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Abstract

The Japanese housing market has been experiencing a rapid increase in the number of vacant housing units due to regulatory obstacles and decreasing population. When vacant housing is not adequately managed, it can cause a negative externality in the surrounding dwelling environment, such as illegal dumping of garbage and increased risks of arson and collapse. This paper investigates the externality of vacant houses in Toshima municipality, one of 23 wards in Tokyo prefecture. We find that a vacant house devalues nearby rental prices by 1~2% on average, and vacant houses with some deficits in the property bring about greater externalities. It is estimated, for instance, that addressing vacant houses with combustible materials present would bring about an increase in property-tax income of approximately 120 million yen in total, or 1.3 million yen per vacant house. Given the substantial number of existing vacant houses, local governments should discern the types of vacant houses that are causing a serious negative externality to take efficient countermeasures to address the issue.

Introduction

The Japanese housing market has been experiencing a rapid increase in the volume of vacant housing. Figure 1 shows the trend in the number of vacant housing units (shown in bars) and the ratio to the amount of housing stock (shown in line plots) from 1968 to 2013 in Japan.[1] The vacancy rate was 4.0% in 1968, but it reached 13.5% in 2013, which is high relative to the ratios in other countries.[2] This increased vacancy ratio in Japan was mainly driven by two factors. One is the demographic trends of depopulation, a decreasing population and more nuclear families. Because the majority of housing properties owned by elderly people are old and have little market value, family members are reluctant to manage or inherit the properties. The other factor is Japan's taxation system. Property taxes that are levied on vacant land are six times higher than the property taxes on land with a building on it. These two factors distort the incentive of owners of vacant (and potentially vacant)

[1] These statistics are based on the Housing and Land Survey conducted by the Ministry of Internal Affairs and Communications (MIC).

[2] According a report published in 2013 by The Real Estate Transaction Promotion Center (available in Japanese at https://www.retpc.jp/consul/overseas_research/), the estimated vacancy rates, defined as the ratio of the gap between the volume of housing stock and the number of households to the volume of housing stock, were approximately 4% in the UK in 2011, 7% in France, 1% in Germany in 2007, 5% in Singapore in 2008, 7% in Taiwan in 2000, and 11% in the US in 2010.

houses to sell, rent or demolish the properties.

<<insert Figure 1, here>>

When vacant housing is not adequately managed, it can be a source of negative externality for the surrounding dwelling environment. In Japan, approximately 26% of vacant houses are physically damaged, and the ratio is as high as 35% for single-family vacant houses.[3] According to a survey of municipalities conducted by the Ministry of Land and Transport in 2009[4], more than 300 out of approximately 1200 municipalities that responded to the questionnaire reported that vacant housing in their municipalities had harmed the landscape and decreased the security in neighborhoods, and approximately 250 municipalities had experienced illegal dumping of garbage and arson in vacant houses. Dilapidated vacant houses can thus cause a serious negative externality. In these circumstances, potential buyers and renters are likely to pay a smaller amount to live near vacant houses than to live in a neighborhood without any vacant house.

[3] These statistics are based on visual assessments by investigators from the Housing and Land Survey in 2013 conducted by the MIC.

[4] The report on the survey can be found at http://www.mlit.go.jp/common/000117816.pdf.

To address the increasing number of vacant housing units, the national government enacted a law, the Act on Special Measures Concerning Vacant Houses, in 2015. This law allows local governments to increase the property tax or even force the demolition of a vacant house when it causes a serious negative externality or is at risk of collapse. Local governments have also gradually started to establish vacant housing ordinances to mitigate the potential risks and the negative externality associated with existing and emerging vacant housing. Local governments have attempted various measures, such as partially subsidizing the costs of demolition and renovation of old buildings, listing vacant houses whose owners are willing to sell or rent, and desterilizing unused properties for use as guest houses and places for public use. However, these measures involve enormous costs. First, the owner of a vacant house has to be identified, which sometimes takes substantial effort due to flaws in Japan's real property registration system.[5] Even if the owner is identified, because she/he is usually reluctant to cope with

[5] Although property owners are supposed to be tracked by property titles, the records are not always kept up-to-date by owners. The Act on Special Measures Concerning Vacant Houses, enacted in 2015, allows local governments to track down property owners using tax register records. Nevertheless, in the case of Toshima municipality, the local government could

the problem in the first place, numerous difficult conversations are required among the owner, family members, real estate agencies and other mediators such as NPOs to find a way to address the property. Given the huge cost of addressing a single vacant house with restricted public financing, it is impractical for a local government to cope with all of the existing vacant housing units in a municipality by itself. Local governments need to discern which vacant houses are causing a serious negative externality to implement effective countermeasures. Eventually, large-scale institutional reforms by the central government will be necessary to reduce the vacant housing stock in the long run.

The purpose of this paper is to estimate the externality of vacant houses using a hedonic approach and to assess the benefits of addressing different types of vacant houses depending on the conditions of the property. Awazu (2014) is the only published research to estimate the externality of vacant housing in Japan.[6] He uses data on vacant houses and

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not reach 121 owners out of 594 vacant family houses during a survey conducted in 2016-2017.

