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Aging and House Prices

-The Impact of Aging Housing Stock to Housing Market in the Tokyo Metropolitan Area-

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Abstract

Based on an analysis of the housing market, this paper focuses on external diseconomies of aging condominiums. It is possible that the quality of condominium stock deteriorates over time more rapidly than does that of ordinary housing. This deterioration in quality leads to a reduction in the quality of housing services received by residents and, further, this worsening of the residential environment may lead to external diseconomies. We run hedonic models to identify the external diseconomies of aging condominiums on the residential market. The results of our estimated models indicate that such external diseconomies for detached housing occur in areas where detached houses and condominiums coexist, and these exert a downward pressure on prices. Detached housing prices are lowered by around 3.2% for each 1% increase in the proportion of the total building floor area in neighborhoods in which condominiums were built before 1990. In other words, we can state that aging condominiums begin to generate diseconomies in their vicinities around 20 years after they were built.

***Keywords*:**

Aging condominium; External diseconomies; Hedonic approach; Depreciation

***JEL Classification*:**

E31, R21, R31

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1. Aging Condominium Stock

Japan's population is both shrinking and aging at rates that are unprecedented in any other major developed country (Saita, Shimizu and Watanabe (2016), Tamai, Shimizu and Nishimura (2017)). The population decline and the change in demographics are expected to have a significant impact on the country's cities and housing markets. In cities and housing markets in which there is little supply elasticity, these changes are already causing various problems. The rapid urbanization that occurred because of postwar economic growth, and the subsequent plan for remodeling the Japanese archipelago, led to social issues throughout the 1970s and 1980s, such as housing shortages and soaring land prices. Then, the entry of the baby boomer generation into the housing market generated the biggest housing demand in the postwar era, which was a key factor behind the real estate bubble that began in the mid-1980s (Shimizu and Watanabe, 2010).

As a result, there was a surge in the construction of unit ownership-type apartment buildings, that is, condominiums. The construction of condominiums accelerated in the 1970s, especially in urban areas. As condominiums make it possible to supply large numbers of homes while making efficient use of land,[1] they have become a common form of housing in Japan, where space is limited.[2]

Condominiums have played an important role as residential infrastructure, supporting economic and population growth in a country where available land is highly restricted. However, like other public infrastructure, including roads and bridges, condominiums have begun to age. The maintenance and management of aging condominiums are expected to become major problems for Japanese society in the near future.

Considering condominiums as a form of investment, there are three factors that contribute to their deterioration (i.e., depreciation), as noted by Diewert and Shimizu (2016a, 2016b). The first is physical depreciation, which reduces the functionality of the buildings. The second is economic depreciation, which is the result of buildings becoming outdated relative to newer buildings with superior features. The third is deterioration resulting from damage. It has been noted that the life-span of housing is particularly short in Japan (see Diewert and Shimizu(2015) and Diewert, Fox and Shimizu(2016)), so the depreciation rate of Japanese housing may be considered high.

However, under the Act on Building Unit Ownership, condominium owners hold unit ownership rights that include both exclusive and common elements, which means that: a) replacing a condominium building requires the approval of four-fifths of the residents, and b) the consent of all

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[1] "Condominiums" may be defined as corresponding to the "nonwooden apartment buildings" category of owned residential property used in Japan's Housing and Land Survey. According to the 2008 Housing and Land Survey, condominiums built from 1971 onward account for 97% of all stock, with 16% constructed between 1971 and 1980, 21% between 1981 and 1990, 33% between 1991 and 2000, and 27% between 2001 and September 2008.

[2] In the 2008 Housing and Land Survey, the proportion of households nationwide residing in multiunit dwellings (either owned or rented) had surpassed the 40% level (42.8%). The ownership rate was 79.4%, of which 4,539,300 residences (equivalent to 22%) were dwellings in nonwooden multiunit buildings.

owners is required to dissolve the unit ownership relationship.[3] As a result of this system, there are extremely significant social costs associated with upgrading or repairing damaged condominium stock. Therefore, depreciation resulting from the third factor (damage) is small, and the life-span of buildings is prolonged despite their physical and economic deterioration (See Diewert and Shimizu(2016b)). Although the depreciation rate may be considered low compared with other buildings, condominiums' unique characteristics are expected to cause new social issues.

Specifically, there is a strong possibility that the aging of condominium buildings could lead to external diseconomies for the cities in which they are located as a whole. Deteriorating buildings make cities less attractive and "slumification" creates areas with even greater external diseconomies.

So, how quickly is Japan's condominium stock, which is difficult to upgrade or damage, increasing? And how much of an impact will it have on the country's neighborhoods and cities?

It is possible that the quality of condominium stock deteriorates over time more rapidly than does ordinary housing. This deterioration in quality leads to a reduction in the quality of housing services received by residents and, further, the worsening of the residential environment may lead to external diseconomies. These external diseconomies will be even greater for properties that are adjacent to inferior condominium stock. Therefore, the deterioration of neighborhoods and cities varies considerably, depending on the density and concentration of aging condominium stock.

