DISCUSSION PAPER SERIES

Discussion paper No.60

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October, 2010

MASTERY FOR SERVICE

SCHOOL OF ECONOMICS

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The impact of crime on housing land prices and the effects of police boxes and voluntary groups on crime prevention in Japan*

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Many people now fear crime in Japan, which has had the image of being a safe country, because the crime rate has increased dramatically and the rate of crime detection has decreased at the same time. As demand for low-crime residential areas becomes stronger, low-crime rates may affect land prices in Japan. High levels of land prices may reflect the high economic value of low-crime neighborhoods. However, the Ordinary Least Square (OLS) estimate may cause a bias because the crime rate is not necessarily an exogenous determinant of land price. Therefore, in this study, we adopt the instrumental variable (IV) method, and use instrumental variables such as distance from police boxes and existence of voluntary anti-crime groups, and analyze the effects of property crime rates on residential land prices. The results show that a 10% decrease in the rate of burglaries causes an average rise in residential land prices of 1%.

Keywords: Property Crime, Police box, Voluntary crime-prevention group, Instrumental Variable, Propensity Score Matching

JEL Classification: R21; R22 ; R28

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1． Introduction

Japan is well known as a country with fewer crimes in urban areas compared to other developed countries. However, during the 1990s and the 2000s the number of crimes has been increasing dramatically in major cities. The number of crimes in 2006 was about 1.5 times of that 30 years before. On the other hand, the rate of crime detection is only 31.2%, which is a decrease of half from 60% some 30 years ago.[1] According to the National Police Agency of Japan, the total number of recognized criminal-law criminals in 2006 still exceeds 2,000,000, although it is not as high as the figure of about 2,850,000 estimated in 2002.

Within cities, crime is spatially concentrated. For example, in Hikawadai、Nerima ward, the northeast area of the Tokyo Metropolitan Area[2], there were 1.552 burglaries per 100 households in residential areas in the average of 2005-2007,which are 6 times more than the average number of all neighborhoods, 0.258. On the other hand, the figure in Minami-Shinozakicho 5 Chome, Edogawa ward (east area of Tokyo) was 0 from 2005 to 2007. We can find the difference of the number of burglaries not only between wards but also within each ward. For example, in Shibuya ward, the southeast area of the Tokyo Metropolitan Area, the number amounts to 0.360, which are about 1.5 times as many as the average number of every ward, 0.258. On the other hands, the number in Hiroo 2 Chome amounts to 0.966, which are more than 9 times more than the number in Hatagaya 3 Chome, 0.094. Therefore the difference of the number of crimes may be seen at the ward level, but the agglomeration is not caused by each ward itself, but caused by the characteristics

[1] National Police Agency released the figures in the 2008 Police Whitepaper

[2] The area of the 23 wards of the Tokyo Metropolitan area is 621.97 km^2. There were 4,242,089 households, with 8,318,848 persons in the area in 2007.

of neighborhood or location as stated later.

The spatial concentration of crime is shown clearly by mapping the incidence of crime geographically. Figure 1 illustrates the geographical distribution of burglaries in the 23 wards of Tokyo. The map is constructed by counting crimes per 100 households in neighborhoods in 2005. The locations of police boxes are also plotted on the map. High-crime areas exist along major roads and in the southwest area where old wooden buildings are concentrated.

The spatial concentration may be caused by the locations of police boxes or the number of voluntary group members. Police boxes (called "*Koban*" in Japan) form part of a widely prevalent police system along with police stations. Several policemen stationed in police boxes monitor the safety of a neighborhood, make crime reports, and arrest criminals. The number of crimes per 100 households (crime rate) in a neighborhood far from a police box may be high because the frequency of patrols and monitoring by policemen decreases as the distance from a police box increases.

Voluntary crime-prevention groups are organized with the assistance and advice of the Police Agency in Japan. They engage in crime-prevention activities such as providing regional safety information to their neighborhoods, patrolling, finding crimes, and reporting to the police. They have neither firearms nor any equipment for their personal safety and cannot replace the activities of the police, but by patrolling neighborhoods they may contribute to their safety.