[6] The main reason that there are few empirical studies on the externality of vacant dwellings seems to be a lack of sufficient data. First, determining whether each property is vacant is difficult. In general, surveys of vacant houses begin with a visual assessment by investigators of houses selected from random sampling. However, data based on random sampling cannot be used to examine the externality of vacant houses in the approaches of Awazu (2014) and this research. To meet our research

assesses land prices in Soka municipality in Saitama prefecture and finds a negative relationship between the land price and the presence of a nearby vacant house. Few studies have examined externalities by focusing on vacant houses outside Japan, although there have been a number of studies on the externality of foreclosures.[7] In most cases, foreclosed houses are likely to be vacant during the period from the time when the house is seized until the time when the house is purchased by a new owner. Most studies find a negative relationship between the presence of foreclosures and the prices of nearby properties, although this does not necessarily indicate the magnitude of the negative externality of nonforeclosed vacant houses because of the confounding factors associated with foreclosed houses. Mikelbank (2008) and Whitaker and Fitzpatrick (2013) examine externalities of both foreclosed properties and vacant properties together by using data in Columbus, Ohio, and confirm the negative impact of vacant properties that are not foreclosed properties.

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purpose, the survey needs to cover all existing houses, which would require a huge cost to complete the investigation. The local governments supporting the research of Awazu (2014) and this study are two of the few municipalities to conduct large-scale surveys covering all dwelling units. The second reason is the difficulty of constructing a panel dataset because determining the timing of vacancy is challenging.

[7] For instance, Bak and Hewings (2017), Campbell et al. (2011) and Gerardi et al. (2015).

Paredes and Skidmore (2017) utilize data on dilapidated housing in Detroit to explore its externalities on nearby property prices. They estimate that one additional dilapidated house is associated with approximately 9% and 3% reductions in nearby property prices within 0.05 miles and 0.1 miles, respectively, which seems to be too large for the externality of dilapidated houses. The estimated negative externality of vacant houses in Awazu (2014) using cross-sectional data also ranges to as high as 10%. We suspect that the area of each neighborhood for which they use regional dummy variables in the hedonic estimation to control for unobserved area-specific effects is so large that the estimates reflect not only the externality of dilapidated houses or vacant houses but also the fact that the low property prices in the neighborhood lead to more dilapidated or vacant houses. Controlling for finer regional fixed effects or employing a difference-in-difference approach with panel data is necessary to separate the externality from the confounding area-specific effects.

In our study, we use 81 regional dummy variables, each of which controls for the neighborhood fixed effect of an area of 0.16 square km (400 m x 400 m) on average.

Furthermore, dummy variables for the land-use classification and the proximity to nearby apartment buildings with high vacancy rates are included in the hedonic estimation to separate area-specific effects that cannot be addressed by the regional dummy variables only. The results show that the presence of vacant houses within 50 m and within 50-100 m reduces the rental price by 1.7% and 0.8% on average, respectively. The degrees of externality vary depending on the physical conditions of the vacant houses. In particular, vacant houses with damage to the walls and the presence of combustible materials on the property contribute to larger reductions in nearby rental prices. It is estimated that addressing the 93 vacant houses with combustible materials, for instance, would bring about a 130 million yen increase in property-tax income, which provides an evidence-based justification for publicly funded countermeasures to address vacant houses.

The next two sections explain the data and the empirical strategy. Then, the estimation results are discussed, followed by a concluding remark.

Data

To examine the externality of vacant houses, we use two cross-sectional datasets. (i) One includes data on the locations and conditions of vacant houses, and (ii) the other includes data on the rents, locations and physical attributes of rental housing units around vacant houses.

(i) Data on vacant houses

The data on vacant houses are provided by Toshima municipality in Tokyo prefecture under contract research between the municipality and the authors. The data were obtained from a large-scale field survey conducted between September 2016 and March 2017. The survey was conducted in two steps. First, investigators visited all existing houses in the municipality and listed the potentially vacant houses based on visual assessment. A house was categorized as a “potential vacant house” if there was no sign that someone was living there; for instance, the mailbox was filled with flyers, and the electricity meter was not operating. In this step, 2,117 out of 28,723 family houses were listed as “potential vacant houses”. In the second step, more detailed field surveys were conducted, and letters were sent to the owners of the potentially vacant houses to confirm their vacancy. Finally, after receiving responses from the owners, 594 houses were determined to be “vacant houses”.

These vacant houses include those with no reply or with replies admitting that the houses had been left unused for a long time as well as those with unknown owners. In addition to vacant houses, the data also record the locations of apartment buildings with vacancy ratios higher than 30%.

The data on the vacant houses come with physical conditions evaluated by investigators' visual assessment. The assessed conditions include whether the building is slanted and damage to a gate, fence, wall, roof, outer wall, gutter, window shutter, balcony, nameplate, antenna, carport or shed as well as the existence of any fallen objects, exuberated branches, combustible material, mailbox and electricity meter. When the status or existence of these items could not be confirmed by visual assessment, they were reported as "unknown". Unfortunately, the survey does not record whether a gate, fence, wall, etc. exists, and therefore, the classification is likely to be "unknown" even when an object such as a gate or a fence is not present on a property, which confounds the interpretation of the estimation results. Accordingly, we use select conditions of damage regarding objects that should exist in any house, namely, wall, roof, gutter and window, for the empirical analysis.

Table 1 describes the number of vacant houses by condition.