In recognition of the above issues, this paper will forecast the impact that the increase in aging condominiums will have on the Tokyo area following the 2020 Tokyo Olympic Games. To begin, Chapter 2 considers the future state of aging condominium stocks in quantitative terms, focusing on the Tokyo area (Tokyo, Chiba, Saitama, and Kanagawa Prefectures), which has the largest supply of condominiums in the country. Chapter 3 measures the impact of external diseconomies on land prices caused by aging condominiums in the surrounding areas at the neighborhood level (500 by 500 m areas). Chapter 4 concludes the paper by summarizing the findings.

2. Aging Condominium Stock

2.1. Data

To analyze aging condominiums, we have constructed a condominium database. Although housing stock-related statistics can be obtained from the Japanese Government's Housing and Land Survey, because it is a sampling survey, there are significant errors and other problems, including a lack of detailed statistics at the level of individual neighborhoods (e.g., data sorted by census districts such as towns and streets) in the summary tables and a lack of information about the attributes of individual buildings. Therefore, for this paper, we collected and organized micro-level data gathered by private

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[3] An amendment to the law in 2014 made it possible to approve dissolution of the unit ownership relationship by means of a special majority vote for condominiums built according to old earthquake-proofing standards.

companies. Specifically, we used data supplied to new condominium databases by the Real Estate Economic Institute and Recruit, as well as residential map data from Zenrin. The three data sources differ in nature.

The Real Estate Economic Institute data provide information about the supply of new condominiums. Information exists for condominium buildings from 1975 onward[4] and the institute has detailed data from 1995 onward that include information on individual units. The source of this data is information taken from pamphlets created while new buildings were at the development stage. As the database is created using pamphlets, the data are organized by sale period.[5] It is likely that these data are incomplete because some buildings were not surveyed.[6]

Recruit's building-related database uses information collected since 1986 by the company for its real estate listings magazine. Recruit publishes listings of both new and existing condominiums. If information about a property is included in an advertisement at least once, it is used in the condominium-related database. We used the individual data from Recruit in this paper. This enabled us to supplement our Real Estate Economic Institute data with data from the period before 1975.[7] However, although it is possible to obtain the total number of units in Recruit's building information, the total floor area is not recorded. Therefore, we obtained the total floor area by matching Recruit data with Zenrin residential map data.[8]

The combination of both databases provides us with data on 159,770 buildings (26,421 of which were common to both the Real Estate Economic Institute and the Recruit data). To capture aging condominium trends, we analyzed total building numbers, the number of units, and total floor area.[9]

2.2. Condominium Supply Trends in the Tokyo Area

There are numerous methods of estimating future stock levels, such as cohort analysis, which is used in population forecasts, or the build-up method, based on new supply flow and depreciation.

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[4] All data from 1975 onward were converted into electronic data. In total, we obtained data on 35,262 buildings.

[5] For example, in the case of a large-scale condominium with 300 dwellings, the units may be sold in multiple phases. If there are three phases, with 100 units sold in each phase, these phases would be treated as three different buildings in the database. Consequently, if results are aggregated across the three phases, the number of buildings will be overestimated. Therefore, we converted such data into information for a single building by combining the phase one to phase three data.

[6] According to the Real Estate Economic Institute, it captures around 90% of the condominium supply in the Tokyo metropolitan area.

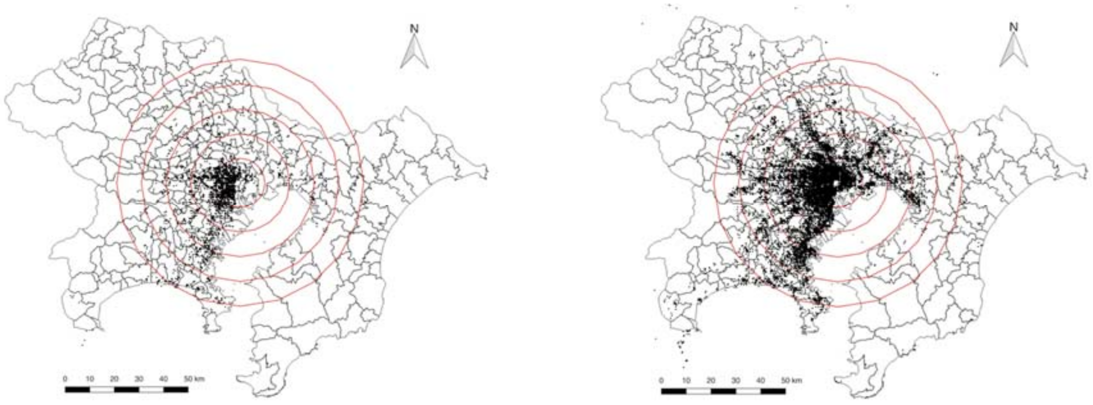
[7] For example, if a condominium completed in 1970 was included in a listings magazine published in 2005, that building data would also be included. From 1986 onward, there were advertisements run for approximately 863,000 units, enabling us to obtain data for 52,187 buildings in the Tokyo metropolitan area. When integrating the two databases, it is necessary to adjust for buildings that are present in both the Real Estate Economic Institute and the Recruit building data. Therefore, we deleted redundant data so that no duplication occurred.