The Metropolitan Police research voluntary group members and publish their numbers for the areas covered by police stations, which may comprise several neighborhoods, every year. We can obtain the ratio of the number of voluntary group members to the population in each neighborhood. The crime rate in a neighborhood with a high ratio of voluntary group members may be low because of a voluntary group's activities.

Although most residents of high-crime areas may not suffer from property crime directly because they can increase their level of security by themselves, they may face economic losses from a devaluation of land prices because some residents of high-crime areas move to low-crime areas for fear of crime. This movement would cause economic losses through an emigration of labor from the area and a decrease of residential land demand, which would accelerate the increase of crime and a spiraling decline of land prices. On the other hand, demand in low-crime areas will increase. Therefore, the low-crime residential land price will increase, which reflects the utility of residents of low-crime areas. By analyzing differences between land prices in low-crime areas and those in high-crime areas, we can determine how residents evaluate security. The analysis would be useful for planning crime-prevention measures in the city in the future.

Estimating the effects property crimes in a neighborhood have on land prices has not been attempted until recently in Japan, because the police authority did not publish data on crimes at a geographically localized level until 2001. The Metropolitan Police Bureau has published detailed data in Tokyo since 2002.

There are two fundamental problems with an empirical analysis of the impacts of property crimes on land prices.

First, the crime rate is an endogenous variable, and a negative correlation between land prices and crime rates does not necessarily mean that an increase in the crime rate decreases land prices, because changes in the value of land also changes the behavior of criminals, affecting the number of crimes in each neighborhood simultaneously when the number of property crimes affects land prices in that neighborhood. For example, in a high land-price area, where high-income residents may live, we observe a higher number of burglaries because criminals target the properties of wealthy people. At the same time, high-income households can afford to keep a good environment in their neighborhoods, which drives land prices higher. In this case, the estimated coefficients of Ordinary Least Square (OLS) will be positively biased and we may find a positive relationship between crime and land price from OLS, even though the causal relationship between crime rate and land price is negative. On the other hand, low land prices may attract low-income residents who cannot afford to keep a good environment in their neighborhood, which drives land prices lower. We also observe many property criminals in areas where the proportion of low-income residents is high, because low-income criminals are prone to commit crimes in their own neighborhoods because of transportation costs and low-income residents cannot afford to defend themselves against crime. (As a result, fewer criminals can be found in an area where the proportion of middle-class people is higher than in the other area.) In this case, the regression estimation may be biased toward a negative relationship. As a result, an OLS regression can lead us to a biased estimation because of the endogeneity of crime.

Second, there may be measurement errors in reported crime data in addition to the bias caused by endogeneity.

Simultaneity and measurement errors can cause a bias in the estimated effects of crime on land prices obtained by the OLS regression. To solve the problem, we adopt the Instrumental Variable estimation (IV) using panel data and Propensity Score Matching (PSM).

In this study, we analyze the factors that affect the crime rate (the number of crimes per 100 households) and estimate land price in the 23 wards of Tokyo using explanatory factors including the crime rate. The analysis covers burglaries and felonious or violent crimes and the effects in several levels of crime rates. The crime rate is estimated using certain factors as instrumental variables, for example, the distance from police boxes or the ratio of the number of voluntary group members working to prevent crimes to the population in each neighborhood. In addition, we divide the land market into several submarkets by its characteristics and regions, and analyze the effect of crimes in the submarkets.

The paper is organized as follows. In Section 2, we introduce previous studies on the effects of crime rates on land prices. In Section 3, we introduce the data, model and method we use in this report. In Section 4, we present the results of the estimation, and then offer conclusions in Section 5.

2. Brief review of the literature

Several studies in the US and the UK estimate the influence of crime rates on property values based on the Hedonic approach. Although considerable research has been conducted to analyze the determinants of land prices in urban areas in Japan by OLS, few studies examine the effects of crime rates on land prices.

In the US, Thaler (1978) analyzed the effects of property crime rates on land prices in Rochester, New York. Thaler set up a model explaining house prices using property crimes per unit of population as well as land-use form, distance from public accommodation and rooms, and claims that property crimes have significant effects on house prices. Hellman and Naroff (1979) estimated the determinants of housing prices in Boston using distance from the downtown area, household income level, and crimes per 1000 persons based on the theoretical model of Muth (1969). They concluded that crimes have negative effects on housing prices, and that the elasticity is -0.63. Lynch and Rasmussen (2001) attempted to use the Hedonic analysis to estimate the effects of violent and property crimes on house prices in Jacksonville, Florida through neighborhood variables such as percentage of Hispanics, percentage of owner-occupied housing, and median household income as independent variables. Violent crimes per unit of population have negative effects on house prices, but property crimes per unit of population have positive effects.