<<insert Table 1, here>>

(ii) Data on rental housing

The data on rental housing are obtained through the website of a real estate agency, Home's.[8] Detailed addresses and various housing attributes as well as the registered rents for 4,132 listed properties in Toshima municipality were extracted from the website in July 2017. The information on the housing attributes includes floor level, floor area, number of bedrooms, walking time to the closest rail station, age of the building, type of building, type of construction structure and the existence of various amenities such as a balcony, security camera, air conditioner, etc. These attributes are used as control variables in the hedonic function introduced in the next section. Rental housing samples with missing values and outlying values of continuum variables above the 99th percentile and below the first percentile are excluded, which generates a dataset of 3,802 observations for the empirical analysis.

[8] https://www.homes.co.jp/.

By using the addresses of housing properties in both datasets on vacant houses and rental housing units, we construct variables for the proximity to (or the intensity of) neighboring vacant houses and apartment buildings with high vacancy rates.

Figure 2 shows the geographic distribution of the sample of rental housing units, in which a darker plot indicates a rental housing unit with a greater number of nearby vacant houses. The areas enclosed by solid lines are the 81 districts in Toshima municipality. Basic statistics and definitions of the variables used in the following analysis are described in Table 2.

<<insert Figure 2 and Table 2, here>>

Empirical Model

We estimate the following hedonic housing-rental-price function to examine the externality of vacant houses:

$$\ln(Rent_i) = \mathbf{VH}_i \boldsymbol{\alpha} + \mathbf{X}_i \boldsymbol{\beta} + \varepsilon_i,$$

where the dependent variable, $\ln(Rent_i)$, is a logarithmic value of the monthly rent of rental housing unit i; $\mathbf{VH}_i$ is a row vector of variables indicating the proximity to (or intensity of) vacant houses surrounding rental housing unit i; $\boldsymbol{\alpha}$ is a column vector of parameters associated with $\mathbf{VH}_i$; $\mathbf{X}_i$ is a row vector of variables for housing i's attributes and neighborhood characteristics; $\boldsymbol{\beta}$ is a column vector of parameters associated with $\mathbf{X}_i$; and ε_i is an error term.

In addition to various housing attributes, the control variables, $\mathbf{X}_i$, include 81 district dummy variables and categorical dummy variables for land-use classification as well as variables regarding proximity to nearby apartment buildings with vacancy rates higher than 30%. The district dummy variables can address the unobservable effect in each district in an area of approximately 0.16 square km (i.e., 400 m x 400 m) on average. A high vacancy rate in an apartment building may reflect the unattractiveness of the area around the apartment, or the fact that the owner does not maintain the building properly, causing a negative externality in the surrounding dwelling environment, as with vacant houses. Although we cannot distinguish between these two effects, such variables are helpful to capture the local unobservable effects that cannot be addressed by only using district dummy variables.[9]

We estimate four hedonic functions using different sets of $\mathbf{VH}_i$ as follows.

Model 1

$$\mathbf{VH}_i^1\boldsymbol{\alpha}^1 = \alpha_{50}^1 dVH_i^{50} + \alpha_{100}^1 dVH_i^{100},$$

In Model 1, the dummy variables dVH_i^{50} and dVH_i^{100} indicate rental housing i from which the closest vacant house is located within 50 m and within 50-100 m, respectively. The parameter α_{50}^1 (α_{100}^1) implies a rental price difference between a rental housing unit from which the closest vacant house is located within 50 m (between 50-100 m) and a rental housing unit from which the closest vacant house is located further than 100 m. Because the impact of an externality diminishes with distance, we expect that $\alpha_{50}^1 < \alpha_{100}^1 < 0$ if a vacant house has a significantly negative impact on a neighboring dwelling environment.

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[9] In addition to all the control variables explained in text, there is another type of variable used in the regression. Because we do not observe vacant houses outside Toshima municipality, the externality may be underestimated near the boundary of the municipality, which is known as a boundary effect. To address the boundary effect, cross-terms between the proximity variables for nearby vacant houses and dummy variables indicating rental housing samples located within 50 m and 50-100 m are added as control variables.

Model 2

$$\mathbf{VH}_i^2 \boldsymbol{\alpha}^2 = \alpha_{50}^2 dVH_i^{50(2)} + \alpha_{100}^2 dVH_i^{100(2)} + \alpha_{Dist}^2 DistVH_i,$$

In Model 2, the distance to the closest vacant house, $DistVH_i$, is introduced to examine the marginal effect of the distance to the closest vacant house, and thereby, the dummy variables are adjusted to $dVH_i^{50(2)}$ and $dVH_i^{100(2)}$, which indicate rental housing i from which the second closest house is within 50 m and within 50-100 m, respectively. If the negative impact of the closest vacant house decreases with distance, α_{Dist}^2 is expected to show a positive sign.

Model 3

$$\mathbf{VH}_i^3 \boldsymbol{\alpha}^3 = \alpha_{50}^3 cVH_i^{50} + \alpha_{100}^3 cVH_i^{100},$$

In Model 3, instead of using dummy variables, the counts of vacant houses within 50 m and within 50-100 m, cVH_i^{50} and cVH_i^{100}, are used to examine the relationship between the geographic intensity of vacant houses and nearby rental prices. Here, α_{50}^3 (α_{100}^3) implies a marginal effect of having an additional vacant house within 50 m (within 50-100 m).

