the airport, ranging from 0m to 6000m, and from 6000m to 14000m in 2000m intervals. The estimation results are consistent with our hypothesis, showing a statistically significant negative impact on property prices in the subsample closest to the airport. In the 6000m-8000m distance bands, the coefficients were negative but not statistically significant. Within 8000m-10000m distance bands, we find the negative effects on directly below property prices with 10% statistical significance, and the coefficient is smaller than one shown in column (1). For the subsample more than 10000m away from Haneda Airport, the coefficients were positive and statistically insignificant. This trend, where the negative impact and statistical significance decrease with increasing distance from the airport, aligns with the trend of noise levels decreasing with distance. The result reinforces our discussion that the observed negative impact is due to noise exposure.

5.3 Property rent

To compare with the results of property sales, we examine the impact of the new landing flight paths on property rent of located directly below the flight paths. For this analysis, we use the same estimation model as Model (1), but replace the dependent variable, the natural logarithm of property prices, with the natural logarithm of rental prices. The results of these estimations are presented in Table 4.

[Table 4 around here]

The estimation results in Table 4, in contrast to the sales results, suggest that the new landing flight paths did not have a significant effect on property rent. In Column (3), there is a significant decline in property rent for properties located within the 1000-1500 meters buffer from the new landing flight paths after the announcement. However, there is no observable trend that rental prices decrease more as properties closer to the new flight paths, which does not align with the hypothesis that anticipated noise exposure from the new flight paths would decrease property rent. Furthermore, the finding that the new flight paths do not affect property rent directly below, remains consistent even when applying the robustness checks used for sales property in Section 5.2 to property rent.[10]

In interpreting the difference between sales and rental results, our findings align with previous research suggesting that home renters value amenities less than homeowners (Caplan et al., 2021). Similarly, empirical studies focusing on the Tokyo metropolitan area have shown that property rents are less sensitive to environmental conditions than property prices (Kuroda and Sugasawa, 2023; Sugasawa et al., 2024). Our findings are consistent with prior research examining differences in amenity valuation between property rents and prices.

Compared to previous research, our findings are not consistent with studies that found significant effects of flight noise level changes on property rents. Boes and Nüesch (2011) focused on the area around Zurich Airport and demonstrated that property rents significantly decreased in areas where

[10]Due to space constraints, the results of the robustness checks on rental prices are omitted but will be made available upon request.

noise levels increased by more than 3dB. Urban areas may have a higher proportion of young single-person households, such as university students, compared to suburban or rural areas. Single-person households are often away from home during the day, making them less likely to be affected by daytime noise exposure compared to family households. To verify this, we divide the sample of rental properties into subsamples based on whether the property is larger than 50 square meters.[11] The results of this analysis are shown in Table 5.

[Table 5 around here]

Column (1) of Table 5 presents the results for rental properties smaller than 50 square meters. The result is consistent with those shown in Table 4, and indicates that aircraft noise does not have a significant effect on rental prices. In contrast, the result in Column (2) reveals that the rent for properties larger than 50 square meters located directly below the new landing flight paths of Haneda Airport significantly decreased after the introduction of the new flight paths. The coefficient suggests that property rents directly below the new flight paths decreased by approximately 3.6%. These findings support our hypothesis that the insignificance of the impact of the new landing flight paths on property rents, as shown in Table 4, may be due to the tendency of single-person households to be away from home during the day. Thus, while rental properties do not show significant effects from the new flight path on average, there is a significant decrease in rents for the subsample likely to be occupied by family households.

We find smaller impact of new noise exposure from the new landing flight paths of Haneda Airport on both property prices and rental prices than that found in previous research. The lower estimated values in our results might be attributable to the average quality of the housing or the surrounding noise levels. This aspect is discussed in more detail in Subsection 6.1.

6 Mechanisms of the effects of the flight noise

The analysis in the preceding section confirmed that the new landing flight paths of Haneda Airport decreases directly below property prices, but the effects are smaller than one shown in the previous studies. In this section, we discuss two potential factors that could help understanding the small

[11] According to the Minimum Housing Standards in the Basic Plan for Housing set by the MLIT (2021), the minimum housing standard for a four-person household is 50 square meters. Therefore, we define properties of 50 square meters or more as those likely to be occupied by family households.

effects: (1) the heterogeneity of the property characteristics and peripheral noise level, (2) observing the effects across time elapsed from the commencement of the new landing flight paths.

6.1 Property characteristics and residential environment

The level of noise exposure experienced by residents can be influenced not only by location but also by the quality of the property and the surrounding environment. We use an interaction term model (DDD model) to examine how heterogeneity in factors such as property quality and the surrounding environment affects the trend of property price decline due to aircraft noise. First, we examine the differences in the impact of flight noise based on property price level. The DDD model used for the estimation is as follows:

$$\begin{aligned}\ln price_{isymd} = \alpha + \beta AfterNFP_{ymd} + \sum_{b=1}^{3}\gamma_b Distband_{bi} + \sum_{b=1}^{3}\delta_b AfterNFP_{ymd} * Distband_{bi} \\ +\zeta Higherprice_i + \eta AfterNFP_{ymd} * Higherprice_i + \sum_{b=1}^{3}\theta_b Distband_{bi} * Higherprice_i \qquad (3) \\ +\sum_{b=1}^{3}\iota_b AfterNFP_{ymd} * Distband_{bi} * Higherprice_i + \boldsymbol{\phi X_{isym}} + \mu_s + \tau_{ym} + \sigma_{sy} + \epsilon_{isymd},\end{aligned}$$

where an explaining variable, $Higherprice_i$ is a dummy variable that becomes one if the transacted property i's price is higher than the median price of our estimation sample. We focus on the coefficient of ι_b and interpret the difference between properties with lower price and ones with higher price in the effects from the new landing flight paths of Haneda Airport.

Table 6 displays the results of DDD estimates for sales properties to observe the difference of the effects of beginning to be used of the new landing flight paths of Haneda Airport between higher and lower price level.

[Table 6 around here]

The results in Table 6 suggest that the average property prices directly below the new flight paths of Haneda Airport have decreased after the commencement of the flight paths. The coefficient indicates a price decline of approximately 6.5%, which is statistically significant at the 1% level. On the other hand, the triple interaction term in Table 6 suggests that properties directly below the new landing flight paths with prices higher than the median experienced a significant increase in prices following the new flight paths begun to be used.

The coefficient indicates that the new landing flight paths decrease housing price approximately by 6.5% in properties with price lower than median. However, we also find the impact is smaller in properties with price higher than median price by about 3.6%, with the difference being around 2.8 percentage points. Taken together, these results indicate that while higher-priced properties also experienced a price drop after the commencement of the new flight paths, however, the impact of this decline was smaller compared to properties priced below the median. A possible interpretation of these findings is that lower-quality properties generally have inferior soundproofing capabilities, making them more susceptible to the impact of new flight noise exposure.

To further examine the variation in the impact of noise exposure on property prices due to property attributes, we focus on the age of the apartment buildings in which the properties are located. For our estimation model, we use the DDD model employed in estimating Model (3) in Table 6. However, instead of a dummy variable that equals one for properties priced above the median, we use a dummy variable that becomes one for properties located in apartment buildings with an age above the sample median. The results of this estimation are presented in Table 7.

[Table 7 around here]

We observe Table 7 and find that significant price decreases due to the new Haneda Airport flight paths occur in properties located in older building apartments. Conversely, the effect of the new flight paths on properties in newer building apartments directly below the flight paths, while having a negative coefficient without statistical significance. The result suggest that the negative impact of noise from the new flight paths primarily affects properties in older building apartments. The consistent findings across Tables 6 and 7 are that attributes indicative of lower property quality increase the impact of noise. In urban areas with higher housing demand and a higher concentration of affluent residents, it is likely that there are more high quality real estates compared to suburban or rural areas, potentially reducing the average impact of noise. Furthermore, these results imply that there may be a severe disparity in noise exposure effects between individuals with higher income and individuals with lower income who may only be able to resident in lower-quality housing.

In addition to property characteristics, other peripheral noise sources can affect noise damage that properties expose from the new flight paths. To examine the point, we focus on the proximity to roads generating traffic noise. We use the traffic noise data linked to emergency transport roads

(Ministry Environment) as used in the main results in columns (2) and (5) in Table 2. For the estimation model, instead of $Higherprice_i$ in model (3), we use a dummy variable that becomes one for properties located within 50 meters of a road where noise levels of 65dB or higher have been observed.[12] Following Von Graevenitz (2018), we limit the sample to properties within 200 meters of roads where noise levels of 65dB or higher have been observed. Table 8 presents the results of this analysis.

[Table 8 around here]

The result in Table 8 indicate that property prices directly below the new landing flight paths decreased after the paths began to be used. According to the coefficient, property prices under the flight paths decreased by approximately 11.6% on average. In contrast, the triple interaction term using the dummy variable for properties located within 50 meters of noise generating roads shows different results. According to its coefficient, properties located within 50 meters of noise generating roads experienced an approximately 7.4% increase in property prices after the new flight paths began, with a 1% statistical significance. The coefficient is smaller than the average price decline (approximately 11.6%) directly below the new flight paths. In summary, properties close to roads already expose to traffic noise experienced a price decline of approximately 4.2% after the new flight paths began, which is smaller than the average price decline.

This result suggests that in areas with existing noise, the additional noise impact from the new flight paths may be reduced. One explanation for the smaller noise impact observed in our results is that urban areas may already have high levels of noise from traffic and commotion, leading to a smaller negative impact from newly introduced noise compared to studies focusing on suburban or rural areas.

6.2 Time elapsed effects

To further investigate the mechanism through which noise affects property prices, we identify the impact of Haneda Airport's new flight paths on property prices on a yearly basis. The estimation model is as follows:

[12] According to Von Graevenitz (2018), the reduction in the level of road noise exposure for residences diminishes with distance. We use properties within 50 meters of the road as the group assumed to be most strongly affected by traffic noise.

$$\ln price_{isymd} = \alpha + \sum_{\substack{t=2017 \\ t\neq 2019}}^{2022} \beta_t YearNFP_t + \sum_{b=1}^{3} \gamma_b Distband_{bi} + \sum_{b=1}^{3} \sum_{\substack{t=2017 \\ t\neq 2019}}^{2022} \delta_{bt} YearNFP_t * Distband_{bi}$$
$$+\boldsymbol{\phi X_{isym}} + \mu_s + \tau_m + \sigma_{sy} + \epsilon_{isymd}, \tag{4}$$

where, $YearNFP_t$ is a dummy variable which becomes one if transacted period of property i is t. t is the year adjusted to the start date of the new flight paths of Haneda Airport, which began on March 29, 2020. For example, $t = 2020$ indicates properties that were transacted between March 29, 2020, and March 28, 2021. Here, one year before the commencement of the new flight paths, $t = 2019$, serves as the reference period. We focus on δ_{bt} to observe the effect of the new flight paths on the property price within distance band b in each year t

Figure 3 shows the evolution of DiD estimates for sales (left panels) and rents (right panels) across time elapsed from the commencement of the new flight paths of Haneda Airport. Figure 3 consists of three rows. The first row shows the results for properties located within 500 meters of Haneda's new flight paths. The second row displays the results for properties located within 500 to 1000 meters. The third row presents the results for properties located within 1000 to 1500 meters. The light blue shading represent the 95% confidence intervals with clustered standard errors at the street (*cho-cho*).