In these studies, the endogeneity of crime rates was not considered. As mentioned before, housing prices or land prices can affect crime rates simultaneously. The endogeneity of crime will cause a bias in the estimation.

Bowes and Ihlanfeldt (2001) analyzed factors affecting crimes in Atlanta. They showed that crimes per acre have a significantly negative influence on house prices and that crime rates become high when the proportion of low-income people is high. However, they estimated the determinants of crime and house prices independently, and they did not conduct simultaneous estimations of crime rates and house prices.

Gibbons (2004) investigated the determinants of property value in London using a measure of crime damage per 100 squares, space, floors, building years, distance to city center (Soho district), building density, households density, population density, distance to nearest subway station, and distance to the council office as explanatory variables. He used the IV estimation and showed that crime damage affects housing land prices and that a 10% increase in crime leads to a fall of property values of 1.5%.

In addition, Linden and Rockoff (2006) clarified that house prices in the neighborhood of criminals fell because location information on criminals provided by the enforcement of Megan's Law was disclosed. In other words local property values fell because the residence of a criminal was regarded as a threat to security.

Few studies conducted empirical analyses on the relations between land prices and crimes in residential areas in Japan. Hiraoka (2005) empirically analyzed the relationship between crime rates and land prices in Osaka, but his results showed no significant relationship between crime rates and land prices. Kutsuzawa, Yamaga, Mizutani, and Ohtake (2007) analyzed the effects of crime rates on land prices by the instrumental variable method using locations of police boxes, ratio of low-income people, and ratio of road area as instrumental variables for crime rates from cross-sectional data. The analysis showed that a 10% increase in crime causes a 1.7% decrease in land prices. The data include neither time-series crime data nor voluntary group members and the number of land price sample amounts to less than 1,000, therefore the analysis covers neither panel-data analysis nor Propensity Score Matching and it did not cover the analysis of voluntary group members' activities. Only burglary crimes were analyzed and felonious or violent crimes were not analyzed. The segregation of the market is attempted in only geographically divided areas.

Based on previous literature, we estimated the effects of various crime rates on land prices in the 23 wards of Tokyo using panel data from 2005 to 2007. Its samples amount to more than 18,000, and we analyzed the submarkets divided by several areas and characteristics.

Because crime rates are endogenous variables, we estimated the effects of crime rates on land prices using distance from police boxes and voluntary members rate as instrumental variables. In addition, we also use Propensity Score Matching to test the validity of the IV analysis.

３. Methodology

We estimated the Hedonic land price model using crime rates, location characteristics, and neighborhood characteristics as explanatory variables. In the estimation, we treated crime rates as an endogenous variable because the number of property crimes can be affected by regional factors such as locations of police boxes or voluntary members ratio.

Table 1 shows definitions of dependent, explanatory, and instrumental variables, and Table 2 summarizes these variables.

(1) Data

We used the land price data provided by the Tokyo Real Estate Foundation, which is a business organization of real estate enterprises in Tokyo. The Foundation conducts a survey of land prices on March 1st every year in the area of the 23 wards of Tokyo. The Foundation ask its members (they are appraisers qualified by the Ministry of Land, Infrastructure, Transport and Tourism) to evaluate the land price. They evaluated the land price based on the Appraisal Standard which the Minister of Land, Infrastructure, Transport and Tourism designated.

The data include land price data at around 6,000 points of residential areas, location characteristics data, and neighborhood characteristics data.

We also obtained data on the number of crimes including burglaries and felonious or violent crimes[3] in more than 3,000 neighborhoods that are small block areas called "*chome*" or "*machi*." The data were recorded and supplied by the Metropolitan Police Agency. We calculated the sum of crimes per 100 households in the neighborhood as *crime rate* and analyzed the relationship between crime rate and land price. The Metropolitan Police Authority has the data of crimes in each neighborhood area and discloses them at neighborhood level. It discloses neither meshed data nor data at street level or point level. The limited disclosure of locations of property crimes may bias the estimated coefficient. The addresses in the cities of Japan, however are neither formulated in street level nor buffers level, but in neighborhood level. The data of land price can be matched to the crime data by the address formulation based on neighborhood. We, therefore use the data of crimes on the level of neighborhoods.