Model 4

$$\mathbf{VH}_i^4\boldsymbol{\alpha}_{(j)}^4 = \alpha_{50(j)}^4 dVH_{i(j)}^{50} + \alpha_{100(j)}^4 dVH_{i(j)}^{100} + \gamma_{50(j)}^4 dVH\_ukn_{i(j)}^{50} + \gamma_{100(j)}^4 dVH\_ukn_{i(j)}^{100},$$

This model is intended to investigate the heterogeneous impacts of a neighboring vacant house depending on its physical condition. Among the various conditions of vacant houses recorded in the survey, we selected conditions for damage to the wall, roof, gutter and window as well as the existence of fallen objects, combustible material, exuberated branches and a slant to the building to be examined in the analysis. When investigators were unable to assess each of the conditions by visual assessment, the status was marked as "unknown".

In this model, the first two variables, $dVH_{i(j)}^{50}$ and $dVH_{i(j)}^{100}$, indicate rental housing i, from which the closest vacant house with a particular condition j is located within 50 m and 50-100 m, respectively. The latter two, $dVH\_ukn_{i(j)}^{50}$ and $dVH\_ukn_{i(j)}^{100}$, indicate rental housing i from which the closest vacant house with the "unknown" status on the particular condition whose condition j is located within 50 m and 50-100 m, respectively. To control for the effect of the presence of other vacant houses without any issue or uncertainty on the condition j, dummy variables regarding the presence of such a vacant house in the neighborhood are included as control variables in the regression. Given the eight types of physical conditions, we run eight separate regressions to examine how each type of vacant house influences the nearby rental price.[10]

The parameters suggest magnitudes of potential benefit (or the recovery of the rental price) when the nearby vacant houses with a particular condition are removed, replaced with a new house, or reused as a standard nonvacant house. It must be noted, however, that fixing only the damaged part of the property or removing the

[10] To provide a clearer understanding of the model, let us take the existence of combustible material as an example. Then, the variable $dVH^{50}_{i(Combustible)}$ takes the value of one if the closest vacant house where some combustible material is found is located within 50 m and zero otherwise. The variable $dVH\_ukn^{50}_{i(Combustible)}$ takes the value of one if there is a vacant house within 50 m if investigators were uncertain about the existence of combustible material and zero otherwise. The parameter $\alpha^{4}_{50(Combustible)}$ indicates the difference between the rental price due to the presence of a vacant house with combustible material within 50 m and the rental price when there is no vacant house within 100 m with any combustible material or the status is uncertain. The parameter $\gamma^{4}_{50(Combustible)}$ indicates the difference between the rental price due to the presence of a vacant house with uncertainty about the existence of combustible material within 50 m and the rental price when there is no vacant house within 100 m with any combustible material or the status is uncertain. The variables and parameters regarding the 50-100 m radius can be interpreted in a similar manner. To control for the effect of the presence of other vacant houses without any combustible material in the neighborhood, dummy variables regarding the presence of such vacant houses are included as control variables in the regression.

combustible/fallen objects does not recover the nearby rental price by what is suggested by the parameters. Rather, the parameters should be interpreted as the extent to which the nearby rental price recovers when the entire property with the vacant house is addressed. We are not able to estimate the externality caused by each particular part or object, which would require complete information on the condition of every single part of the vacant houses.

Estimation Results

We first look at Table 3 for the estimation results for Models 1, 2 and 3. The top panel of the table presents the different types of proximity variables for neighboring vacant houses and apartments with high vacancy rates used in the models. The estimated coefficients for the proximity variables are shown in the middle panel with the signs and significance levels next to the coefficients and White's robust standard errors in parentheses. The coefficients for the other variables are shown in Table A1 in the Appendix.

<<insert Table 3, here>>

For Model 1, the coefficients of dVH_i^{50} and dVH_i^{100} are -0.017 and -0.009, respectively, and they are significantly different from zero. This means that if the closest vacant house is located within 50 m (50-100 m), the rental price is lower by 1.7% (0.8%) relative to when the closest vacant house is located further than 100 m away. The coefficient of dVA_i^{50} is negative and statistically significant, indicating that the presence of an apartment building with a high vacancy rate is associated with a low rental price in the area.

For Model 2, the coefficient of $DistVH_i$ is 0.076 and is statistically significant. This result indicates that the rental price appreciates by approximately 0.8% when the distance to the closest vacant house increases by 100 m. The results also reveal that the presence of a second closest vacant house within 50 m negatively influences the rental price.

For Model 3, the coefficients of cVH_i^{50} and cVH_i^{100} are -0.007 and -0.002, respectively, and both are significant, indicating that an additional vacant house within 50 m (within 50-100 m) lowers the rental price by 0.7% (0.2%). The negative sign for cVA_i^{50} indicates that a cluster of apartments with many empty units is associated with a low rental price in the neighborhood.

These results confirm that vacant houses cause negative spatial externalities by decreasing the quality of the dwelling environment in the neighborhood. Additionally, the results show that the presence of an apartment building with a high vacancy rate is negatively correlated with nearby rental prices. The latter observation implies two possibilities: (i) the owner of such an apartment building is reluctant to maintain the property to attract new tenants such that it causes the same type of negative externality as vacant houses, or (ii) the presence of an apartment building with a high vacancy rate may reflect the fact that the surrounding area is not attractive for some reason. Although we cannot estimate these two effects separately, the proximity variables for the apartment buildings together with the district dummy variables and the land-use-classification dummy variables enable us to extract the impact of vacant houses by controlling for complex unobserved local-area-specific effects.