[Figure 3 around here]

Before the commencement of the new flight paths of the Haneda Airport, there are no statistically significant differences between the treatment and control groups in each panel, supporting the validity of the parallel trend assumption. However, post-trendlines represent different patterns for the panels.

In the Figure 3a, we observe a significant decrease in prices after that the new flight paths started to be used. The estimated coefficients indicate that the new landing flight paths cause a reduction of 4.9–5.8% in the property prices located within 500 meters from the flight paths. Interestingly, the trend of price decline continued for only two years and disappeared by 2022. We will use the remaining part of the paper to discuss the factors that caused this price recovery.

Even in the coefficients of property prices, properties located within 500-1000m and 1000-1500m from the new landing paths of Haneda Airport did not show a consistent trend of price decline. Moreover, the panels focusing on rental properties did not indicate any significant changes in property rents following the commencement of the new flight paths. As an exception, properties located 1000-1500m from the new flight paths exhibited a significant price decline as of 2022. However, considering that the buffer is the farthest from the new flight paths within the treatment group, it is unclear whether this is due to the impact of flight noise.

Despite the reduced usage of the new flight paths during the COVID-19 pandemic in 2020 and 2021, we find the significant and strong decline in property prices directly below the new landing flight paths. The result suggests that the impact of aircraft noise exposure on property prices might be primarily influenced by the occurrence of significant noise in the area, while the number of flights might have a limited effect. To verify this possibility, we focus on the difference in flight numbers between the two landing paths of Haneda Airport. Appendix Figure A3 shows the annual landing counts for Runway A and Runway C. The usage of Runway C consistently exceeds that of Runway A in our study period.[13]

We utilize the difference in the usage numbers between two flight paths to examine the impact of flight volume on property prices. The estimation model replaces $Higherprice_i$ in Model (3) with a dummy variable that equals one if the property is closer to the C flight path than to the A flight path. Table 9 describes the estimation results.

[Table 9 around here]

We examine Table 9 and find that the significant price decline due to the introduction of the new flight path of Haneda Airport occurred directly below the new flight paths. However, the triple interaction term indicating the impact of the new flight path under the C flight path did not show statistical significance. These results suggest that the negative noise impact from the new flight paths was not different between the areas below the A and C flight paths, despite the difference in flight numbers. The results of Table 9 support our hypothesis that property prices are significantly impacted by the occurrence of large noise levels in the surrounding area, while the frequency of exposure has a limited effect. From the above discussion, we can interpret that the reduction in flight numbers during the COVID-19 pandemic did not significantly influence the noise impact trends observed in Figure 3.

The new landing flight paths of Haneda Airport are used only during the daytime. This suggests that the impact of noise may be greater for family households, where members are likely to stay at home during the day, compared to single households, where members are more likely to be out working

[13] According to the MLIT, the usage counts for Runway A (Runway C) for the new landing paths were 2,358 (5,168) in 2020, 3,444 (6,770) in 2021, 4,281 (9,482) in 2022, and 6,340 (13,197) in 2023.

during the day. To confirm this, we create subsamples based on whether the property area exceeds 50 square meters and analyzed the effects over time like 5. Although we do not have information on the household characteristics of property purchasers, we alternatively adopt information on property characteristics to discuss the differences in noise response by household type. The estimation result is discussed in Appensix Appendix B.3.

Additionally, we focus on the impact of Haneda Airport's new landing flight paths on the number of property transactions directly below the flight paths. Since the REINS data includes only properties that have been successfully sold, properties that were not transacted due to excessive negative noise impacts are excluded from our sample. This potential exclusion of properties with decreased demand is a common issue in studies using property transaction data. For our analysis, we count the number of transactions by street (*cho-cho*), year adjusted to the start of the new flight paths, and 500-meter bands from the new landing flight paths. The estimation model is as follows:

$$
\begin{aligned}
\ln transactions_{bst} = \alpha + \sum_{\substack{t=2017 \\ t\neq 2019}}^{2022} \beta_t YearNFP_t + \sum_{b=1}^{3} \gamma_b Distband_{bs} \\
+ \sum_{b=1}^{3} \sum_{\substack{t=2017 \\ t\neq 2019}}^{2022} \delta_{bt} YearNFP_t * Distband_{bs} + \mu_s + \epsilon_{bst},
\end{aligned}
\tag{5}
$$

where, $Transactions_{bst}$ represents the number of transactions the area within distance band b from the new landing flight paths of Haneda Airport of street s in period t.

Figure 4 presents the estimation results.

[Figure 4 around here]

From the left panel, we find that in the area directly below the new landing flight paths, the number of transactions significantly decreased immediately after the onset of noise, with this impact gradually recovering over time. In contrast, consistent negative effects on the number of transactions were not observed in areas within 500-1000 meters and 1000-1500 meters from the new flight paths.

Several implications can be drawn from these results. First, the observed decline in property prices directly below the new landing flight paths does not appear to be driven by a supply-side.[14] This suggests that the negative effects on prices in our estimations are driven by a decrease in demand of

[14] For a discussion on the mechanism of property price declines through increased transaction volumes due to external negative impacts on properties, see Bhattacharya et al. (2021).

buyers. Second, there is a possibility that properties significantly impacted by the introduction of the new landing flight paths were excluded from the sample. Our estimation results could underestimate the actual negative impact of the new landing paths of Haneda Airport on sales property transactions.

We find that the significant decrease in the number of transactions was resolved by 2022 like property prices. The result suggests that buyers gradually became less concerned about the noise caused by the new landing flight paths, resulting in the resolution of the price decline trend. The Appendix Figure A5 shows the trend in the number of complaints regarding Haneda Airport's new flight paths, published by MLIT. The figure suggests that the number of complaints about the flight paths decreased over time. This data is consistent with our interpretation that people's awareness of flight noise from the new flight paths diminished over time.

A potential reason for the diminishing impact of the new landing flight path over time could be the progression of selection directly below the flight path. In areas with high noise levels, demographic and property characteristics might adapt to the noise, which could reduce the impact of noise on property transactions over time (Boes et al., 2013; Huss et al., 2010; Von Graevenitz, 2018). In heavily affected areas, it is likely that the population of individuals with not good health conditions that make them more susceptible to noise decreases. However, we have not been able to obtain health data for the region. Instead, we focus on changes in the population ratio within the area. People with high mobility can quickly relocate if they find the noise from Haneda Airport's new flight path undesirable. The Appendix Table A7 shows the 2020 census data, detailing the population in the municipalities within our study area, categorized by five-year age bands and duration of residence at the current address. The table indicates that the highest proportion of individuals with less than five years of residence is found among aged $25-29$ and $29-34$. Based on this, we conduct an analysis using the population ratio of individuals aged $25-34$ as the dependent variable.

We utilized population data from the Basic Resident Register published by each municipality, which includes population figures by street (*cho-cho*) and age group. By aggregating this data, we observed the population in five-year age groups from 2018 to 2023 at an annual level for streets (*cho-cho*) centered within the areas used in our main analysis.[15] We calculated the population ratio for each street by dividing the population aged $25-34$ by the total population of the street (*cho-cho*). The specific estimation model is as follows.

[15]The population statistics for each year record the population as of January 1st. To align with the timing of the new flight path introduction in our main analysis, the statistics recorded on January 1, 2018, are considered as 2017 data. The municipalities included in the analysis are Meguro Ward, Minato Ward, Ota Ward, Setagaya Ward, and Shinagawa Ward.

$$
\begin{aligned}
poprate_{smy} = \alpha + \sum_{\substack{y=2017 \\ y\neq 2019}}^{2022} \beta_y YearNFP_y + \sum_{b=1}^{3} \gamma_b Distband_{bs} \\
+ \sum_{b=1}^{3} \sum_{\substack{y=2017 \\ y\neq 2019}}^{2022} \delta_{by} YearNFP_y * Distband_{bs} + \tau_m + \epsilon_{smy},
\end{aligned} \tag{6}
$$

We use the population ratio of individuals aged $25-34$ in the street s within municipality m for year y as the dependent variable. For comparison, we also use the population ratio of seniors aged 65 and over, who typically have lower mobility. Each street s is classified into a distance band b based on the proximity of its centroid to Haneda Airport. Figure 5 shows the estimation results.

[Figure 5 around here]

The left panel 5a shows that, following the introduction of Haneda Airport's new flight paths, the proportion of the population aged $25-34$ in streets directly under the flight paths began to decline. This decrease in the $25-34$ age group's population ratio gradually became more pronounced, reaching a statistically significant negative value by 2022. This finding suggests that the proportion of the $25-34$ years old population in streets directly below the new flight paths dropped by approximately 1 percentage point. On the other hand, as seen in the right panel 5b, the population aged 65 and over did not experience any statistically significant impact from the new flight paths. We interpret these results as indicative of younger individuals, who are more affected by noise, choosing not to reside in areas directly below the new flight paths. This trend suggests the possibility that areas directly under the new flight paths gradually adapt to the new flight noise as noise-averse individuals move away. The declining public concern regarding noise, as shown in Appendix Figure A5, may reflect the trend of adaptation to noise in the directly affected areas.

Additionally, we estimate the impact of Haneda Airport's new flight paths on the population size and property characteristics (floor area, building age, and floor level of sales properties) of the underlying area. A detailed discussion of the estimation model and results is provided in Appendix C. The estimation results indicate that the introduction of the new landing flight paths of Haneda Airport did not lead to significant changes in the population size or property characteristics transacted in the affected area. These findings have several implications. First, the decline in property prices observed in the main results, as well as the recovery in price levels by 2022, were not driven by changes in population size or property characteristics. Moreover, when new noise disturbances arise, the selection process begins with changes in population composition, which precede changes in property characteristics. Based on these discussions, we conclude that the recovery of property prices under the new flight paths can be attributed to a decline in people's concern about noise due to changes in population composition, and a reduction in noise exposure following the end of the COVID-19 period, when people spent less time at home.