[3] Felonious crimes include murder, robbery, arson and rape. Violent crimes include assault, bodily injury, intimidation and extortion.

The average area of a neighborhood was 19.84 ha, and there were 1,355 households and 2,657 residents in an area on average. The number of burglaries from 2005 to 2007 was 0.258 cases per 100 households in each neighborhood on average.

The crime rates are different not only among wards but also neighborhoods, and the differences are caused not by each ward itself, but by the characteristics of location or neighborhood. The data of crime data is researched only by the Tokyo Metropolitan Authority coincidently and no other observation is included. Land price has nothing to do with the ward the point is belonging to, because the residents are not interested in the ward of their residence, but in the characteristics of their residence, and crime rates have nothing to do with the ward where crime rates show, because criminals also tend to commit the crimes not in the specific wards, but in the place which is favorable for them to do.

Therefore, we assume the crime rates are not clustered at the ward level and we use the IV estimation just with robust standard error method and panel IV estimation as shown in (2) and (3).

We also used location characteristics and neighborhood characteristics data as explanatory variables of land prices.

Location characteristics variables include walking time from a sample point to the nearest station, travel time from the nearest station to Tokyo Station, city planning regulations on land use, building space per site and floor space per site, and dummy variables for railway or subway lines of the nearest stations.

Neighborhood characteristics variables include percentage of owner-occupied households, "unburnable rate" (which means the proportion of non-wooden building floor space of total building floor space), the rate of households within annual household income groups (6 groups: below 3 million yen, from 3 million to 5 million yen, 5 million yen to 7 million yen, 7 million yen to 10 million yen, 10 million yen to 15 million yen, and more than 15 million yen), and the proportion of land use in each neighborhood (We used the proportion of commercial use, industrial use, farm and agricultural use, roads, and parks). We also used the average area of housing floor per person in the neighborhood as an alternative variable to household income to imply the affluence of households in the neighborhood.

We calculate the walking time from the nearest station and travel time from Tokyo Station using "Yahoo! Travel" "Yahoo! Map." Data on land use, wooden building floor space, and percentage of owner-occupied households were obtained from the City Planning Bureau of the Tokyo Metropolitan Government. We obtained data on the number of households within annual household income groups from UDS Co. Ltd., which makes the model based on the data of the household number of each ward within several annual income levels in the Housing and Land Survey and their characteristics data in the National Census.[4] The UDS data is trustworthy and even in

[4] The Housing and Land Survey shows us the number of households within annual household income groups in each wards. In the National Census we can see the data of the number of various kinds of residents such as high school graduates, college graduates, university graduates, 20-34 years persons, 40-59 years persons, professional workers, technical workers and administrative workers in 100 meter square meshes, which are assumed to be correlated to annual income. UDS makes the model to explain the number of residents within annual household income groups in each mesh by using the above characteristics of the residents. UDS calculates the number of residents in the meshes by using the model and they also count the number in each neighborhood based on the data by each mesh.

the research subsidized by the national government, the data is utilized.

In addition, we obtained data on the distance from property to police boxes (including police stations)[5] and number of voluntary group members involved in crime-prevention activities. We used these as instrumental variables to explain the crime rate. There are about 6,000 police boxes in Japan (1,000 police boxes are in the 23 wards of Tokyo), and according to the Police Whitepaper (2006) by the police agency, at least 2 policemen in each police box are on duty all the day and their activities in police box are expected to prevent crimes in neighborhoods. Consequently, its scale and function is not different among police boxes[6].

We measured the distance between property and police boxes using the GIS system of the Center for Spatial Information Science at University of Tokyo (CSIS). The distance was assumed to affect the capacity of the police to prevent crime, because the frequency of patrols and monitoring by policemen decreases as the distance from police boxes increases.