Next, we move to Table 4 for the results of Model 4. The first two columns, [4-1] and [4-2], show the estimated coefficients together with the signs and significance levels.

The results are obtained from eight separate regressions that each use four proximity variables regarding a particular condition. The three columns on the right are estimates of extra tax revenues in cases where vacant houses with the particular conditions are addressed. We first explain the results of the coefficients and then discuss the tax revenues.

<<insert Table 4, here>>

Regarding the coefficients for $dVH_{i(j)}^{50}$ and $dVH_{i(j)}^{100}$, the results show that vacant houses entail a negative externality if the building is slanted, if there is damage to a wall, roof or window, if there is a fallen object or combustible material, and if the house has exuberating branches[11]. Although the results are not statistically significant due to the small number of vacant houses with damage to a wall within 50 m, there may be a substantial

[11] Although the externality is expected to be more significant at a closer distance, the results do not show significant signs of a negative externality within 50 m in terms of damage to a wall, roof or window or with the presence of a fallen object, although the signs become significant at 50-100 m. There are two possible explanations for these results. First, the number of observations of rental housing within 50 m of vacant houses with these conditions is not high enough to produce significant results. For instance, there are only three and 12 vacant houses that have damage to a wall and the roof, respectively, out of 594 vacant houses, as shown in Table 1. The second possibility is that the area with a vacant house that has a particular condition is likely to also have nonvacant housing with the same condition, which can be referred to as a type of peer effect, in which people think, for instance, that it is acceptable to not fix a damaged roof because their neighbors also do not fix their roofs. Panel data and more sophisticated estimation strategies are needed to test these possibilities.

negative impact on nearby rental prices in terms of the magnitude of the coefficient. Vacant houses with combustible materials present and exuberating trees/branches also have relatively large impacts on nearby rental prices.

It is interesting to observe some negative and significant signs for the coefficients of $dVH\_ukn_{i(j)}^{50}$ and $dVH\_ukn_{i(j)}^{100}$. These results imply that a negative externality exists when there is some uncertainty about the condition of a property. In particular, uncertainty about slanted buildings has a significantly negative impact. We assume that the vacant houses that were recorded with an "unknown" status are protected by a high outer wall or trees, thus giving neighbors an uneasy feeling about the safety of the dwelling.

Using the results of Model 4, the potential increase in property-tax income in the Toshima municipality from addressing vacant houses with a specific condition can be calculated. The procedure for addressing a poorly managed vacant house, either by removing the house and replacing it with a new house or by making use of the existing house for a different purpose, requires considerable costs in money and time, including identifying the owner, communicating with all stakeholders to seek a way to address the house, and finding a new tenant or owner or someone else to utilize the vacant house. Given the limited public financing that can be used to address the vacant house issue, it is helpful to discern the types of vacant houses that have significantly negative impacts on the neighboring dwelling environment to introduce effective measures that focus on these particularly problematic houses.

We take the following steps to estimate the increase in property-tax income.

1. We assume that the relative property-price differences across districts in the municipality are the same as the relative rental-price differences across these districts. Accordingly, we regress the rental prices on the district dummy variables by using our data to estimate the relative property-price differences across districts.
2. Statistics on the annual incomes from property taxes and city planning taxes can be obtained up to the municipality level. Using the data on income from taxes as well as the number of households in each district in Toshima municipality, the average property-tax income per household in each district can be computed by taking into account the relative price difference calculated in step 1.

3. We assume that the geographic distribution of rental housing units in our data is the same as the actual geographic distribution of property units in Toshima municipality. Then, we estimate the number of households that lie within 50 m and within 50-100 m of vacant houses with each particular condition in every district.

4. The change in property-tax revenue due to the presence of vacant houses with condition j in the municipality is estimated as follows: $\Delta\text{Rev}_{(j)} = \sum_d \overline{\text{Rev}_d}\left(\widehat{\alpha^4_{50(j)}} N^{50}_{d(j)} + \widehat{\alpha^4_{100(j)}} N^{100}_{d(j)}\right)$, where d indicates the district, $\overline{\text{Rev}_d}$ is the average property tax per household in district d calculated in step 2, $\widehat{\alpha^4_{50(j)}}$ and $\widehat{\alpha^4_{100(j)}}$ are the parameters estimated in Model 4; and $N^{50}_{d(j)}$ and $N^{100}_{d(j)}$ are the number of households within 50 m and 50-100 m of vacant houses calculated in step 3, respectively. If the vacant houses with condition j are addressed, the property-tax income is expected to increase by $\left|\Delta\text{Rev}_{(j)}\right|$.

The three columns from [4-3] to [4-5] show the point estimates for the total tax increases, the tax increase per vacant house with condition j, and the 95% significance intervals, respectively. When looking at the estimates for the total tax increase, addressing vacant houses with uncertainty about the condition of the roof would generate the greatest increase in property-tax income of approximately 300 million yen. However, because the number of vacant houses with an "unknown" status regarding the roof, i.e., 465 out of 594, is high, addressing all of these vacant houses would be costly. From a cost-benefit perspective, the number of vacant houses with each of the different conditions needs to be taken into account to evaluate the benefit of targeting a particular type of vacant house.

The column, [4-4], shows the point estimates (i.e., the total increase in property-tax income divided by the number of vacant houses with a particular condition). The results indicate that addressing the three vacant houses with damage to the walls would be the most efficient in terms of a cost-benefit analysis. If the demolition cost is two million yen per house on average, removing all three vacant houses using public financing would yield a net financial benefit of approximately four million yen.