7 Concluding remarks

We examined the impact of the announcement (August 8, 2019) and commencement (March 29, 2020) of Haneda Airport's new landing flight paths on the directly below housing market, using these events as natural experiments. The straight flight paths to the runway allowed us to address the potential endogeneity of arbitrary path deciding and sample selection, thus facilitating robust estimation. Our findings revealed that the commencement of the flight paths led to an approximate 4.5% decrease in the property prices directly underneath the new flight paths. The impact corresponds to a decrease of about 0.1% in property proces per 1 dB (Lden) increase. Additionally, our study found that a decrease in housing prices was more pronounced for lower-priced or older properties. These results suggest that noise impacts are greater for lower-quality properties, highlighting the potential inequality in exposure to noise pollution.

In contrast, the announcement of the new flight paths did not significantly affect property prices, and property rent was unaffected by both the announcement and the commencement. Overall, our estimated results are smaller or negligible compared to those reported in previous studies. One possible interpretation is that the presence of other noise sources in urban areas causes a smaller impact compared to suburban or rural settings. We confirmed that the additional impact of flight noise was reduced in the case of properties exposed to large road noise. If the disadvantages of increased noise in urban areas are smaller than previously thought, the net benefits of expanding transportation infrastructure may need to be revised upwards. More empirical research is needed on the effects of exogenous changes in noise levels in urban areas on surrounding regions.

In addition, we found that the proportion of populations with high mobility characteristics decreased directly under the new flight paths of Haneda Airport. The progression of selection due to changes in demographic composition could potentially lead the area to adapt to the noise, thereby reducing the impact of noise on property prices. On the other hand, the population size and the characteristics of transacted properties were not significantly affected by the introduction of the new flight paths. Changes in demographic composition could potentially influence property prices in the long term through shifts in population size and property characteristics. Therefore, observing the trends in housing markets newly affected by flight paths over a longer period is an intriguing future research direction.

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Figures and Tables

Figures

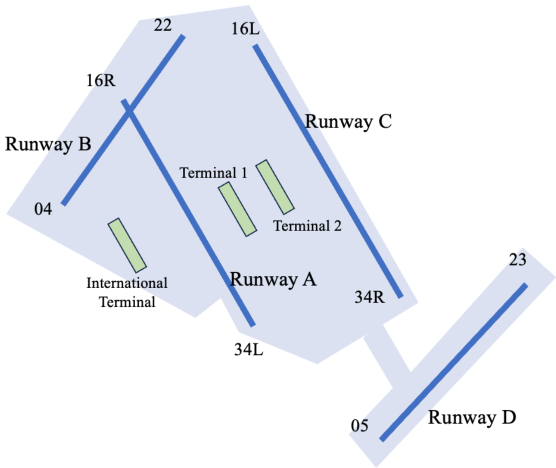


Figure 1: Distribution of runways and terminal buildings of Haneda Airport

Note: The light blue polygon indicates the premises of Haneda Airport. The blue lines represent the runways. The light green rectangles indicate the locations of the terminal buildings. The names of the runway directions are marked at both ends of the runways. The new landing flight path A at Haneda Airport lands on runway 16R, while the new flight path C lands on runway 16L.

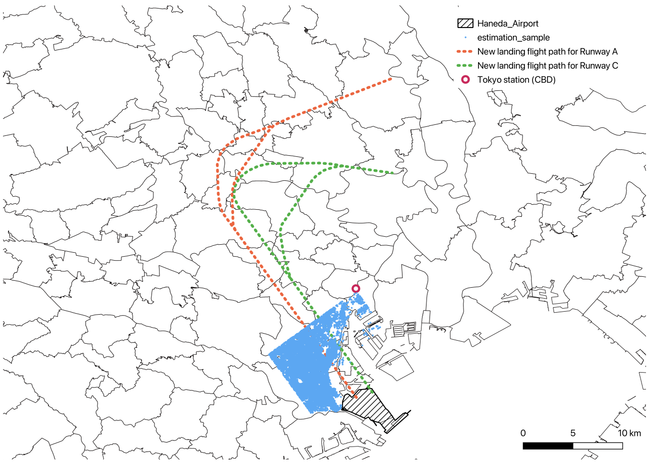
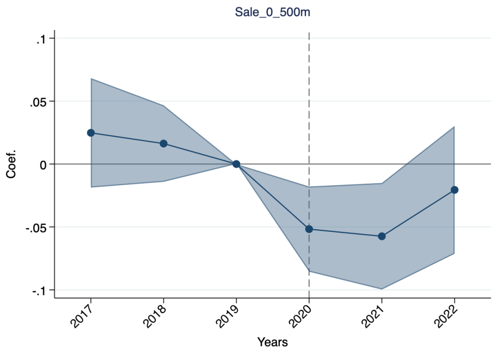
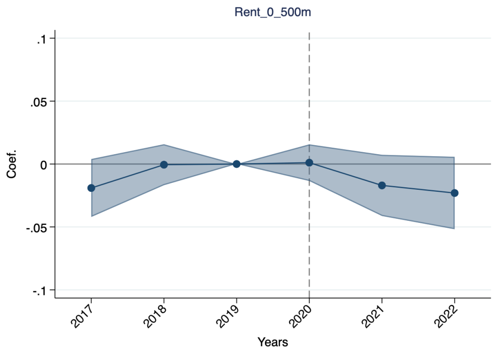


Figure 2: Map of New Landing Paths of Haneda Airport and Properties used in Estimations

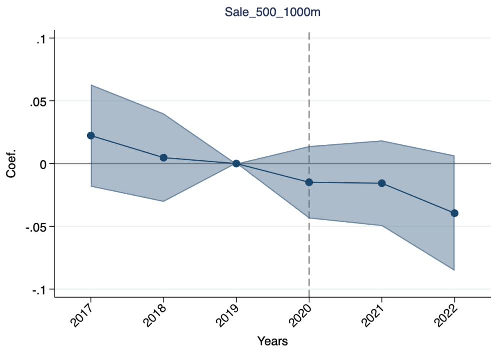
Note: The lines represent the borders of municipalities in the Tokyo Metropolitan Area. The light blue circles show the location of transactions used in our estimation. The orange and light green dashed lines represent Haneda Airport's new landing flight paths A and C, respectively. The purple circle indicates the location of Tokyo Station (CBD).



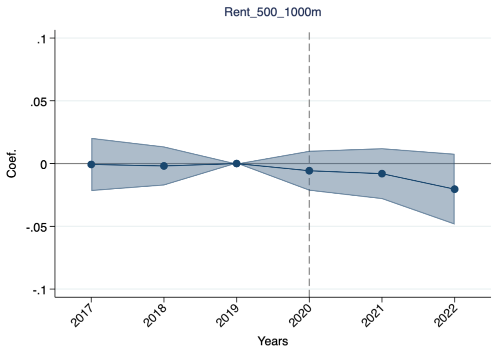
(a) Effect on sale prices



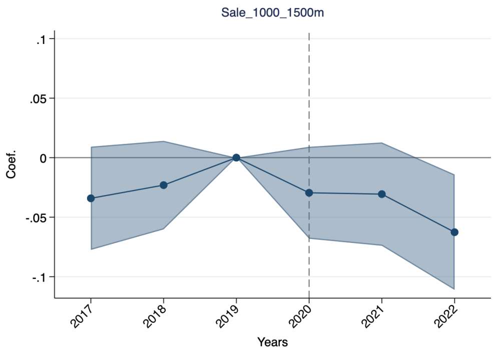
(b) Effect on rents



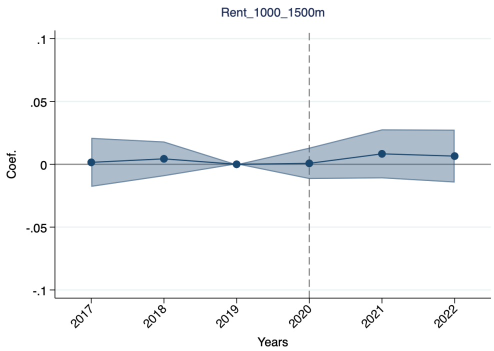
(c) Effect on sale prices



(d) Effect on rents



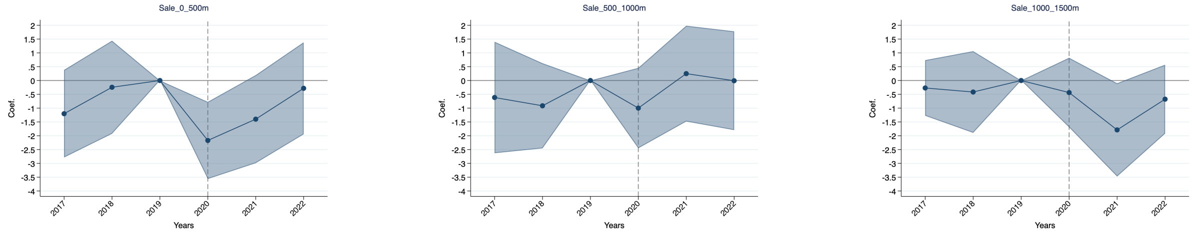
(e) Effect on sale prices



(f) Effect on rents

Figure 3: Time-elapsed effects of the introduction of the new landing flight paths

Note: The left panels show the results for the cases of sales properties, while the right panels present the effects of the new landing flight paths of Haneda Airport on rental property deals. The blue points are the estimated coefficients on the variable cross-term between a dummy variable representing distance bands and a dummy variable identifying properties transacted after the new flight paths started for the housing price/rent. The ribbons are the corresponding 95% confidence intervals. Standard errors are clustered at the street (*cho-cho*) level.



(a) $0-500m$ from the NFP (b) $500-1000m$ from the NFP (c) $1000-1500m$ from the NFP

Figure 4: The effect of the new landing flight paths on the number of sales property transactions

Note: The left panel shows the results for the cases of sales properties within 0-500 meters from the new landing flight paths. Then, the central panel displays the estimation results for the sales properties within 500-1000 meters from the new landing flight paths, while the right panel presents the effects of the new landing flight paths of Haneda Airport on property transactions within 1000-1500 meters. The blue points are the estimated coefficients on the variable cross-term between a dummy variable representing distance bands and a dummy variable identifying properties transacted after the new flight paths started for the number of housing transactions. The ribbons are the corresponding 95% confidence intervals. Standard errors are clustered at the street (*cho-cho*) level.

(a) Population ratio aged $25-34$ (b) Population ratio aged 65 and over

Figure 5: The effect of the new landing flight paths on population composition

Note: The left panel shows the results for the effects of the new landing flight paths on population ratio aged $25-34$ of directly below streets (*cho-cho*). The right panel displays the effects of the new landing flight paths of Haneda Airport on population ratio of individuals aged 65 or over in directly below streets (*cho-cho*). The blue points are the estimated coefficients on the variable cross-term between a dummy variable representing distance bands and a dummy variable identifying streets in each year. The ribbons are the corresponding 95% confidence intervals. To align with the timing of the new flight path introduction in our main analysis, the statistics recorded on 2018 are considered as 2017 data. Standard errors are clustered at the municipality level.