The Tokyo Metropolitan Authority can set new police box or change the location, and the distances from police boxes is changing as shown in Table 3, and we assume that the longer it becomes, the larger the number of crimes tends to be, because the effect of policemen's activities will be weaker in the farther place from police boxes. Police box is peculiar system in Japan , and there are few studies about the relationship between crimes and the distance from the police boxes except our analysis. Ahmadi

[5] Several police officers stay at police station and they are involved in similar activities to the one in police boxes, but their works are mainly administrative work in several neighborhoods area.
[6] We do not have more detailed data about the scale and function about police box, we, therefore, do not use synthetic variables.

(2003), however, point out that the number of crimes have a positive relationship with the distance of police stations, and the relationship between crimes and police station can be applied to the relationship between crimes and police boxes, because the function of police stations is similar to that of police boxes. The police authority may increase police boxes in the neighborhoods where crimes are increasing, and the distance from police boxes may have negative relationship with crimes. The police authority in Japan must cope with the demand of local residents equally and the budget of the Metropolitan Police Authority is limited. As a result, police boxes tend to be set spatial equally and the number of police boxes in each ward is changed gradually as shown in Table 4. We show the validity of our assumption that the distance from police boxes have positive effect on the crime rates in neighborhoods in the IV analysis and panel IV analysis of Section4.

The number of the members of voluntary groups involved in crime prevention has been increasing rapidly in Japan and numbered over 40,000 in 2008. For example, one voluntary group, which is called "Meidaimae Peace Makers," is involved in crime-deterring activities such as patrolling in Setagaya Ward, located in southwest Tokyo, and contributes significantly to reducing burglaries. As Calquhoun (2004) pointed out, the activities of the neighborhood watch provide the police with "good eyes and ears" in the United Kingdom neighborhood watch groups and voluntary crime–prevention groups contribute to preventing crimes in neighborhoods.

The police authorities in Japan regard these voluntary groups as important partners for deterring crimes. The police authorities encourage many citizens and private companies to organize voluntary groups for crime prevention to secure community safety, and collect data on the number of groups and their members in the area around each police station.

We obtained data from the Tokyo Metropolitan Police Authority on voluntary group members in the 23 wards of Tokyo that are assumed to affect crimes.

The number of voluntary group members from 2005 to 2007 is shown in Table 3. The rate of voluntary members group is increasing and the crime rates are decreasing from 2005 to 2007.

We assume that the larger the number of voluntary members is, the smaller the rate of crime is, because many voluntary members will be better guard against burglaries. In the place of the high crime rate, they may consider their participation in voluntary group to prevent the increase of crime rates and the loss of their own property, but they can move to the place of low crime rate to avoid the damage by the increase of crime rate or the burden of the activities in the voluntary groups. We, therefore assume high crime rates in the neighborhoods do not cause the high rate of voluntary group members. We show the validity of our assumption in IV analysis and panel IV analysis of Section4. We also testify the influence of crime rate on voluntary members rate by using the time lag variable.

(2) OLS and IV estimation

For the paper, we estimated the function of housing land price by specifying the explanatory variables of crime rate and other factors, and we estimated the property crime rate from instrumental variables to respond to the endogeneity problem of the crime rate.

The estimated model for land prices is expressed by Equation (1), which is a standard Hedonic price model with information specific to a property (For example, walking time to the nearest station, travel time from the nearest station to Tokyo Station, regulation of city planning on land) and number of property crimes in the neighborhood.

$$\ln P_i = \alpha + \beta x_i + \gamma CrimeRate_i + \phi year_i + \varepsilon_i \tag{1}$$

$\ln P_i$ is the log-price of property i; x_i is a set of exogenous variables that indicate property characteristics and neighborhood characteristics; $CrimeRate_i$ is crime rate, that is burglaries per 100 households and felonious or violent crimes and per 100 households in the neighborhood where property i is located; $year_i$ is a set of dummy variables for the year when land price was researched; and, ϵ is a random error term. If the increase in the crime rate decreases land prices in the area including point i, parameter γ should be negative. The problem is that information on property i is not always completely observed, and that unobserved information is treated as an error, which can be related to the number of property crimes in each area. In other words, we cannot distinguish whether the land price is high because the number of burglaries in the neighborhood is high or the number of crimes is high because the land price in the neighborhood is high. The instrumental variable method is an effective means to solve the problem. The relationship between crime rate and instrumental variables can be expressed by Equation (2).

$$\begin{aligned} &CrimesRate_i = \rho + \delta Z_i + \sigma x_i + \lambda year_i + \upsilon_i \\ &Cov(z, \varepsilon) = 0 \end{aligned} \tag{2}$$

Z_i in Equation (2) is a set of instrumental variables. We adopt the distance between police boxes and property *i* (including police stations, distance from police boxes) and the ratio of the members of voluntary groups working to prevent crimes to the population in the neighborhood of property *i* (voluntary members ratio) as instrumental variables that could influence the property crime rate.