[8] For Zenrin's residential maps, building shapes are surveyed and organized as polygon data. Information on the number of floors is also collected for each building. Therefore, we estimated a building's total floor area by multiplying the floor plate (obtained from the shape) by the number of floors.

[9] In the case of data that could not be matched with Zenrin data, we performed estimates of the total number of units or total floor area. For example, if we had only the total number of units but not the total floor area, we inferred the total floor area using techniques such as multiplying the average unit floor area by the total number of units. Conversely, if we knew only the total floor area and not the total number of units, we obtained the latter by dividing the total floor area by the average unit floor area.

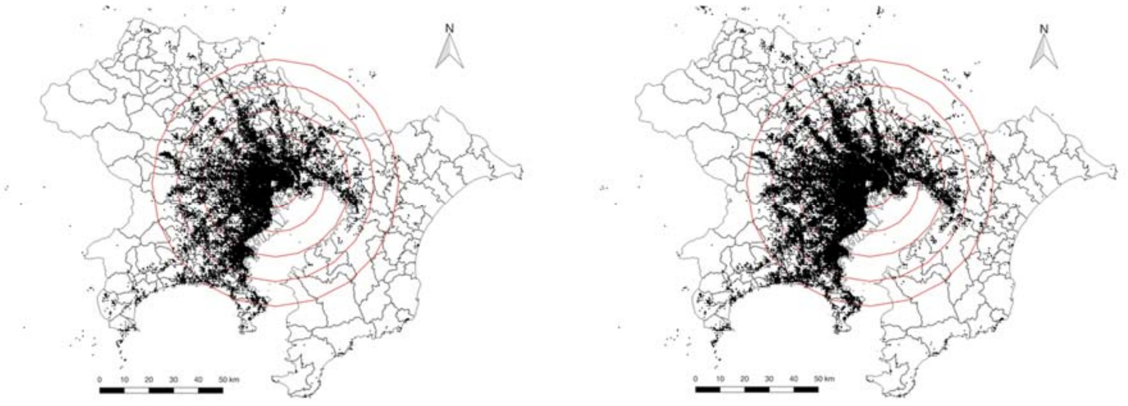
For this paper, we estimated the number of aging condominiums from 2015 onward by defining the useful life of buildings and assuming that they would not be replaced during that period of time.[10]

Prior to the analysis, we aggregated the number of buildings, the number of units, and the total floor area by the time period for condominiums completed up to December 2015. In total, the condominium stock covered by the database represents 159,770 buildings, 9,445,656 units, and 477,838,743 m^2 of floor space. In terms of spatial changes, if we take condominiums built before 1970 as a starting point, the stock grew rapidly: it tripled over the next five years, doubled during the five-year span ending in 1980, and increased by 1.6 times during the five-year period ending in 1985. Since then, the condominium stock has grown by only 1.2 times; however, it has increased at a significantly faster rate than the population or GDP, both of which have slowed during the same period.



(1-a) Distribution of Condominiums Built Before 1970

(1-b) Distribution of Condominiums Built Before 1980



(1-c) Distribution of Condominiums Built Before 1990

(1-d) Distribution of Condominiums Built Before 2000

Figure 1: Condominium Supply Distribution by Period

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[10] This is a highly plausible hypothesis, given that most condominium buildings are not being replaced for the reasons discussed earlier. In addition, most condominiums that are currently being replaced are special cases that were affected by the Great Hanshin Earthquake or buildings where surplus capacity is being sold off through redevelopment. Cases of replacement driven by population decline may be considered extremely rare. Given that the database used for the analysis covers around 90% of the assumed stock, we deemed that this hypothesis would not lead to overestimation.

Figure 1 maps out these changes in condominium supply. Based on these maps, condominium stock in the Tokyo area expanded rapidly toward suburban areas throughout the 1980s and 1990s. Although condominiums were largely restricted to certain parts of central Tokyo in 1970, they spread out across an increasingly wide area through the 1980s, 1990s, and 2000s. To examine their spread across the region, we observed increases in aging condominiums by distance zones, using the census districts comprising municipalities in the Tokyo metropolitan area, which is defined here as a perfect 70 km circle that centers on the former Tokyo Metropolitan Government Building.[11]

Cross-tabulation by construction date and distance zone shows that almost 11% of the total floor area was supplied during the five years from 1981 to 1985. This period may be considered the first condominium boom period. Subsequent booms occurred following the collapse of the bubble, from 1996 to 2000 (15%) and 2001 to 2005 (18%).

In spatial terms, as of 2015, the highest concentration of condominiums was in the 10–20 km zone from the center, which accounts for 27% of the total. Although 75% of all stock is within 30 km of the center, there is a sizeable stock that should not be overlooked within the 30–50 km range (approx. 2.05 million units or 103.36 million m^2).

3. Neighborhood Externalities of Aging Condominiums

3.1. Estimation Model

This paper uses a hedonic approach to estimate the external diseconomies and neighborhood externalities associated with aging condominiums.

The hedonic approach is a method that expresses the correspondence relationship between price and quality as a linear vector and analyzes the formation structure by means of estimating a price function. It has a wide range of applications, including performing quality adjustments for price indexes and estimating the economic value of nonmarket goods.