Tables

Table 1: The descriptive statistics

	Sale				Rent			
Sample used in estimations								
	Mean	Std.Dev	Min	Max	Mean	Std.Dev	Min	Max
Property characteristics								
Property price or rent (in 1,000 JPY)	57,032.96	29,305.92	5,300	159,900	103.85	44.99	36	290
# of rooms	1.88	0.81	1	6	1.24	0.50	1	6
Floor area (in m^2)	57.79	20.96	8.86	148.93	31.71	14.26	1.00	145.21
# of stories in the building	18.44	14.42	2	58	6.69	6.54	1	58
Floor level	9.76	9.59	1	58	3.83	3.93	1	53
Age of the building (in month)	219.13	161.53	0	1,034	256.38	164.14	0	1,145
Observations								
# of streets	262				296			
# of properties	15544				90672			
Whole sample in REINS								
	Sale				**Rent**			
	Mean	Std.Dev	Min	Max	Mean	Std.Dev	Min	Max
Property characteristics								
Property price or rent (in 1,000 JPY)	44,546.54	25,865.95	5,300	159,980	90.30	37.83	35	290
# of rooms	2.15	0.89	1	6	1.28	0.55	1	6
Floor area (in m^2)	60.21	20.81	8.66	149.85	31.42	14.23	1.00	150.00
# of stories in the building	12.23	9.66	1	58	5.09	4.27	1	58
Floor level	6.56	6.44	1	58	3.06	2.64	1	54
Age of the building (in month)	246.78	164.99	0	1,066	261.85	166.34	0	1,148
Observations								
# of properties	109646				680010			

Table 2: Main Results

	(1)	(2)	(3)	(4)	(5)
Model:	New flight paths effect			Announcement effect	
Sample:	Transactions for sale				
Dependent variable:	$\ln price$				
After new flight paths started	-0.0089	0.0783**	-0.0095		
	(0.0217)	(0.0381)	(0.0221)		
$0-500m$ from new flight paths	-0.0008	0.0095	-0.0200	0.0088	0.0121
	(0.0443)	(0.0477)	(0.0623)	(0.0515)	(0.0522)
$500-1000m$ from new flight paths	0.0040	0.0010	-0.0128	0.0108	0.0097
	(0.0416)	(0.0426)	(0.0597)	(0.0486)	(0.0467)
$1000-1500m$ from new flight paths	0.0251	0.0187	-0.0112	0.0271	0.0248
	(0.0328)	(0.0348)	(0.0707)	(0.0339)	(0.0373)
$0-500m$ from new flight paths × After new flight paths started	-0.0454***	-0.0893***			
	(0.0157)	(0.0258)			
$500-1000m$ from new flight paths × After new flight paths started	-0.0143	-0.0589***			
	(0.0132)	(0.0226)			
$1000-1500m$ from new flight paths × After new flight paths started	-0.0135	-0.0383			
	(0.0163)	(0.0259)			
Lden level (dB) × $0-500m$ from new flight paths			0.0005		
			(0.0013)		
Lden level (dB) × $500-1000m$ from new flight paths			0.0005		
			(0.0012)		
Lden level (dB) × $1000-1500m$ from new flight paths			0.0011		
			(0.0021)		
Lden level (dB) × After new flight paths started × $0-500m$ from new flight paths			-0.0010**		
			(0.0004)		
Lden level (dB) × After new flight paths started × $500-1000m$ from new flight paths			-0.0004		
			(0.0004)		
Lden level (dB) × After new flight paths started × $1000-1500m$ from new flight paths			-0.0004		
			(0.0005)		
After new flight paths were announced				-0.0505*	-0.0724
				(0.0275)	(0.0492)
$0-500m$ from new flight paths × After new flight paths were announced				-0.0015	-0.0144
				(0.0162)	(0.0263)
$500-1000m$ from new flight paths × After new flight paths were announced				0.0202	0.0106
				(0.0140)	(0.0214)
$1000-1500m$ from new flight paths × After new flight paths were announced				0.0240	-0.0038
				(0.0196)	(0.0357)
Property characteristics control	Y	Y	Y	Y	Y
Distance from amenities control	Y	Y	Y	Y	Y
Other noise information	N	Y	N	N	Y
Floor-plan FE	Y	Y	Y	Y	Y
# of rooms FE	Y	Y	Y	Y	Y
Building construction FE	Y	Y	Y	Y	Y
Located floor FE	Y	Y	Y	Y	Y
# of stories FE	Y	Y	Y	Y	Y
Street FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
Month FE	Y	Y	Y	Y	Y
Street × Year FE	Y	Y	Y	Y	Y
# of observations	15,544	6,752	15,544	7,751	3,609
# of buildings	365	289	365	343	262
Adj R-sq	0.94	0.94	0.94	0.94	0.94

The table shows the coefficients and standard errors of the main estimation results. The sample is limited to the properties transacted between March 29, 2017 and March 28, 2023, and located within 10km from Haneda airport and 5km from the new landing flight paths A and C of Haneda airport. The omitted category regarding the distance from new flight paths represents the properties located within 1.5-5km from the new landing flight paths A or C of Haneda airport. Standard errors clustered at the street (*cho-cho*) level are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 3: Placebo tests

	(1)	(2)
Sample:	Transactions for sale	
Dependent variable:	$\ln price$	
	1 year placebo	2 years placebo
$0-500m$ from new flight paths	0.0144	0.0081
	(0.0510)	(0.0505)
$500-1000m$ from new flight paths	0.0178	0.0181
	(0.0488)	(0.0484)
$1000-1500m$ from new flight paths	0.0214	0.0154
	(0.0345)	(0.0343)
1 year placebo dummy	-0.0541**	
	(0.0237)	
$0-500m$ from new flight paths × 1 year placebo dummy	-0.0133	
	(0.0147)	
$500-1000m$ from new flight paths × 1 year placebo dummy	-0.0020	
	(0.0174)	
$1000-1500m$ from new flight paths × 1 year placebo dummy	0.0353*	
	(0.0201)	
2 years placebo dummy		0.0391*
		(0.0228)
$0-500m$ from new flight paths × 2 years placebo dummy		-0.0108
		(0.0156)
$500-1000m$ from new flight paths × 2 years placebo dummy		-0.0149
		(0.0130)
$1000-1500m$ from new flight paths × 2 years placebo dummy		0.0198
		(0.0189)
Property characteristics control	Y	Y
Distance from amenities control	Y	Y
Other noise information	N	N
Floor-plan FE	Y	Y
# of rooms FE	Y	Y
Building construction FE	Y	Y
Located floor FE	Y	Y
# of stories FE	Y	Y
Street FE	Y	Y
Year FE	Y	Y
Month FE	Y	Y
Street × Year FE	Y	Y
# of observations	7,751	7,751
# of buildings	343	343
Adj R-sq	0.95	0.94

The table shows the coefficients and standard errors of the estimation results considering trends of housing markets before new flight paths of Haneda airport started to be used. The sample is limited to the properties transacted between March 29, 2017 and March 28, 2020. The properties used in the estimations are located within 10km from Haneda airport and 5km from the new landing flight paths A and C of Haneda airport. The omitted category regarding the distance from new landing flight paths represents the properties located within 1.5-5km from the new landing flight paths A or C of Haneda airport. Standard errors clustered at the street (*cho-cho*) level are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Estimations for rental properties

	(1)	(2)	(3)
Model:	New flight paths effect		Announcement effect
Sample:	Transactions for rent		
Dependent variable:	$\ln rent$		
After new flight paths started	-0.0176*	-0.0274*	
	(0.0099)	(0.0147)	
$0-500m$ from new flight paths	0.0145	0.0287	0.0275
	(0.0168)	(0.0224)	(0.0206)
$500-1000m$ from new flight paths	0.0015	0.0092	0.0105
	(0.0130)	(0.0169)	(0.0168)
$1000-1500m$ from new flight paths	-0.0013	0.0060	0.0027
	(0.0122)	(0.0156)	(0.0147)
$0-500m$ from new flight paths × After new flight paths started	-0.0006	0.0067	
	(0.0074)	(0.0138)	
$500-1000m$ from new flight paths × After new flight paths started	-0.0073	-0.0103	
	(0.0090)	(0.0162)	
$1000-1500m$ from new flight paths × After new flight paths started	0.0039	0.0123	
	(0.0085)	(0.0101)	
After new flight paths were announced			0.0001
			(0.0092)
$0-500m$ from new flight paths × After new flight paths were announced			0.0128
			(0.0084)
$500-1000m$ from new flight paths × After new flight paths were announced			0.0005
			(0.0068)
$1000-1500m$ from new flight paths × After new flight paths were announced			-0.0094*
			(0.0057)
Property characteristics control	Y	Y	Y
Distance from amenities control	Y	Y	Y
Other noise information	N	Y	N
Floor-plan FE	Y	Y	Y
# of rooms FE	Y	Y	Y
Building construction FE	Y	Y	Y
Located floor FE	Y	Y	Y
# of stories FE	Y	Y	Y
Street FE	Y	Y	Y
Year FE	Y	Y	Y
Month FE	Y	Y	Y
Street × Year FE	Y	Y	Y
# of observations	90,672	54,767	47,362
# of buildings	412	346	403
Adj R-sq	0.93	0.92	0.93

The table shows the coefficients and standard errors of the estimation results for rental properties. The sample is limited to the properties transacted between March 29, 2017 and March 28, 2023, and located within 10km from Haneda airport and 5km from the new landing flight paths A and C of Haneda airport. The omitted category regarding the distance from new flight paths represents the properties located within 1.5-5km from the new landing flight paths A or C of Haneda airport. Standard errors clustered at the street (*cho-cho*) level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 5: Subsample analyses for rental properties if floor area $< 50m^2$ or not

	(1)	(2)
Sample:	floor area $< 50m^2$	floor area $>= 50m^2$
Dependent variable:	$\ln rent$	
After new flight paths started	-0.0185*	0.0207
	(0.0106)	(0.0239)
$0-500m$ from new flight paths	0.0102	0.0866
	(0.0173)	(0.0603)
$500-1000m$ from new flight paths	-0.0040	0.0179
	(0.0132)	(0.0446)
$1000-1500m$ from new flight paths	-0.0047	0.0166
	(0.0107)	(0.0464)
$0-500m$ from new flight paths × After new flight paths started	-0.0017	-0.0364**
	(0.0074)	(0.0158)
$500-1000m$ from new flight paths × After new flight paths started	-0.0028	-0.0070
	(0.0097)	(0.0120)
$1000-1500m$ from new flight paths × After new flight paths started	0.0037	0.0148
	(0.0075)	(0.0243)
Property characteristics control	Y	Y
Distance from amenities control	Y	Y
Other noise information	N	N
Floor-plan FE	Y	Y
# of rooms FE	Y	Y
Building construction FE	Y	Y
Located floor FE	Y	Y
# of stories FE	Y	Y
Street FE	Y	Y
Year FE	Y	Y
Month FE	Y	Y
Street × Year FE	Y	Y
# of observations	79,813	10,291
# of streets	405	341
Adj R-sq	0.90	0.89