However, we should note two limitations when interpreting the results. First, the significance intervals must be assessed. Because of the small number of vacant houses with damaged walls, the standard deviation of the estimate is so large that evaluating the benefit just by looking at the point estimate is not convincing enough. In this regard, addressing vacant houses with exuberated branches or combustible materials, or with uncertainty about the building slant, would produce tax gains greater than one million yens per vacant house with a higher probability. Furthermore, as mentioned previously, the cost associated with addressing vacant houses not only includes the cost of demolition or rehabilitation but also involves difficult and time-consuming communications and arrangements with the stakeholders. Nevertheless, local governments should recognize the potential benefits of targeting different types of vacant houses to make better decisions with regard to countermeasures.

Conclusion

We estimated the externality of vacant houses in Toshima municipality in Tokyo, Japan, using a hedonic approach with data on 594 vacant houses and 3,806 rental housing units. The estimation results reveal that having the closest vacant house within 50 m and 50-100 m reduces the nearby rental price by 1.7% and 0.9% on average, respectively. Confounding neighborhood-specific effects are addressed by introducing very fine district dummy variables, categorical dummy variables on land-use classifications and proximity variables for nearby apartment buildings with high vacancy rates. Furthermore, vacant houses with combustible materials on the property, damaged walls, and where there is uncertainty regarding the presence of a slanted building tend to have greater negative externalities. The results indicate that by focusing on addressing vacant houses with combustible materials for instance, the local government of Toshima municipality can increase its property-tax income by approximately 120 million yen, or 1.3 million yen per vacant house. These figures are approximately the same in the case of vacant houses with uncertainty about whether the building is slanted. Addressing vacant houses with damaged walls would contribute to significantly improving the surrounding dwelling environment, although more observations of vacant houses with this condition are necessary to generate compelling evidence. With the limited public finances, it is essential for local governments to identify the vacant houses that are causing a serious negative externality to implement efficient countermeasures. Because the housing market situation differs widely across regions, examining the externality of vacant houses by conducting a survey and analysis as in this study is essential. Lastly, although the Japanese government has long been promoting constructions of new residential buildings through a variety of policies to stimulate the economy, the institutional reform to utilize the existing housing stock is necessary in the context of the decreasing population and the increasing number of vacant houses.

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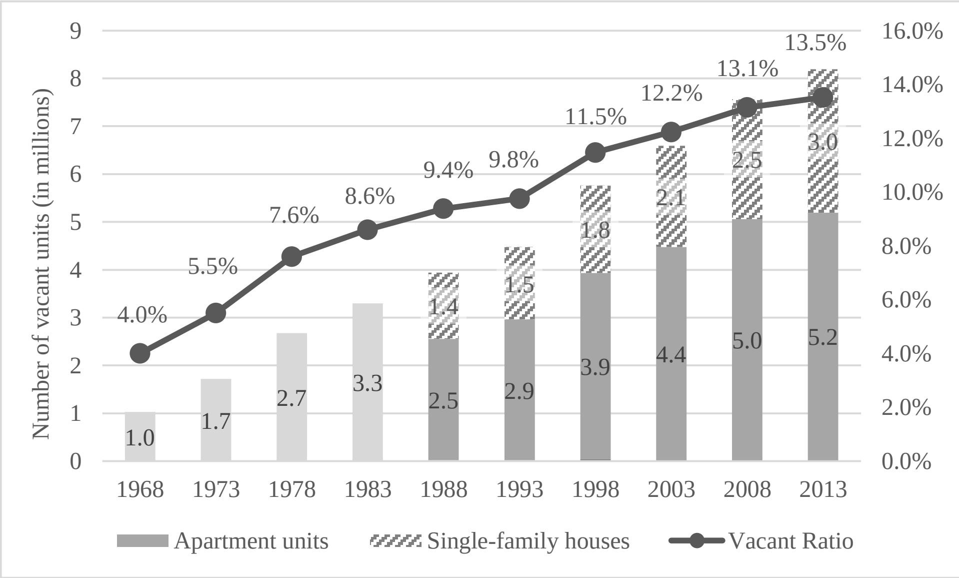
Appendix

<<insert Table A1, here>>

Figure 1: Number and ratios of vacant housing units in Japan



Source: Housing and Land Survey conducted by the Ministry of Internal Affairs and Communications.

Figure 2: Distribution of rental housing units and number of vacant houses within 50 m

The map shows the geographic distribution of the rental housing unit sample used in the regression analysis. Darker colors indicate a greater number of vacant houses within 50 m in the sample. The empty areas without any rental housing units are a large rail station (Ikebukuro station), universities (Gakusyuin Women's College, Tokyo College of Music, and Rikkyo University) and cemeteries (Zoshigaya cemetery and Somei cemetery).