Here, we wish to measure neighborhood externalities associated with the accumulation of aging condominiums. The most significant problem when considering this issue is that there is no precise definition of aging condominiums.

Therefore, we decided to analyze the impact on housing prices by specifying year t as the estimation

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[11] This area comprises 14 wards (e.g., Chiyoda Ward) within the 0–10 km range, 27 wards and cities (e.g., Kawaguchi City, Ichikawa City, Ota Ward, Musashino City, and Kawasaki Ward in Kawasaki City) within the 10–20 km range, 48 cities and wards within the 20–30 km range (e.g., Omiya Ward in Saitama City, Hanamigawa Ward in Chiba City, Fuchu City, and Tsurumi Ward in Yokohama City), 47 wards and municipalities within the 30–40 km range (e.g., Nishi Ward in Saitama City, Kawagoe City, Chuo Ward in Chiba City, Kisarazu City, Tachikawa City, and Minami Ward in Yokohama City), 48 wards and municipalities within the 40–50-km range (e.g., Hanno City, Sakura City, Hachioji City, and Yokosuka City), 34 municipalities within the 50–60 km range (e.g., Gyoda City, Mobara City, Hinohara Village, Hiratsuka City), and 41 municipalities within the 60–70 km range (e.g., Kumagaya City, Kamogawa City, Okutama Town, and Odawara City).

time and diachronically changing the number of years T since the building was constructed.

When attempting to estimate neighborhood externalities associated with the accumulation of aging condominiums using a hedonic function, there is a tacit assumption that market participants will verify these externalities and that this will have an effect on location behavior. Accordingly, in this paper, we decided to use the proportion of the total building floor area within a 500 × 500 m mesh(block) in 2010 that is accounted for by condominiums built prior to year t as an indicator. In other words, we derived the effect of aging based on how many of the buildings in a given area are aging condominiums.

Further, to estimate the effect that the ratio of aging condominiums within a 500 × 500 m mesh has on housing prices, it is necessary to first verify the difference between areas with condominiums and areas without condominiums within that mesh. In areas with condominiums, it is necessary to control for whether they are conveniently located and, therefore, housing prices are inherently high, or whether the presence of condominiums has inherent external diseconomies, which has the effect of driving housing prices down.

To distinguish the effects of aging condominiums, we opted to control for their effect by introducing an area dummy for areas where there is a supply of condominiums. That is, to examine the extent to which price differences exist based on how many aging condominiums have accumulated within a given area, we first eliminated the effect of areas deemed suitable for condominiums prior to year T by means of the area dummy.

In addition, as a means of checking robustness, we restricted determination of aging condominiums' external diseconomies to areas where condominiums are present and measured the external diseconomies associated with the presence of aging condominiums. The measurement method is as shown below.

First, we derive the effect of the presence of condominiums (Model 1).

$$\log P_{(i,j)} = a_0 + a_1 O_{T=2010,i} + \sum_{m} a_2^m \, logX_i^m + \sum_{n} a_3^n \, NE_k^n + \sum_{s} a_4^s H_i^s + \varepsilon_{(i,j)} \tag{1}$$

Here, the price of housing *i* in area *j* is denoted by $P_{(i,j)}$, with area *j* being a 500 × 500 m mesh. $O_{T=2010,\ j}$ is a factor reflecting the effect of aging condominiums, taking 2010 as the starting point. More specifically, because the detached house prices aggregated here are based on cross-section data covering Tokyo in 2010, we examine the effect of the presence of condominiums by analyzing condominium stock built prior to 2010 (T=2010) and investigating the total condominium floor area (i.e., for all condominiums that existed in 2010) as a proportion of the total building floor area. This indicates how strong the price-lowering effect is when the ratio of condominiums to buildings within a small area increases. X is the attributes of detached housing (e.g., time to the nearest station, building age, occupied area), *NE* is the neighborhood effect within area *k*, and *H* is a proxy variable for examining the attributes of the buyer purchasing a given property.

Next, we examine the cohort effect by building time period (Model 2). Here, $O_{T=2010,\ ,j}$ is changed to $O_{Tt,,j}$. In other words, we examine the impact on detached housing prices by investigating various periods that begin a specified amount of time t prior to 2010. For example, if t=10, we examine the period up to 10 years before 2010 (i.e., up to 2000) to determine the proportion of the total building floor area in a given district accounted for by the total floor area of condominiums constructed in that period. If t=20, we examine the proportion of the total building floor area in a given district accounted for by the total floor area of condominiums constructed 20 years or more prior to 2010 (i.e., up to 1990). The assumption is that when t is varied in this way, it enables us to determine how far back one must investigate, prior to 2010, to find a negative impact on detached housing prices.

$$\log P_{(i,j,t)} = a_0 + \sum_{l} a_1^l \, O_{Tt,i} + \sum_{m} a_2^m \, logX_{t,j}^m + \sum_{n} a_3^n \, NE_{t,k}^n + \sum_{s} a_4^s H_{t,i}^s + \varepsilon_{(i,j)} \tag{2}$$

Using this model enables us to obtain information regarding when consumers become aware of condominium externalities. That is, assuming that consumers have a medium- to long-term perspective, they may judge that there is a strong possibility that the environment in which condominiums are located will deteriorate eventually, regardless of whether condominiums are actually aged now. In that case, from the very time that they are built, condominiums may lower the price of real estate in their area. Further, if the impact of condominiums on the surrounding environment is based solely on their disaster-resistance capabilities (or lack of them), then it is likely that there will be a marked difference for condominiums built after 1982, the year in which new earthquake-proofing standards were adopted. However, if the impact is not based solely on disaster-resistance capabilities, then their influence on real estate asset values should not be defined by the change in standards in 1982.