The table shows the coefficients and standard errors of the estimation results for rental properties. The sample is limited to the properties transacted between March 29, 2017 and March 28, 2023, and located within 10km from Haneda airport and 5km from the new landing flight paths A and C of Haneda airport. The omitted category regarding the distance from new flight paths represents the properties located within 1.5-5km from the new landing flight paths A or C of Haneda airport. Standard errors clustered at the street (*cho-cho*) level are in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

Table 6: Cross-term model for different price level

	(1)
Model:	Cross-term
Dependent variable:	$\ln price$
After new flight paths started	-0.0163
	(0.0210)
$0-500m$ from new flight paths	-0.0100
	(0.0450)
$500-1000m$ from new flight paths	0.0045
	(0.0423)
$1000-1500m$ from new flight paths	0.0239
	(0.0360)
$0-500m$ from new flight paths × After new flight paths started	-0.0651***
	(0.0225)
$500-1000m$ from new flight paths × After new flight paths started	-0.0233
	(0.0174)
$1000-1500m$ from new flight paths × After new flight paths started	-0.0306
	(0.0231)
Price higher than median	0.0490***
	(0.0115)
After new flight paths started × Price higher than median	0.0017
	(0.0095)
$0-500m$ from new flight paths × Price higher than median	0.0271
	(0.0191)
$500-1000m$ from new flight paths × Price higher than median	0.0066
	(0.0199)
$1000-1500m$ from new flight paths × Price higher than median	0.0231
	(0.0237)
After new flight paths started × $0-500m$ from new flight paths × Price higher than median	0.0367*
	(0.0213)
After new flight paths started × $500-1000m$ from new flight paths × Price higher than median	0.0184
	(0.0169)
After new flight paths started × $1000-1500m$ from new flight paths × Price higher than median	0.0227
	(0.0233)
Property characteristics control	Y
Distance from amenities control	Y
Other noise information	N
Floor-plan FE	Y
# of rooms FE	Y
Building construction FE	Y
Located floor FE	Y
# of stories FE	Y
Street FE	Y
Year FE	Y
Month FE	Y
Street × Year FE	Y
# of observations	15,544
# of buildings	365
Adj R-sq	0.95

The table shows the coefficients and standard errors of the cross-term estimation results. The sample is limited to the properties transacted between March 29, 2017 and March 28, 2023, and located within 10km from Haneda airport and 5km from the new landing flight paths A and C of Haneda airport. The omitted category regarding the distance from new flight paths represents the properties located within 1.5-5km from the new landing flight paths A or C of Haneda airport. Standard errors clustered at the street (*cho-cho*) level are in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

Table 7: Cross-term model for different building age

	(1)
Model:	Cross-term
Dependent variable:	$\ln price$
After new flight paths started	-0.0230 (0.0216)
$0-500m$ from new flight paths	-0.0111 (0.0445)
$500-1000m$ from new flight paths	-0.0095 (0.0428)
$1000-1500m$ from new flight paths	0.0183 (0.0329)
$0-500m$ from new flight paths × After new flight paths started	-0.0174 (0.0161)
$500-1000m$ from new flight paths × After new flight paths started	-0.0086 (0.0160)
$1000-1500m$ from new flight paths × After new flight paths started	0.0079 (0.0157)
Building age older than median	-0.0311*** (0.0112)
After new flight paths started × Building age older than median	0.0327*** (0.0106)
$0-500m$ from new flight paths × Building age older than median	0.0145 (0.0172)
$500-1000m$ from new flight paths × Building age older than median	0.0191 (0.0167)
$1000-1500m$ from new flight paths × Building age older than median	0.0102 (0.0249)
After new flight paths started × $0-500m$ from new flight paths × Building age older than median	-0.0557*** (0.0192)
After new flight paths started × $500-1000m$ from new flight paths × Building age older than median	-0.0154 (0.0183)
After new flight paths started × $1000-1500m$ from new flight paths × Building age older than median	-0.0347 (0.0250)
Property characteristics control	Y
Distance from amenities control	Y
Other noise information	N
Floor-plan FE	Y
# of rooms FE	Y
Building construction FE	Y
Located floor FE	Y
# of stories FE	Y
Street FE	Y
Year FE	Y
Month FE	Y
Street × Year FE	Y
# of observations	15,544
# of buildings	365
Adj R-sq	0.94

The table shows the coefficients and standard errors of the cross-term estimation results. The sample is limited to the properties transacted between March 29, 2017 and March 28, 2023, and located within 10km from Haneda airport and 5km from the new landing flight paths A and C of Haneda airport. The omitted category regarding the distance from new flight paths represents the properties located within 1.5-5km from the new landing flight paths A or C of Haneda airport. Standard errors clustered at the street (*cho-cho*) level are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 8: Cross-term analysis for proximity to major roads

	(1)
Model:	Cross-term
Dependent variable:	$\ln price$
After new flight paths started	0.0856**
	(0.0387)
$0 - 500m$ from new flight paths	0.0112
	(0.0465)
$500 - 1000m$ from new flight paths	-0.0087
	(0.0412)
$1000 - 1500m$ from new flight paths	0.0212
	(0.0396)
$0 - 500m$ from new flight paths $\times$ After new flight paths started	-0.1155***
	(0.0298)
$500 - 1000m$ from new flight paths $\times$ After new flight paths started	-0.0529**
	(0.0249)
$1000 - 1500m$ from new flight paths $\times$ After new flight paths started	-0.0464
	(0.0291)
$50m$ within the closest road	-0.0308**
	(0.0135)
After new flight paths started $\times$ $50m$ within the closest road	-0.0266
	(0.0173)
$0 - 500m$ from new flight paths $\times$ $50m$ within the closest road	-0.0346
	(0.0287)
$500 - 1000m$ from new flight paths $\times$ $50m$ within the closest road	-0.0219
	(0.0198)
$1000 - 1500m$ from new flight paths $\times$ $50m$ within the closest road	-0.0246
	(0.0285)
After new flight paths started $\times$ $0 - 500m$ from new flight paths $\times$ $50m$ within the closest road	0.0741***
	(0.0264)
After new flight paths started $\times$ $500 - 1000m$ from new flight paths $\times$ $50m$ within the closest road	0.0064
	(0.0285)
After new flight paths started $\times$ $1000 - 1500m$ from new flight paths $\times$ $50m$ within the closest road	0.0208
	(0.0381)
Property characteristics control	Y
Distance from amenities control	Y
Other noise information	Y
Floor-plan FE	Y
# of rooms FE	Y
Building construction FE	Y
Located floor FE	Y
# of stories FE	Y
Street FE	Y
Year FE	Y
Month FE	Y
Street $\times$ Year FE	Y
# of observations	6,752
# of buildings	289
Adj R-sq	0.94

The table shows the coefficients and standard errors of the cross-term estimation results. The sample is limited to the properties transacted between March 29, 2017 and March 28, 2023, and located within 10km from Haneda airport and 5km from the new landing flight paths A and C of Haneda airport. In addition, the estimation use properties located within 200 meters from the closest emergency road. The omitted category regarding the distance from new flight paths represents the properties located within 1.5-5km from the new landing flight paths A or C of Haneda airport. Standard errors clustered at the street (*cho-cho*) level are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 9: Heterogeneity between flight paths A and C

	(1)
Model:	Cross-term
Dependent variable:	$\ln price$
After new flight paths started	-0.0174
	(0.0220)
$0-500m$ from new flight paths	-0.0737
	(0.0666)
$500-1000m$ from new flight paths	-0.0347
	(0.0590)
$1000-1500m$ from new flight paths	0.0354
	(0.0515)
$0-500m$ from new flight paths × After new flight paths started	-0.0562***
	(0.0216)
$500-1000m$ from new flight paths × After new flight paths started	-0.0046
	(0.0136)
$1000-1500m$ from new flight paths × After new flight paths started	-0.0333
	(0.0235)
Flight path C side	-0.1237
	(0.0799)
After new flight paths started × Flight path C side	0.0148
	(0.0193)
$0-500m$ from new flight paths × Flight path C side	0.1248
	(0.0855)
$500-1000m$ from new flight paths × Flight path C side	0.0717
	(0.0769)
$1000-1500m$ from new flight paths × Flight path C side	-0.0192
	(0.0661)
After new flight paths started × $0-500m$ from new flight paths × Flight path C side	0.0147
	(0.0323)
After new flight paths started × $500-1000m$ from new flight paths × Flight path C side	-0.0168
	(0.0253)
After new flight paths started × $1000-1500m$ from new flight paths × Flight path C side	0.0392
	(0.0342)
Property characteristics control	Y
Distance from amenities control	Y
Other noise information	N
Floor-plan FE	Y
# of rooms FE	Y
Building construction FE	Y
Located floor FE	Y
# of stories FE	Y
Street FE	Y
Year FE	Y
Month FE	Y
Street × Year FE	Y
# of observations	15,544
# of buildings	365
Adj R-sq	0.94

The table shows the coefficients and standard errors of the cross-term estimation results. The sample is limited to the properties transacted between March 29, 2017 and March 28, 2023, and located within 10km from Haneda airport and 5km from the new landing flight paths A and C of Haneda airport. The omitted category regarding the distance from new flight paths represents the properties located within 1.5-5km from the new landing flight paths A or C of Haneda airport. Standard errors clustered at the street (*cho-cho*) level are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Appendix A Noise data construction

We use noise data recorded and published by national and regional noise measuring devices to estimate the amount of aircraft noise exposure for each property. Two indicators are used for noise: the monthly average noise level caused by the new landing flight paths of Haneda Airport, and Lden which weights the noise level according to the time of day when it occurs. The monthly average noise level is used to identify areas where significant noise is considered to have been generated by the new flight paths of Haneda Airport.[A1] Lden is often adopted in previous studies to calculate changes in property values per dB, and we use the indicator to compare our estimation results with previous studies.

We limit the analysis to noise measuring instruments located within 20 km of Haneda Airport and within 1 km of the new landing flight paths to estimate the impact of the distance from Haneda Airport and the new landing flight paths on observed noise. The reason for setting the distance within 20 km from Haneda Airport is to ensure a sufficient sample size. There were 29 noise measuring instruments recording average noise and 14 instruments recording Lden within this range. Appendix Figure A2 shows the locations of noise measuring instruments recording average noise and those recording Lden, respectively.