Table 1: Conditions of vacant houses (out of 594 vacant houses)

Variables used in estimations for Model 4 and 5		obs.
Lean	1 = building slants	22
Lean_ukn	1 = condition of the building slant is unknown	90
	every wall of the building stands vertically	482
Wall	1 = wall is damaged	3
Wall_ukn	1 = condition of a wall is unknown	430
	wall is not damaged	161
Roof	1 = roof is damaged	12
Roof_ukn	1 = condition of a roof is unknown	465
	roof is not damaged or does not exist	117
Gutter	1 = gutter is damaged	44
Gutter_ukn	1 = condition of a gutter is unknown	178
	gutter is not damaged or does not exist	372
Window	1 = window is damaged	41
Window_ukn	1 = the condition of windows is unknown	150
	all windows are not damaged	403
Other	1 = no damage on the property except those listed above	105
Other_ukn	1 = condition of the property except those listed above is unknown	146
	nothing is damaged in the property apart from those listed above	343
FallenObj	1 = fallen object exists	15
FallenObj_ukn	1 = existance of a fallen object is uncertain	198
	no fallen object exists	381
Branch	1 = tree and/or long shoot exuberate	89
Branch_ukn	1 = existance of tree or long shoot is uncertain	77
	tree or long shoot does not exist	428
BurnableObj	1 = burnable object exists	93
BurnableObj_ukn	1 = existance of a burnable object is uncertain	152
	burnable object does not exist	349

The survey assesses the conditions of vacant houses regarding whether there is any damage to a gate, fence, wall, roof, outer wall, gutter, window shutter, balcony, nameplate, antenna, carport or shed as well as regarding the presence of any fallen object, exuberating trees and branches, combustible materials, a mailbox and an electricity meter. Unfortunately, the survey does not record the presence of a gate, fence, wall, etc., and therefore, the classification is likely to be "unknown" even when an object such as a gate or a fence is not present, which confounds the interpretation of the estimation results. Accordingly, we use variables for damage only for objects that should exist in any house, namely, walls, roof, gutters and windows, in the empirical estimation.

Table 2: Basic statistics on rental housing sample

Variables		Definition	Mean	S.D.	Min.	Max.
	Rent		9.27	3.28	4.5	24.9
Proximity variables to vacant houses						
	Dist	Distance to the closest vacant house (km)	0.10	0.06	0.01	0.32
	VH50	Number of vacant houses within 50m	0.31	0.62	0	3
	VH100	Number of vacant houses between 50-100m	0.99	1.36	0	7
	dVH50	1 = closest vacant house within 50m; 0 = o.w.	0.25	0.43	0	1
	dVH100	1 = closest vacant house between 50-100m; 0 = o.w.	0.34	0.47	0	1
	dVH50_2	1 = second closest vacant house within 50m; 0 = o.w.	0.07	0.25	0	1
	dVH100_2	1 = second closest vacant house between 50-100m; 0 = o.w.	0.28	0.45	0	1
Proximity variables to apartment buildings with high vacancy rates						
	VA50	Number of apartments with vacant units > 30% within 50m	0.31	0.55	0	2
	VA100	Number of apartments with vacant units > 30% between	0.93	1.05	0	4
	dVA50	1 = closest apartment with vacant units > 30% within 50m; 0	0.27	0.45	0	1
	dVA100	1 = closest apartment with vacant units > 30% between	0.40	0.49	0	1
Control variables						
	FLevel	Floor level	3.66	2.90	1	16
	FArea	Floor space (square meter)	27.62	11.46	10	76.06
	Bedrooms	Number of bedrooms	1.16	0.41	1	3
	Age	Age of the building (month)	249.17	160.65	2	632
	Undergrand	1 = unit located underground; 0 = o.w.	0.02	0.13	0	1
	New	1 = none ever lived in the unit; 0 = o.w.	0.08	0.26	0	1
	FL1	1 = unit located on the first floor of the building; 0 = o.w.	0.19	0.39	0	1
	South	1 = a window facing south; 0 = o.w.	0.23	0.42	0	1
	Park	1 = parking lot available; 0 = o.w.	0.08	0.27	0	1
	AutoLock	1 = building entrance with an autolock system; 0 = o.w.	0.53	0.50	0	1
	AC	1 = air conditioner equipped; 0 = o.w.	0.96	0.19	0	1
	UnitBath	1 = bath and toilet in separate rooms; 0 = o.w.	0.71	0.45	0	1
	AutoBath	1 = automatic bath water boiling system equipped; 0 = o.w.	0.22	0.41	0	1
	Flooring	1 = wooden floor; 0 = floor is made of other materials	0.78	0.42	0	1
	Pet	1 = pet is allowed; 0 = o.w.	0.10	0.30	0	1
	Available	1 = unit is available to rent out immediately; 0 = o.w.	0.76	0.43	0	1
	Insurance	1 = required to buy a residencial insurance; 0 = o.w.	0.98	0.15	0	1
	SecurityCam	1 = sequrity camera system; 0 = o.w.	0.26	0.44	0	1
	CityGas	1 = gas provided by city gas; 0 = o.w.	0.86	0.35	0	1
	PC	1 = prestressed concrete; 0 = o.w.	0.17	0.37	0	1
	RC	1 = reinforced concrete; 0 = o.w.	0.52	0.50	0	1
	SRC	1 = steel-reinforced concrete; 0 = o.w.	0.12	0.32	0	1
	Apartment2	1 = luxury apartment; 0 = o.w.	0.80	0.40	0	1
	Box	1 = apartment with parcel lockers; 0 = o.w.	0.30	0.46	0	1
	DistStation	Walking time distance to the closest station	6.24	3.33	1	1
Categorical						
	Transportation_l	1 = train/subway line l on the closest station; 0 = o.w.				
	LandUse_s	1 = land-use classification is s ¥in (regidencial area,				
	District_d	1 = unit located in district *d*; 0 = o.w.				