We will examine the effect that the presence of a given proportion of condominium stock within the total floor area and constructed in a specific time period has for different time periods. For example, we will determine the effect of the proportion of the total building floor area in a given mesh accounted for by condominiums built in three periods: before 1990, from 1991 to 2000, and from 2000 to 2010. This will enable us to examine the housing price-lowering effect according to the degree of aging of the condominiums.

After verifying whether an external effect exists for condominiums constructed prior to a specific time using Model 2, we will estimate the price-lowering effect of the floor area of condominiums constructed before year T (Model 3), as well as checking the robustness. We will verify the extent of external diseconomies associated with aging condominiums by adding variables such as the effective floor area ratio (the total building floor area within a district divided by the land area), the total building floor area, the total apartment house floor area, the total nonwooden apartment building floor area, and the total wooden apartment house floor area.

3.2. Data

For the purpose of calculating the model, we collected the data itemized below. ¥

Condominium data (O_i)

For the condominium data, we used the Tokyo metropolitan area condominium database that we constructed, as described previously. We aggregated data by condominium age in 500 × 500 m meshes—i.e., by the degree of aging (number of years since construction) at the time of analysis.

Housing price data ($P_{(i,j,t)}$), building attributes ($X^m_{(i,j)}$), and market attributes (MK)

For housing price data, we collected data on transactions concluded during the three-year period from January 2009 to December 2011 in Tokyo's 23 wards and the Tama region ($P_{(i,j,t)}$). The primary data information source that we used was detached house price information from a weekly residential real estate listings magazine published by Recruit. This magazine supplies information about quality and asking price on a weekly basis. For this paper, we have used price information published in the magazine at the point when the listing was removed because the property was sold.

Surrounding environment variable ($NE^n_i, H^s_{,i}$)

When estimating a hedonic function for data covering a wide area, it is necessary to account not only for the land and building attributes but also for spatial disparities (Chen and Rosenthal (2008), Yasumoto, Jones, and Shimizu (2014)). The most representative spatial disparity-related factor in the surrounding environment is the accessibility of public transportation where housing is located. In the Tokyo area, which is served by an extensive train network, housing prices vary significantly based on the convenience of the nearest station, as measured by "time to the nearest station" (TS) and "time to the city center" (TT).

For surrounding environment attributes, we created a surrounding environment indicator for housing located within a 500 × 500 m mesh. Specifically, we created a variable based on three factors: urban planning usage restrictions (based on public regulations), the urban environment (based on the usage status of land and buildings), and household attributes (based on census data).

First, for urban planning usage restrictions, we used an urban planning usage area dummy,[12] the

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[12] For urban planning usage areas, we created three dummy variables, relating to residential use, commercial use, and industrial use. For the residential-use dummy, we combined a category 1 exclusive low-rise residential area dummy, a category 2 exclusive low-rise residential area dummy, a category 1 exclusive medium- and high-rise residential area dummy, a category 2 exclusive medium- and high-rise residential area dummy, a category 1 residential area dummy, a category 2 residential area dummy, and a quasi-residential area dummy. For the commercial-related use dummy, we combined neighborhood commercial areas and commercial areas, whereas for the industrial-use dummy, we included quasi-industrial areas, industrial areas, and exclusive industrial areas.

legally designated floor area ratio, and the building-to-land ratio.

For the land and building usage conditions, we used individual building data from the Tokyo Metropolitan Land Use Survey. We researched conditions in 2006 for Tokyo's wards and 2007 for the Tama region and summarized data on a total of 2,762,226 buildings in the form of GIS data, including data on the building usage status, building area, and structure. Then, for each 500 × 500 m mesh, we calculated the number of buildings, the average area of one floor for each building and standard deviation, the average building height (number of floors) and standard deviation, the total industrial use floor area, and the wooden building floor area ratio (i.e., the proportion of the total floor area accounted for by the wooden building floor area).

As average floor area is a variable that relates to the level of build-up or density, we have assumed that the building floor area standard deviation can serve as a proxy variable for the urban landscape in a given neighborhood. The same applies to building height. In other words, in neighborhoods where the floor area and height standard deviation are small, the urban landscape should be more orderly. Further, we considered that the wooden building floor area ratio would be closely related to the probability of building collapse or fire in the event of a disaster.[13]

With regard to census data, we used the number of households with individuals aged 75 years or over, the number of office workers (specialized/skilled workers + workers in management positions + clerical workers). The number of office workers is a strong proxy for education level and income within a given area because, generally speaking, specialized/skilled workers, workers in management positions, and clerical workers have a higher level of education and average income than do workers in other categories.