[Appendix Figure A2 around here]

The estimation model is as follows:

$$\begin{aligned} Noise_{jym} = \alpha + \beta DistanceHaneda_j + \gamma Aside_j + \delta DistanceNFPA_j * Aside_j \\ + \phi DistanceNFPC_j * Cside_j + \tau_y + \sigma_m + \epsilon_{jym}, \end{aligned} \tag{A1}$$

where, $Noise_{jym}$ represents noise level measured by device j in year y and month m. $Aside_j$ is a dummy variable which equals to one if the noise measurement device j is closer to the new landing flight path to Runway A than the path to Runway C. $DistanceNFPA_j$ ($DistanceNFPC_j$) is the variable showing distance to the new flight path A (C) from the noise measurement device j.

Appendix Table A1 shows the estimation results. We find that an increase in the distance both from Haneda Airport and from the new landing flight paths decreases noise level with statistical significance. According to the estimation results (1), the estimated noise level is approximately 70 dB

[A1] There are noise measuring devices that publish average noise levels on a monthly basis and others that publish on a daily basis. To standardize the indicators, we average the daily noise levels published to a monthly level.

at a distance of around 10 km from Haneda Airport. Since 70 dB is the standard of daytime noise pollution specified by the Tokyo Metropolitan Government, we consider properties within 10 km of Haneda Airport as the treatment group affected by the noise from the new landing flight paths. The impact on samples located more than 10 km away from the airport will be examined in Appendix Table A5.

Appendix B Supplement for the analyses

Appendix B.1 Robustness checks for the main analysis

Appendix Tables A2-A5 represent the results for the robustness checks for the main results.

[Appendix Tables A2-A5 around here]

Section 5.2 considers eight robustness checks (1)–(7) conducted in this appendix. Robustness checks (1)–(4) corresponds to Columns (1)–(4) of Appendix Table A2, (5) to Appendix Table A3, (6) to Appendix Table A4, and (7) to Appendix Table A5.

Appendix B.2 Full result for analysis focusing on the time elapsed effect

Appendix Table A6 shows the full results for the estimations shown in Figure 3.

Appendix B.3 Subsample analysis for sales property if floor area $< 50m^2$ or not

Appendix Figure A4 shows the results of the subsample analysis.

[Appendix Figure A4 around here]

The left panel of Appendix Figure A4 indicates that the new landing flight paths did not have a significant impact on the prices of properties under 50 square meters. In contrast, the right panel shows that the negative impact of the new landing flight paths increases for properties with floor area 50 square meters or larger. These results are consistent with our hypothesis that flight noise effects are greater for larger properties and the result shown in 5.

It was also confirmed in Appendix Figure A4 that the significant negative impact of noise was not observed in 2022. The increase in home-based work due to COVID-19 may have increased home-stay time and, consequently, the impact of daytime noise exposure, even for single-person households. However, the left panel of Appendix Figure A4 does not show a significant price decline trend for smaller properties. A possible explanation for this is the existence of investment behavior where properties are purchased but not inhabited. If there are owners who purchase small properties anticipating future price increases but do not live in them, the impact of noise on property prices may be limited. Since we cannot observe the purpose of property transactions or the actual residence status after the transaction, the extent to which amenity evaluations are considered in investment property transactions remains a subject for future research.

Appendix C Analyses of population size and property characteristics

The appendix discusses the impact of the new landing flight paths on population size and property characteristics of directly below areas. At first, we focus on the population size. For the estimation, we use Model (6), but replace the dependent variable with the natural logarithm of population of each street (*cho-cho*).

Appendix Figure A6 represents the estimation result.

[Appendix Figure A6 around here]

We find that population of the directly below area of the new landing flight paths was not received significant effects after the introduction of the new flight paths. The result means that the new landing flight paths do not significantly increase or decrease population size of directly below streets (*cho-cho*).

Next, we analyze property characteristics as the dependent variables. The estimation model is as follows:

$$\begin{aligned}\ln characteristics_{isymd} &= \alpha + \sum_{\substack{t=2017\\t\neq 2019}}^{2022} \beta_t YearNFP_t + \sum_{b=1}^{3} \gamma_b Distband_{bi} \\ &+ \sum_{b=1}^{3} \sum_{\substack{t=2017\\t\neq 2019}}^{2022} \delta_{bt} YearNFP_t * Distband_{bi} + \mu_s + \tau_m + \sigma_{sy} + \epsilon_{isymd}.\end{aligned} \tag{A2}$$

As dependent variables, we use the natural logarithm of floor area (m^2), building age (year), and floor level of property i.

Appendix Figure A7 shows the estimation results.

[Appendix Figure A7 around here]

The result shows that there were no significant changes in the characteristics of properties transacted directly below the new Haneda Airport flight paths after the flight paths began to be used.

These findings suggest that the observed decrease and subsequent recovery in property prices below the new landing flight paths were not driven by changes in the population size and the property characteristics.

Appendix figures and tables

Appendix figures

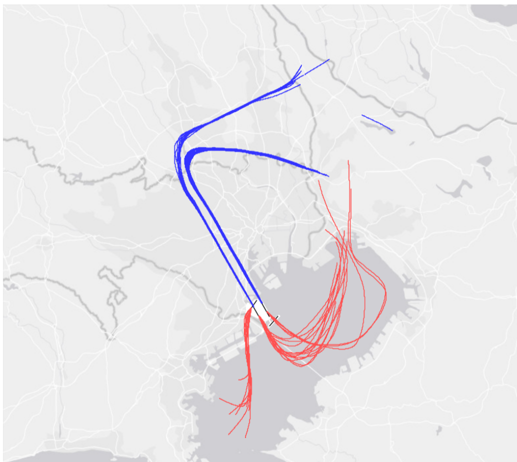
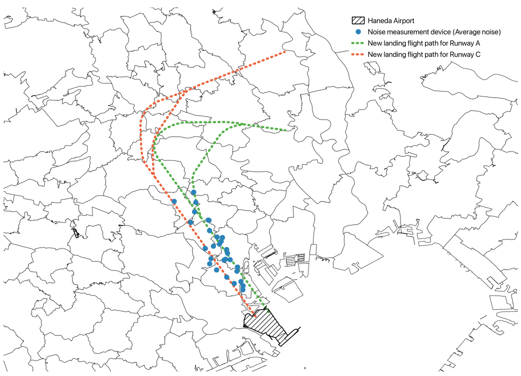
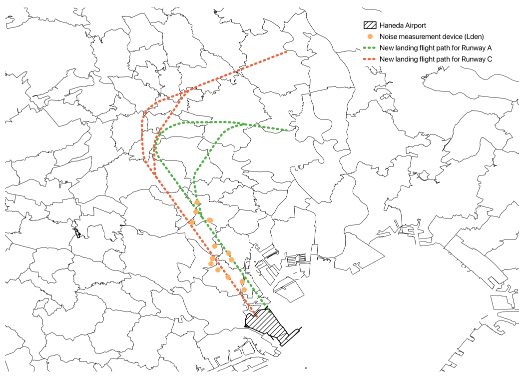


Figure A1: Flight record for new landing flight paths of Haneda Airport

Note: This figure is a flight path map for Haneda Airport's new flight paths during southern winds, as published by MLIT from `https://www.ntrack.mlit.go.jp/plane/track.html`. We obtained the flight path map from May 28, 2024, on July 24, 2024. The blue lines indicate the new landing flight paths, which are the focus of this study. The red lines indicate the new departure flight paths.



(a) Noise measurement devices for average noise



(b) Noise measurement devices for Lden

Figure A2: The distribution of noise measurement devices

Note: The lines represent the borders of municipalities in the Tokyo Metropolitan Area. The blue circles of the left panel show the location of noise measurement devices recording monthly or daily noise level of the new landing flight paths of Haneda Airport. The orange circles of the right panel show the location of noise measurement devices recording monthly Lden noise level. The orange and light green dashed lines represent Haneda Airport's new landing flight paths A and C, respectively.

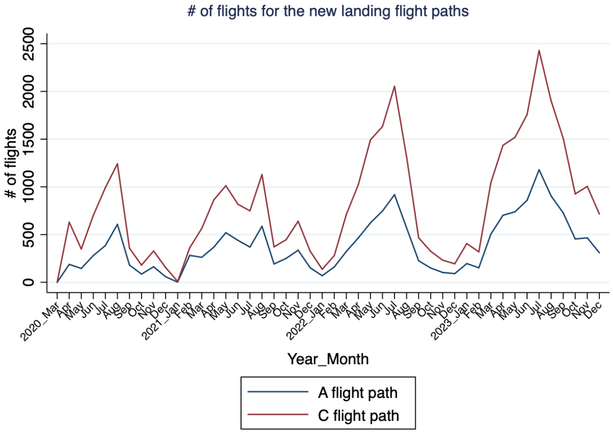
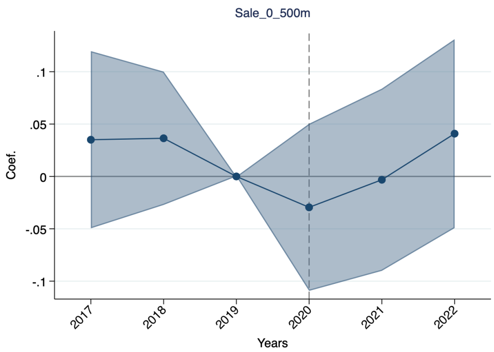


Figure A3: The numbers of flights for the landing flight paths A and C

Note: The blue and red lines respectively represent the monthly count of flights that used Haneda Airport's new landing flight paths, landing on runway A and runway C.



(a) Floor area $< 50m^2$

(b) Floor area $>= 50m^2$

Figure A4: Subsample analysis identifying if floor area $>= 50m^2$ or not

Note: The left panel shows the results for the cases of sales properties with floor area under 50 square meters, while the right panel presents the effects of the new landing flight paths of Haneda Airport on sales properties equal or larger than 50 square meters. The blue points are the estimated coefficients on the variable cross-term between a dummy variable representing distance bands and a dummy variable identifying each year for the housing price/rent. The ribbons are the corresponding 95% confidence intervals. Standard errors are clustered at the street (*cho-cho*) level.

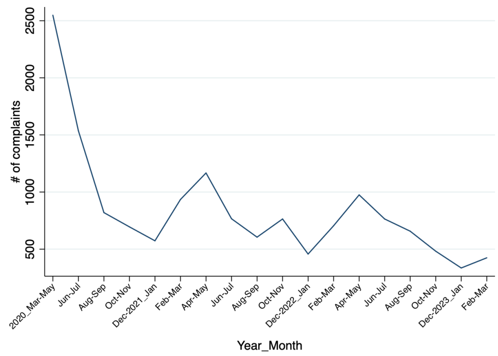
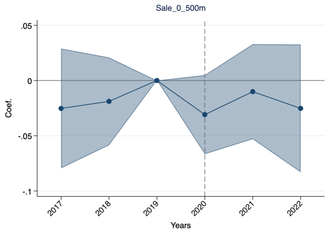


Figure A5: The number of complaints for the new flight paths of Haneda Airport

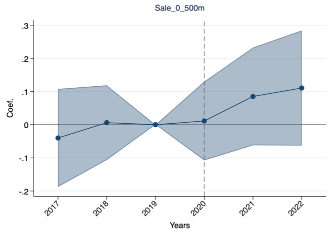
Note: The line represents the number of complaints related to Haneda Airport's new flight paths, as published by MLIT, aggregated every two months. Complaints for March 2020 are combined with those for April and May because the count for March only includes complaints from after the 29th.