Because we assume that the activities of the police to prevent crimes in the neighborhood will become weaker as the distance from police boxes increases, distance is assumed to have a positive effect on the crime rate.

When the voluntary member ratio is high, the crime rate is expected to be low, because many members of voluntary groups watch over the safety of the neighborhood. Therefore, the coefficient of the crime rate for the voluntary member rate is expected to be negative.

We try to estimate the effect of crime rates on land price by using distance from police boxes and voluntary members rates as instrumental variables.

(3) Panel IV estimation

In addition to the IV cross-sectional analysis, we conducted an IV estimation using panel data to examine the effects of crime rate on land price, because crime rate may be correlated with an unobservable fixed effect. The estimation model for land price using panel data is expressed by Equation (3), where δ is error over panels, and η is idiosyncratic error.

$$\ln P_{it} = \alpha_t + \beta x_{it} + \gamma CrimeRate_{it} + \delta_t + \eta_{it} \qquad (3)$$

In Equation (3), the land price of property *i* in year *t* is estimated from exogenous variable *x* and crime rate. Crime rate for year t in the neighborhood where property *i* is located ($CrimeRate_{it}$) is an endogenous variable.

The average of crime rate is 0.258 and the range of the figure is from 0 to 2.106, which shows that the crime rate distribution is skewed to the right, therefore land price changes when crime rate exceed the certain point. We analyze how the dummy variable affects land price when crime rate exceed certain point, from 0.01 to 0.6.

We also analyze the effect of crime rates in several submarkets of Tokyo Metropolitan Area, because the area is so wide that it can be more efficient for us to analyze the effect of crime rate in several segmented areas. There are several ways to divide the Tokyo Metropolitan area. We adopt 4 ways, the division by geographical way (the northeast area, the northwest area and the southwest area), the division by the regulation of floor area ration (less than 100%, from 100% to 200%, from 200% to 300% and above 300%), the division by walking time to the nearest station (less than 7min., from 7 min. to 12 min. above 12 min.) and try the panel IV analysis in each submarket.

We use the following F test for the statistical significance of the market segregation.

$$F_{n-p,\sum(n_i-v_i)} = \frac{\dfrac{SSE_w}{n-p}}{\dfrac{SSE_s}{\sum(n_i-v_i)}} \qquad (4)$$

In the formula, SSE_w means squared residuals in case of not-segmented, n means the total samples, p is the number of parameters in the not-segmented model. SSE_p is the squared residuals in the segmented model. n_i means the number of the samples in the submarket i , and v_i is the number of parameters in the submarket i.

(4) Propensity Score Matching Method

The Propensity Score Matching Method is useful for analyzing non-randomized observational data just as crimes rate and land price are with the IV method. The propensity score is defined by Rosenbaum and Rubin (1983) as the conditional probability of receiving treatment given pre-treatment characteristics as given by Equation (5).

$$p(X) \equiv Pr\{D=1 \mid X\} = E\{D \mid X\}. \quad (5)$$

Where D={0, 1} is the indicator of exposure to treatment and X is the multidimensional vector of pre-treatment characteristics. If exposure to treatment is random within cells defined by X, it is also random within cells defined by the values of the mono-dimensional variable $p(X)$. Given a population of units denoted by i, if the propensity score $p(X_i)$ is known, the Average effect of Treatment on the Treated(*ATT*) can be estimated by Equation (6).

$$\begin{aligned} ATT &\equiv E\{Y_{1i} - Y_{0i} \mid D_i = 1\} \\ &= E\{E\{Y_{1i} - Y_{0i} \mid D_i = 1, p(X_i)\}\} \\ &= E\{E\{Y_{1i} \mid D_i = 1, p(X_i)\} - E\{Y_{0i} \mid D_i = 0, p(X_i)\} \mid D_i = 1\} \end{aligned} \quad (6)$$