3.3. Hedonic Function Estimation Result

Before estimating the hedonic function, we will examine the data characteristics. First, the average detached housing price was 45.4 million yen, with a minimum of 3.8 million yen and a maximum of 299.9 million yen. There was significant variation, with a standard deviation of 21.62 million yen. Therefore, housing included everything from "bargain properties" to "billionaire homes." The occupied floor area (S) was 95.88 m^2 on average, with a minimum of 30.56 m^2 and a maximum of 819.15 m^2. This means that housing ranged widely from so-called "tiny houses" to large-scale homes.

Building age (A) was 3.73 years on average because of the presence of large numbers of new properties. However, with some building ages of more than 36 years, the distribution trails far to the right.

In terms of the distribution of condominiums by construction time (i.e., the total floor area in each

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[13] The Tokyo earthquake risk map is calculated using these data as the primary data source. The collapse probability and fire incidence probability are obtained based on building structure and the degree of build-up. As these are represented as indexes, it can be difficult to interpret them for the purposes of analysis; however, the fact that the indexes calculated here involve continuous quantities simplifies the interpretation.

500 × 500 m mesh in the analysis data accounted for by condominium floor area, based on construction time), out of the 62,480 samples, only 9,252 (15%) were in areas with condominiums built before 1970. The figures rose to 28,311 samples for condominiums built prior to 1980, 40,382 samples for condominiums built prior to 1990, and 47,581 for condominiums built prior to 2000.

In addition, with regard to the condominium floor area proportion indicator's distribution by time period, the average was 2.4% for condominiums built prior to 1970, and it was 6% at the 95th percentile point. The average value changed as follows: 4.3% for the pre-1980 condominium floor area proportion, 5.8% for pre-1990 condominiums, and 7% for pre-2000 condominiums. Although the distribution of samples with a floor area proportion of 10% or more was only around 1% for pre-1970 condominiums, it rose to around 10% for pre-1980 and pre-1990 condominiums, and reached 25% for pre-2000 condominiums.

The hedonic function estimation results are shown in Tables 1 and 2. Examining the overall hedonic function estimation results, when the occupied area (S), land area (L), and front road width (W) increase, housing prices increase. Conversely, they decrease when the building age (A) increases, the travel time to the nearest station (TS) increases, or the distance to the city center becomes further (TT). In addition, prices are lower in areas served only by buses, and they are relatively lower for wooden structures or properties with a private road on the grounds. Transaction prices are relatively higher for properties that remain on the market for a long time (MR). These findings are consistent with prior research and the rules of thumb for housing prices.

Next, with regard to the urban planning usage area dummy for surrounding environment attributes (NE), the results show that prices are relatively high for housing in residential usage areas, whereas commercial and industrial areas have a price-lowering effect. As residential environments in commercial and industrial areas tend not to be high quality, this is likely to bring prices down. Further, higher floor area ratios are found to have a negative and significant effect, which occurs because consumers assume that the area environment will be worse in these areas. However, no significant results were obtained for the effect of the building-to-land ratio.

In terms of the average building floor area per 500 × 500 m mesh, we found that larger average floor areas have a price-raising effect, but when variation (i.e., standard deviation) becomes significant, it has the effect of lowering prices. The most likely reason for this is that greater variation in floor area means that the neighborhood does not have an orderly appearance, which is detrimental to the local urban landscape. In addition, price levels are low when there is a high proportion of wooden buildings. It is likely that this price-lowering effect occurs because, when the average floor area is small and the proportion of wooden buildings is high, there is a higher probability of collapse as a result of disaster and fire, and the residential environment is also presumed to be of lower quality. Further, in areas where factories account for a large amount of floor space, we found that the price-lowering effect was stronger than the effect of urban planning usage.