Figure A6: The effect of the new landing flight paths on population size

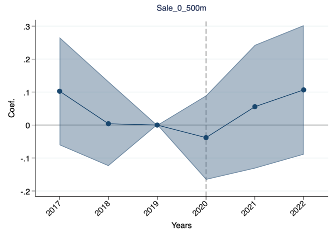
Note: The panel shows the results for the effects of the new landing flight paths on the logarithmic population of directly below streets (*cho-cho*). The blue points are the estimated coefficients on the variable cross-term between a dummy variable representing distance bands and a dummy variable identifying streets in each year. The ribbons are the corresponding 95% confidence intervals. To align with the timing of the new flight path introduction in our main analysis, the statistics recorded on 2018 are considered as 2017 data. Standard errors are clustered at the municipality level.



(a) $ln(floorarea)$



(b) $ln(buildingage)$



(c) $ln(floorlevel)$

Figure A7: The effect of the new landing flight paths on property characteristics

Note: The left panel shows the results for the effects of the new landing flight paths on floor area of directly below sales properties. The central panel is the estimation results for the building age of the sales properties. The right panel displays the effects of the new landing flight paths of Haneda Airport on floor level of sales properties. Each explained variable is logarithmically transformed. The blue points are the estimated coefficients on the variable cross-term between a dummy variable representing distance bands and a dummy variable identifying properties transacted in each year for the property characteristics. The ribbons are the corresponding 95% confidence intervals. Standard errors are clustered at the street (*cho-cho*) level.

Appendix tables

Table A1: Estimation for noise level

	(1)	(2)
Dependent variable:	Average noise (dB)	Lden (dB)
Distance from the Haneda airport terminal building	-0.0005***	-0.0004***
	(0.0000)	(0.0000)
Flight path A side	-1.2457***	0.9493**
	(0.1797)	(0.4778)
Distance from the landing flight path A × Flight path A side	-0.0061***	-0.0057***
	(0.0002)	(0.0006)
Distance from the landing flight path C × Flight path C side	-0.0094***	-0.0090***
	(0.0004)	(0.0009)
transacted year=2021	-0.2534*	1.2446***
	(0.1417)	(0.4032)
transacted year=2022	-0.0574	1.8606***
	(0.1418)	(0.4026)
transacted year=2023	0.3664***	5.1672***
	(0.1417)	(0.4086)
transacted year=2024	0.7283*	
	(0.3963)	
transacted month=2	0.0159	6.8000***
	(0.2672)	(0.7763)
transacted month=3	0.1884	9.7845***
	(0.2509)	(0.7596)
transacted month=4	0.1391	11.1842***
	(0.2516)	(0.7260)
transacted month=5	0.0475	11.3149***
	(0.2503)	(0.7172)
transacted month=6	-0.1116	11.4252***
	(0.2508)	(0.7213)
transacted month=7	-0.1500	12.0366***
	(0.2517)	(0.7004)
transacted month=8	-0.0630	10.4082***
	(0.2513)	(0.6756)
transacted month=9	-0.0619	8.4633***
	(0.2503)	(0.7172)
transacted month=10	-0.0174	7.6977***
	(0.2517)	(0.7098)
transacted month=11	0.1998	8.7854***
	(0.2508)	(0.7213)
transacted month=12	0.0267	6.4015***
	(0.2512)	(0.6802)
# of observations	1,330	372
Adj R-sq	0.68	0.71

The table shows the coefficients and standard errors of the results of estimation for noise level directly below areas of the new landing flight paths. Standard errors clustered at the building level are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table A2: Results of Robustness Checks

	(1)	(2)	(3)	(4)
Sample:	Transactions for sale			
Dependent variable:	$\ln price$	$\ln price$	$\ln price$	$\ln price/m^2$
	ul95	Exclude built after NFP	Exclude reformed units	
After new flight paths started	-0.0154	-0.0091	-0.0055	-0.0214
	(0.0221)	(0.0217)	(0.0221)	(0.0210)
$0-500m$ from new flight paths	0.0099	0.0022	-0.0029	-0.0136
	(0.0386)	(0.0445)	(0.0447)	(0.0308)
$500-1000m$ from new flight paths	0.0163	0.0074	0.0035	-0.0084
	(0.0345)	(0.0417)	(0.0416)	(0.0282)
$1000-1500m$ from new flight paths	0.0098	0.0261	0.0238	0.0024
	(0.0262)	(0.0327)	(0.0333)	(0.0204)
$0-500m$ from new flight paths × After new flight paths started	-0.0269*	-0.0452***	-0.0509***	-0.0327**
	(0.0157)	(0.0157)	(0.0160)	(0.0138)
$500-1000m$ from new flight paths × After new flight paths started	-0.0058	-0.0136	-0.0201	-0.0071
	(0.0131)	(0.0131)	(0.0132)	(0.0113)
$1000-1500m$ from new flight paths × After new flight paths started	0.0003	-0.0157	-0.0121	0.0022
	(0.0158)	(0.0166)	(0.0172)	(0.0130)
Property characteristics control	Y	Y	Y	Y
Distance from amenities control	Y	Y	Y	Y
Other noise information	N	N	N	N
Floor-plan FE	Y	Y	Y	Y
# of rooms FE	Y	Y	Y	Y
Building construction FE	Y	Y	Y	Y
Located floor FE	Y	Y	Y	Y
# of stories FE	Y	Y	Y	Y
Street FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Month FE	Y	Y	Y	Y
Street × Year FE	Y	Y	Y	Y
# of observations	13,933	15,469	15,033	15,544
# of streets	361	365	363	365
Adj R-sq	0.93	0.94	0.95	0.88

The table shows the coefficients and standard errors of the results of robustness checks. The sample is limited to the properties transacted between March 29, 2017 and March 28, 2023, and located within 10km from Haneda airport and 5km from the new landing flight paths A and C of Haneda airport. The omitted category regarding the distance from new flight paths represents the properties located within 1.5-5km from the new landing flight paths A or C of Haneda airport. Standard errors clustered at the building level are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table A3: Using Different Distance Bands from New Landing Flight Paths

	(1)	(2)	(3)	(4)	(5)
Sample:	Transactions for sale				
Dependent variable:	$\ln price$				
Distance bands Xm:	$400m$	$450m$	$500m$	$550m$	$600m$
After new flight paths started	-0.0203	-0.0162	-0.0089	-0.0109	-0.0140
	(0.0207)	(0.0213)	(0.0217)	(0.0215)	(0.0214)
$0-1Xm$ from new flight paths	-0.0454	0.0732*	-0.0008	0.0186	0.0092
	(0.0408)	(0.0396)	(0.0443)	(0.0455)	(0.0440)
$1X-2Xm$ from new flight paths	-0.0348	0.0809**	0.0040	0.0243	0.0167
	(0.0344)	(0.0366)	(0.0416)	(0.0425)	(0.0396)
$2X-3Xm$ from new flight paths	-0.0240	0.0461*	0.0251	0.0220	0.0480**
	(0.0293)	(0.0278)	(0.0328)	(0.0285)	(0.0239)
$0-1Xm$ from new flight paths × After new flight paths started	-0.0251	-0.0287*	-0.0454***	-0.0407***	-0.0277*
	(0.0159)	(0.0158)	(0.0157)	(0.0156)	(0.0157)
$1X-2Xm$ from new flight paths × After new flight paths started	0.0028	-0.0047	-0.0143	-0.0050	0.0023
	(0.0132)	(0.0125)	(0.0132)	(0.0136)	(0.0146)
$2X-3Xm$ from new flight paths × After new flight paths started	0.0070	0.0048	-0.0135	-0.0214	-0.0189
	(0.0173)	(0.0137)	(0.0163)	(0.0175)	(0.0193)
Property characteristics control	Y	Y	Y	Y	Y
Distance from amenities control	Y	Y	Y	Y	Y
Other noise information	N	N	N	N	N
Floor-plan FE	Y	Y	Y	Y	Y
# of rooms FE	Y	Y	Y	Y	Y
Building construction FE	Y	Y	Y	Y	Y
Located floor FE	Y	Y	Y	Y	Y
# of stories FE	Y	Y	Y	Y	Y
Street FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
Month FE	Y	Y	Y	Y	Y
Street × Year FE	Y	Y	Y	Y	Y
# of observations	15,544	15,544	15,544	15,544	15,544
# of buildings	365	365	365	365	365
Adj R-sq	0.94	0.94	0.94	0.94	0.94

The table shows the coefficients and standard errors of the results of robustness checks. The sample is limited to the properties transacted between March 29, 2017 and March 28, 2023, and located within 10km from Haneda airport and 5km from the new landing flight paths A and C of Haneda airport. The omitted category regarding the distance from new flight paths represents the properties located within $3X-5km$ from the new landing flight paths A or C of Haneda airport. Standard errors clustered at the building level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A4: Using Different Distance Limitation from New Landing Flight Paths

	(1)	(2)	(3)	(4)	(5)
Sample:	Transactions for sale				
Dependent variable:	$\ln price$	$\ln price$	$\ln price$	$\ln price$	$\ln price$
Distance limitation from NFP:	$3000m$	$4000m$	$5000m$	$6000m$	$7000m$
After new flight paths started	0.0121	0.0072	-0.0089	-0.0068	-0.0108
	(0.0274)	(0.0228)	(0.0217)	(0.0167)	(0.0156)
$0-500m$ from new flight paths	0.0038	0.0132	-0.0008	-0.0106	-0.0164
	(0.0464)	(0.0457)	(0.0443)	(0.0439)	(0.0450)
$500-1000m$ from new flight paths	0.0086	0.0170	0.0040	-0.0058	-0.0156
	(0.0439)	(0.0429)	(0.0416)	(0.0410)	(0.0419)
$1000-1500m$ from new flight paths	0.0299	0.0338	0.0251	0.0178	0.0102
	(0.0321)	(0.0322)	(0.0328)	(0.0336)	(0.0351)
$0-500m$ from new flight paths $\times$ After new flight paths started	-0.0538***	-0.0568***	-0.0454***	-0.0417***	-0.0383***
	(0.0199)	(0.0175)	(0.0157)	(0.0145)	(0.0137)
$500-1000m$ from new flight paths $\times$ After new flight paths started	-0.0231	-0.0249	-0.0143	-0.0105	-0.0063
	(0.0182)	(0.0153)	(0.0132)	(0.0118)	(0.0111)
$1000-1500m$ from new flight paths $\times$ After new flight paths started	-0.0180	-0.0205	-0.0135	-0.0131	-0.0116
	(0.0188)	(0.0172)	(0.0163)	(0.0158)	(0.0157)
Property characteristics control	Y	Y	Y	Y	Y
Distance from amenities control	Y	Y	Y	Y	Y
Other noise information	N	N	N	N	N
Floor-plan FE	Y	Y	Y	Y	Y
# of rooms FE	Y	Y	Y	Y	Y
Building construction FE	Y	Y	Y	Y	Y
Located floor FE	Y	Y	Y	Y	Y
# of stories FE	Y	Y	Y	Y	Y
Street FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
Month FE	Y	Y	Y	Y	Y
Street $\times$ Year FE	Y	Y	Y	Y	Y
# of observations	10,658	12,337	15,544	19,199	22,714
# of buildings	238	297	365	430	477
Adj R-sq	0.94	0.94	0.94	0.95	0.95