Table 3: Estimation results for Models 1, 2 and 3

	Model 1	Model 2	Model 3
Variables			
VH50	*dVH50*	*dVH50(2)*	*cVH50*
VH100	*dVH100*	*dVH100(2)*	*cVH100*
VA50	*dVA50*	*dVA50*	*cVA50*
VA100	*dVA100*	*dVA100*	*cVA100*
Variables about neighbor vacant houses			
VH50	-0.017***	-0.016**	-0.007**
	(0.005)	(0.007)	(0.003)
VH100	-0.009*	-0.000	-0.002*
	(0.004)	(0.005)	(0.001)
DistVH		0.074*	
		(0.040)	
Variables about neighbor apartments with high vacancy rates			
VA50	-0.012**	-0.011**	-0.009***
	(0.005)	(0.005)	(0.003)
VA100	-0.005	-0.004	0.001
	(0.004)	(0.004)	(0.002)
Observations	3806	3728	3691
R2	0.9212	0.9217	0.9210

***, **, * indicate significance at 1%, 5%, and 10%, respectively. White's robust standard errors are in parentheses.

Table 4: Estimation results for Model 4 and additional property-tax income

		Model 4		Estimates of increase in property tax income (in 1,000 yen)				
				Total		Per vacant house		
		dVH50(j) *dVH_ukn50(j)*	*dVH100(j)* *dVH_ukn100(j)*	Point estimates		Point estimates	95% conf. interval [lower/b, higher/b]	
		[4-1]	[4-2]	[4-3]		[4-4]	[4-5]	
Estimations								
(1)	*Lean*	0.006	-0.021**	-9,983		-454	-3,074	2,167
	Lean_ukn	-0.035***	-0.013**	120,139	***	1,335	650	2,019
(2)	*Wall*	-0.073	-0.036*	19,661		6,554	-6,479	19,586
	Wall_ukn	-0.014***	-0.008*	215,282	***	501	192	809
(3)	*Roof*	-0.006	-0.028**	8,519		710	-133	2,746
	Roof_ukn	-0.017***	-0.011***	299,948	***	645	342	948
(4)	*Gutter*	-0.007	-0.006	18,647		424	-416	1,264
	Gutter_ukn	-0.015***	-0.004	83,408	**	469	47	890
(5)	*Window*	-0.021*	-0.001	19,808		483	-428	1,394
	Window_ukn	-0.010	-0.006	65,087	*	434	-451	318
(6)	*FallenObj*	-0.015	-0.019*	15,831		1,055	-445	2,555
	FallenObj_ukn	-0.011*	0.003	10,755		54	-403	512
(7)	*Branch*	-0.019**	-0.006	91,543	**	1,029	156	1,901
	Branch_ukn	-0.015*	0.010*	-17,345		-225	-960	509
(8)	*Combustible*	-0.022**	-0.020***	124,005	***	1,333	672	1,995
	Combustible_ukn	-0.017**	0.004	190,770	*	1,255	-11	2,521

***, **, * indicates significance at 1%, 5%, and 10%, respectively. Confidence intervals and significances of the estimates of increases in property tax income are computed based on the delta method.

Table A1: Estimation results for Models 1, 2 and 3

	Model 1	Model 2	Model 3
Variables about neighbor vacant houses and apartments of high vacancy rate			
VH50	*dVH50*	*dVH50(2)*	*cVH50*
VH100	*dVH100*	*dVH100(2)*	*cVH100*
VA50	*dVA50*	*dVA50*	*cVA50*
VA100	*dVA100*	*dVA100*	*cVA100*
Variables			
VH50	-0.017***	-0.016**	-0.007**
VH100	-0.009*	-0.000	-0.002*
DistVH		0.074*	
VH50	-0.012**	-0.011**	-0.009***
VH100	-0.005	-0.004	0.001
Control variables			
FLevel	0.009***	0.009***	0.009***
FArea	0.027***	0.027***	0.028***
FArea^2	-0.000***	-0.000***	-0.000***
Bedrooms	0.014**	0.016**	0.015**
Age	-0.001***	-0.001***	-0.001***
Age^2	0.000***	0.000***	0.000***
DistStation	-0.000	-0.000	-0.001
New	0.012	0.015*	0.013
FL1	-0.017***	-0.016***	-0.017***
South	0.012***	0.013***	0.012***
Park	0.023***	0.022***	0.023***
AutoLock	0.030***	0.030***	0.030***
AC	-0.016*	-0.017**	-0.017*
SharedBath	-0.025	-0.023	-0.021
UnitBath	0.029***	0.029***	0.028***
AutoBath	0.027***	0.025***	0.025***
Flooring	0.010**	0.011***	0.009**
Pet	0.031***	0.028***	0.031***
Available	0.014***	0.014***	0.015***
SecurityCam	0.007	0.008*	0.007*
CityGas	-0.013**	-0.013**	-0.013**
Box	0.012**	0.011**	0.010**
LuxApartment	0.001	0.003	0.002
Fixed effects			
Building Structures (4)	X	X	X
Districts (81)	X	X	X
Train/Subway lines (13)	X	X	X
Land-use zonings (8)	X	X	X
Observations	3806	3728	3691
R2	0.9212	0.9217	0.9210

***, **, * indicate significance at 1%, 5%, and 10%, respectively. White's robust standard errors are in parentheses.