Table 1: Hedonic Function Estimation Results, Part 1

	Tokyo - All Areas				**Areas with Condominiums**	
	Model.1		**Model.2**		**Model.3**	
	Condominium effect		**Time effect**		**Time effect**	
	Regression coeffi	t-value	ession coeff	t-value	ession coeff	t-value
Constant term	-57572.91	-28.71	-57302.06	-28.53	-61060.46	-24.04
O: condominium effect						
Condominium effect: 2010	**-0.015**	**-1.79**			-	-
Or(-90): Proportion of pre-1990 condominiums			**-0.046**	**-3.33**	**-0.032**	**-2.31**
Or(91-00): Proportion of 1991-2000 condominiums			**-0.007**	**-0.32**	**-0.008**	**-0.42**
Area control dummy	0.042	21.45	0.042	21.59	-	-
X: Building attributes						
S: occupied area	0.584	142.25	0.584	142.29	0.580	134.40
L: land area	0.295	101.97	0.295	101.96	0.294	95.43
A: age	-0.065	-112.72	-0.065	-112.75	-0.060	-92.00
W: front road width	0.033	14.03	0.033	14.02	0.028	10.69
TS: distance to nearest station	-0.075	-49.51	-0.075	-49.58	-0.080	-47.71
Bus: bus zone dummy	-0.074	-19.04	-0.074	-19.02	-0.099	-17.42
NR: number of rooms	-0.005	-7.34	-0.005	-7.35	-0.003	-3.90
WD: wooden building dummy	-0.073	-21.57	-0.073	-21.61	-0.069	-19.54
CD: garage dummy	0.015	4.15	0.015	4.13	0.012	3.26
PR: private road dummy	-0.002	-1.07	-0.002	-1.06	-0.002	-1.10
MK: market characteristics						
MT: time on market (×1000)	0.199	27.69	0.199	27.69	0.190	24.21
NE: Neighborhood characteristics						
TT: time to Tokyo station	-0.100	-17.460	-0.099	-17.40	-0.121	-19.36
Urban planning usage dummy: residential-related use	0.006	1.900	0.006	1.88	0.001	0.16
Urban planning usage dummy: commercial-related use	-0.011	-2.580	-0.011	-2.58	-0.005	-1.13
Urban planning usage dummy: industrial-related use	-0.012	-3.470	-0.012	-3.45	-0.016	-4.18
FAR: floor area ratio	-0.021	-12.420	-0.021	-12.36	-0.017	-9.71
EFAR: effective floor area ratio	0.029	11.830	0.028	11.78	0.016	6.18
LAR: building-to-land ratio	0.003	0.270	0.003	0.26	-0.061	-4.50
500-m mesh: average number of floors per building	-0.006	-1.670	-0.006	-1.65	0.001	0.28
500-m mesh: built floor area - average	0.117	6.400	0.117	6.38	0.238	8.41
500-m mesh: built floor area - standard deviation	-0.018	-4.180	-0.018	-4.14	-0.022	-3.57
500-m mesh: wooden building floor area proportion	-0.087	-4.300	-0.089	-4.38	-0.080	-2.75
500-m mesh: total industrial building floor area	-0.005	-12.420	-0.005	-12.44	-0.006	-13.19
HH: area (buyer) characteristics						
500-m mesh: population aged 75-plus	-0.015	-13.85	-0.014	-13.75	-0.016	-14.27
500-m mesh: specialized/skilled workers	0.050	38.37	0.050	38.43	0.044	31.69
Spatial coordinates						
Longitude	761.540	28.31	757.392	28.11	749.098	21.96
Latitude	246.009	9.73	247.054	9.77	489.188	15.72
Longitude squared	-2.725	-28.27	-2.710	-28.07	-2.680	-21.93
Latitude squared	-3.463	-9.78	-3.477	-9.82	-6.863	-15.74
D: time dummy*	Yes		Yes		Yes	
Other dummy variables						
Administrative district dummy**	Yes		Yes		Yes	
Trackside dummy***	Yes		Yes		Yes	
Number of samples	62,478		62,478		49,870	
Degree of freedom-adjusted R-squared	0.852		0.852		0.843	

*2010 and 2011 year dummy. **Includes dummy variables for 47 municipalities. ***Includes 27 trackside-related dummy variables.

Table 2: Hedonic Function Estimation, Results Part 2

	Model 4-1	Model 4-2	Model 4-3	Model 4-4	Model 4-5	Model 4-6
	Baseline model (BM)	**BM+effective floor area ratio**	**BM + total building floor area**	**BM + apartment house**	**BM + non-wooden apartment house**	**BM + wooden apartment house**
Constant term	-60382.230 ***	-61033.490 ***	-61033.490 ***	-60301.850 ***	-60295.850 ***	-60682.930 ***
Or(-90): proportion of pre-1990 condominiums	**-0.043** ***	**-0.032** ***	**-0.032** ***	**-0.043** ***	**-0.043** ***	**-0.042** ***
Floor area ratio	-0.017 ***	-0.017 ***	-0.017 ***	-0.017 ***	-0.017 ***	-0.016 ***
Building-to-land ratio	-0.062 ***	-0.061 ***	-0.061 ***	-0.062 ***	-0.062 ***	-0.063 ***
Effective floor area ratio	-	0.016 ***	- -	- -	-	-
Total building floor area (×1000)	-	-	0.633 ***	- ***	-	-
Apartment house floor area (×1000)	-	-	-	-0.105	-	-
Non-wooden apartment house (×1000)	-	-	-	-	-0.114	-
Wooden apartment house (×1000)	-	-	-	-	-	0.038 ***
Number of samples	49,870	49,870	49,870	49,870	49,870	49,870
Degree of freedom-adjusted R-squared	0.843	0.843	0.843	0.843	0.843	0.843

*2010 and 2011 year dummy. **Includes dummy variables for 47 municipalities. ***Includes 27 trackside-related dummy variables.

N.B. *** indicates that the null hypothesis is rejected at the 1% level of significance, ** at the 5% level of significance, and * at the 10% level of significance.

In terms of buyer attributes, in areas where there were many elderly residents (aged 75 years or over), prices were relatively low; conversely, in areas where there were many specialized/skilled workers, prices were relatively high. “Specialized/skilled workers” is an employment category in the national census that is known to have a comparatively high income level. Therefore, this variable may be considered a proxy for the area’s income level.