The table shows the coefficients and standard errors of the results of robustness checks. The sample is limited to the properties transacted between March 29, 2017 and March 28, 2023, and located within 10km from Haneda airport and 5km from the new landing flight paths A and C of Haneda airport. The omitted category regarding the distance from new flight paths represents the properties located within 1.5-3km, 1.5-4km, 1.5-5km, 1.5-6km, and 1.5-7km from the new landing flight paths A or C of Haneda airport. Standard errors clustered at the building level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A5: Using Different Distance Limitation from New Landing Flight Paths

	(1)	(2)	(3)	(4)	(5)
Sample:	Transactions for sale				
Dependent variable:	$\ln price$	$\ln price$	$\ln price$	$\ln price$	$\ln price$
Distance limitation from Haneda airport:	$0-6000m$	$6000-8000m$	$8000-10000m$	$10000-12000m$	$12000-14000m$
After new flight paths started	0.0045	-0.0274	-0.0116	-0.1618**	-0.0926*
	(0.0449)	(0.0353)	(0.0237)	(0.0671)	(0.0547)
$0-500m$ from new flight paths	0.0023	0.0415	-0.0238	0.1181*	-0.0823
	(0.0689)	(0.0775)	(0.0464)	(0.0673)	(0.0947)
$500-1000m$ from new flight paths	0.0131	0.0533	-0.0162	0.1192*	-0.0813
	(0.0644)	(0.0686)	(0.0435)	(0.0603)	(0.0566)
$1000-1500m$ from new flight paths	-0.0029	0.0927**	-0.0091	0.1380**	-0.0795*
	(0.0529)	(0.0438)	(0.0362)	(0.0539)	(0.0404)
$0-500m$ from new flight paths × After new flight paths started	-0.0655**	-0.0205	-0.0403*	0.0379	0.0413
	(0.0315)	(0.0208)	(0.0235)	(0.0379)	(0.0363)
$500-1000m$ from new flight paths × After new flight paths started	-0.0356	-0.0149	-0.0061	0.0133	0.0879**
	(0.0307)	(0.0174)	(0.0211)	(0.0297)	(0.0385)
$1000-1500m$ from new flight paths × After new flight paths started	-0.0217	0.0054	-0.0064	0.0581*	0.0254
	(0.0320)	(0.0221)	(0.0259)	(0.0323)	(0.0311)
Property characteristics control	Y	Y	Y	Y	Y
Distance from amenities control	Y	Y	Y	Y	Y
Other noise information	N	N	N	N	N
Floor-plan FE	Y	Y	Y	Y	Y
# of rooms FE	Y	Y	Y	Y	Y
Building construction FE	Y	Y	Y	Y	Y
Located floor FE	Y	Y	Y	Y	Y
# of stories FE	Y	Y	Y	Y	Y
Street FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
Month FE	Y	Y	Y	Y	Y
Street × Year FE	Y	Y	Y	Y	Y
# of observations	4,246	4,785	6,443	4,230	4,465
# of buildings	125	103	157	127	161
Adj R-sq	0.95	0.95	0.94	0.93	0.93

The table shows the coefficients and standard errors of the results of robustness checks. The sample is limited to the properties transacted between March 29, 2017 and March 28, 2023, and located within 10km from Haneda airport and 5km from the new landing flight paths A and C of Haneda airport. The omitted category regarding the distance from new flight paths represents the properties located within 1.5-5km from the new landing flight paths A or C of Haneda airport. Standard errors clustered at the building level are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table A6: Full result for estimations for time elapsed effect

	(1)
Model:	Time elapsed
Dependent variable:	$\ln price$
Year2017	0.0108 (0.0346)
Year2018	0.0497** (0.0235)
Year2019	0.0000 (.)
Year2020	-0.0094 (0.0218)
Year2021	-0.0349 (0.0314)
Year2022	-0.0271 (0.0382)
$0-500m$ from new flight paths	-0.0080 (0.0444)
$500-1000m$ from new flight paths	0.0034 (0.0416)
$1000-1500m$ from new flight paths	0.0469 (0.0349)
$0-500m$ from new flight paths × Year2017	0.0242 (0.0219)
$500-1000m$ from new flight paths × Year2017	0.0201 (0.0206)
$1000-1500m$ from new flight paths × Year2017	-0.0346 (0.0217)
$0-500m$ from new flight paths × Year2018	0.0150 (0.0152)
$500-1000m$ from new flight paths × Year2018	0.0041 (0.0177)
$1000-1500m$ from new flight paths × Year2018	-0.0251 (0.0191)
$0-500m$ from new flight paths × Year2019	0.0000 (.)
$500-1000m$ from new flight paths × Year2019	0.0000 (.)
$1000-1500m$ from new flight paths × Year2019	0.0000 (.)
$0-500m$ from new flight paths × Year2020	-0.0491*** (0.0165)
$500-1000m$ from new flight paths × Year2020	-0.0082 (0.0140)
$1000-1500m$ from new flight paths × Year2020	-0.0200 (0.0176)
$0-500m$ from new flight paths × Year2021	-0.0576*** (0.0208)
$500-1000m$ from new flight paths × Year2021	-0.0137 (0.0168)
$1000-1500m$ from new flight paths × Year2021	-0.0281 (0.0221)
$0-500m$ from new flight paths × Year2022	-0.0244 (0.0251)
$500-1000m$ from new flight paths × Year2022	-0.0383 (0.0233)
$1000-1500m$ from new flight paths × Year2022	-0.0633*** (0.0243)
Property characteristics control	Y
Distance from amenities control	Y
Other noise information	N
Floor-plan FE	Y
# of rooms FE	Y
Building construction FE	Y
Located floor FE	Y
# of stories FE	Y
Street FE	Y
Year FE	N
Month FE	Y
Street × Year FE	Y
# of observations	15,544
# of streets	365
Adj R-sq	0.94

The table shows the coefficients and standard errors of the estimation for time-elapsed effects of the new landing paths of Haneda Airport. The sample is limited to the properties transacted between March 29, 2017 and March 28, 2023, and located 5km from the new landing flight paths A and C of Haneda airport. The omitted category regarding the distance from new flight paths represents the properties located within 1.5-5km from the new landing flight paths A or C of Haneda airport. The dummy variables for the transaction year used in the analysis are adjusted to the timing of the new flight path's introduction. For an instance, $Year2017$ represents properties that were transacted between March 29, 2017, and March 28, 2018. Standard errors clustered at the building level are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table A7: Population size and ratio by age and years of residence range

	Population size % of population in the relevant age range						
	Total	From birth	0 – 5 years	5 – 10 years	10 – 20 years	More than 20 years	Unknown
Total	3,187,117	214,500 6.7	718,512 22.5	379,243 11.9	446,646 14.0	574,094 18.0	854,122 26.8
0 – 4 years old	127,317	54,496 42.8	36,925 29.0	0 0.0	0 0.0	0 0.0	35,896 28.2
5 – 9 years old	125,019	30,673 24.5	34,808 27.8	25,635 20.5	0 0.0	0 0.0	33,903 27.1
10 – 14 years old	113,604	22,339 19.7	19,993 17.6	25,288 22.3	17,800 15.7	0 0.0	28,184 24.8
15 – 19 years old	110,464	16,386 14.8	20,681 18.7	15,358 13.9	32,860 29.7	0 0.0	25,179 22.8
20 – 24 years old	171,441	10,956 6.4	60,706 35.4	11,340 6.6	25,412 14.8	10,798 6.3	52,229 30.5
25 – 29 years old	220,113	6,876 3.1	95,932 43.6	13,545 6.2	12,083 5.5	12,897 5.9	78,780 35.8
30 – 34 years old	227,444	6,228 2.7	99,186 43.6	23,452 10.3	9,269 4.1	11,098 4.9	78,211 34.4
35 – 39 years old	245,260	6,394 2.6	87,477 35.7	42,709 17.4	15,762 6.4	11,754 4.8	81,164 33.1
40 – 44 years old	256,071	6,627 2.6	66,901 26.1	52,126 20.4	36,881 14.4	14,576 5.7	78,960 30.8
45 – 49 years old	275,722	7,655 2.8	52,455 19.0	49,865 18.1	65,389 23.7	25,669 9.3	74,689 27.1
50 – 54 years old	243,139	7,017 2.9	37,860 15.6	35,138 14.5	65,197 26.8	39,016 16.0	58,911 24.2
55 – 59 years old	198,488	6,902 3.5	27,318 13.8	23,824 12.0	49,845 25.1	50,454 25.4	40,145 20.2
60 – 64 years old	152,346	7,152 4.7	18,043 11.8	15,689 10.3	32,085 21.1	55,353 36.3	24,024 15.8
65 – 69 years old	141,483	7,347 5.2	13,547 9.6	12,697 9.0	24,809 17.5	65,256 46.1	17,827 12.6
70 – 74 years old	164,414	7,310 4.4	13,649 8.3	12,202 7.4	24,757 15.1	87,481 53.2	19,015 11.6
75 – 79 years old	127,102	4,580 3.6	9,757 7.7	8,284 6.5	15,819 12.4	74,128 58.3	14,534 11.4
80 – 84 years old	96,145	2,933 3.1	8,344 8.7	5,316 5.5	9,981 10.4	56,636 58.9	12,935 13.5
85 – 89 years old	68,120	1,866 2.7	7,711 11.3	3,701 5.4	5,762 8.5	37,857 55.6	11,223 16.5
90 – 94 years old	32,296	627 1.9	5,075 15.7	2,135 6.6	2,231 6.9	16,362 50.7	5,866 18.2
more 95 years old	10,228	128 1.3	2,099 20.5	935 9.1	700 6.8	4,745 46.4	1,621 15.8