To account for territorial effects not captured by these variables, we introduced longitude and latitude coordinates and their squares, but none of the results were found to be significant.[16]

3.4.Effect of External Diseconomies Associated with Aging Condominiums

First, Model 1 analyzes the externality of the effect associated with the presence of condominiums (Table 1, Model 1). Specifically, we examined the effect of the proportion of the total building floor area in a given 500 × 500 m mesh that was accounted for by condominiums supplied until 2010. We refer to this as the “condominium effect.” The estimation results show that when the ratio of condominium floor area to total building floor area increases by 1%, there is a corresponding detached house price-suppressing effect of –1.5%.

When the effect estimation results are considered by age (i.e., by condominium development period), as shown in Table 1, Model 2, the price-lowering effect is greatest in the case of condominiums supplied before 1990 (–4.6%). This result is statistically significant. No significant results were obtained for the effect of condominiums supplied from 1991 to 2000. With regard to these findings, Shimizu et al. (2014) have pointed out that the condominium price curve over time becomes steeper for condominiums built from 10 to 23 years ago. Assuming that it takes some time for a decline in condominiums’ convenience to impact the surrounding area, it makes sense that pre-1990 condominium stock has a greater negative effect.

The fact that only condominiums supplied before 1990 have a downward impact on real estate values in the area is likely to signify that consumers only begin to view condominiums as having a negative effect once they have reached a certain age. Further, it is clear from this empirical analysis that all condominiums that have reached a certain age have a negative impact on the surrounding area, not just those built according to old earthquake resistance standards.

Model 3 examines the effect by condominium stock age solely in areas with a supply of condominiums. Although the results obtained are similar to those in Model 2, the price-lowering effect of condominiums built prior to 1990 dropped from –4.6% to –3.2%. This is because the base for measuring the effect of aging condominiums changed to areas in which condominiums were first

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[16] The estimation method, known as the parametric polynomial expansion model, was proposed by Jackson (1979). It aims to increase the flexibility of fit based on a higher-order polynomial equation using coordinate values (latitude and longitude). It introduces the square and cube of the coordinate values and a multidimensional cross-term into the explanatory variable. When determining an effect that has strong territoriality, such as the effect of aging condominiums, it is necessary to avoid the issue of omitted variable bias as much as possible. Therefore, we factored in the coordinate values.

supplied from 2000 onward.

In Table 2, to check the robustness of Model 3, we reestimated the model when the analysis was restricted to areas with a supply of condominiums, with variables added that were assumed to influence the proportion of aging condominiums. More specifically, we estimated a model that restricted the effect of aging condominiums in Model 3 to the proportion of condominiums built before 1990 (Model 4-1), a model that factored in the effective floor area ratio (Model 4-2), a model that factored in the total building floor area within the neighborhood (Model 4-3), a model that factored in the total apartment house floor area within the neighborhood (Model 4-4), a model that factored in the total nonwooden apartment house floor area within the neighborhood (Model 4-5), and a model that factored in the total wooden apartment house floor area within the neighborhood (Model 4-6).

The effect of condominiums built before 1990 is –4.2% in the baseline model, but the aging condominium effect drops to –3.2% when the effective floor area ratio and total building floor area are factored in, with both results being statistically significant. No significant effects were found for apartment house, nonwooden apartment house, or wooden apartment house, so the aging condominium effect was equivalent to the baseline model.

To summarize the above findings, external diseconomies for detached housing resulting from aging condominiums occur in areas where detached houses and condominiums coexist, and these exert a downward pressure on prices. Detached housing prices are lowered by around 3.2% for each 1% increase in the proportion of the total building floor area in a neighborhood with condominiums built before 1990. In other words, we can say that aging condominiums begin to generate diseconomies in their vicinity around 20 years after they are built (i.e., 1990 or earlier in our study).

4. Conclusion

In recent years, the appearance of large numbers of vacant lots and vacant houses has become a social issue in Japan, especially in regional cities. This has distorted the distribution of resources on the housing market, which is a spatial market. Although it is expected that this distortion will be resolved via market mechanisms, there are limits to the market's capabilities, and policy-based intervention has become necessary.

The presence of unmanaged housing, such as vacant homes, causes external diseconomies in the city where such housing is located. The area in the vicinity of vacant homes deteriorates, which has a ripple effect that is detrimental to the city as a whole.

The problems of distorted resource distribution on the housing market and vacant houses are now becoming more severe in regional cities; however, it is easy to predict that, with the passage of time, they will also have an effect on major urban centers. The issue is likely to be particularly serious in the Tokyo metropolitan area from 2030 onward.

In Tokyo and other major cities, there has been a large supply of condominiums since 1970. Given that it is more difficult to replace or convert the use of these condominiums than is the case for normal detached housing, the condominiums will make adjusting resource distribution a more difficult policy issue. That is, the vacant house problem that is already occurring in regional cities will expand to include condominiums in major cities, which is highly likely to make the problem more severe. This paper has made it clear that the problems associated with aging condominiums will increase at an accelerating rate over time. Policy measures to address this issue are urgently required.

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