In this paper, treatment means that the property i is located in a neighborhood where the crime rate is higher than the median of all property crime rates, therefore, D=1 means the crime rate is more than 0.20 cases per 100 households (median of all property crime rate) and D=0 means the crime rate is less than 0.20 cases per 100 households. We try the same analysis under several standards of $D=1$, that is we specify the sample as D=1 when the crime rates are more than the figure from 0.01 to 0.8. We try several estimations to analyze the effect of crime rate on land price when crime rates exceed the certain level as we analyzed the effect in the Panel IV analysis. $p(X)$ is the probability of D=1 and the probability is estimated by a probit analysis using the vector of location characteristics, neighborhood characteristics, distance from police boxes and voluntary members ratio of property *i*., which are used to estimate crime rate in IV analysis. In Equation (6), Y_{1i} and Y_{0i} are the potential outcomes in the two counterfactual situations of respectively treatment and no treatment (control). Y_{1i} therefore means the average land price under D=1 and Y_{0i} means the average land price under D=0.

The following two hypotheses are needed to derive *ATT* given (6).

i) Balancing of pre-treatment variables

If $p(X)$ is the propensity score then,

$$D \perp X \quad | \, p(X) \tag{7}$$

where X is the vector of characteristics of property. We conducted a test for the Balancing Hypothesis in the *ATT* estimation.

ii) Unconfoundedness given the propensity score.

Assignment to treatment is unconfounded given the propensity score.

$$Y_1 \text{ and } Y_0 \quad \perp D \quad | \, p(X) \tag{8}$$

As Imbens (2004) stated, the assumption is based on the "conditional independence assumption" which means that the potential outcome of Y_1 ,Y_0 and D are independent on the pre-treatment data, X. The crime rate which is used in IV estimation is endogenous variable, but in the propensity score matching, the independence of D from Y_1 ,Y_0 is conditional on X. As Lechner (2007) stated, some control variables may be influenced by the treatment, it doesn't matter propensity score matching if conditional independence assumption is satisfied. The propensity score matching therefore does not contradict to the motivation of IV estimation. Some studies as shown in Hackl, Halla and Prunkner (2007) try the propensity score matching along with IV estimation.

We therefore try the propensity score matching analysis along with the IV estimation to check the result of IV estimation, because the propensity score matching method is completely different from OLS or panel IV analysis. To estimate *ATT* using equation (8), we must match treatment unit and control unit because $p(X)$ is a continuous variable and the probability of two units with exactly the same value of propensity score is in principle zero, as Becker and Ichino (2002) stated. We use the three most widely used methods, which are Nearest Neighbor Matching, Kernel Matching, and Stratification Matching.[7] We calculate *ATT* to test the influence of the property crime rate and the robustness of the IV analysis in Equation (1).

4. Results

(1) Analysis by OLS and IV

We attempted OLS and IV analyses of land prices in the 23 wards of Tokyo and the influence of crime rate on land price. At first, we begin our analysis as regards with the effects of crime rate of burglaries, because the number of burglaries is far larger than the other crimes. We step on to the analysis as to felonious or violent crimes after burglaries.

The estimation result of OLS is shown in Column (1) of Table 5. The result shows that the coefficient of the logarithm of land price on crime rate is 0.059. The result shows that crime rate is positively associated with the area where the housing land price is high

[7] Becker and Ichino (2002) presented the formula for Nearest Neighbor Matching, Kernel Matching, and Stratification Matching.

and where high-income residents may live. As shown in the IV estimation later, the coefficient of crime rate on the ratio of high-income households is positive, which means the crime rate is higher in a neighborhood with affluent people. We infer that the estimated positive coefficient of OLS is contaminated by an upward bias from the endogeneity of crime rate.

Let us begin with the IV estimation to solve the endogeneity problem. Columns (2) and (3) of Table 5 show the results of the cross-sectional IV estimation with year dummy variables. Columns (4) and (5) of Table 5 show the results of the IV estimation with panel data.（We use household income as a dependent variable in the analysis of Columns (2) and (4). The average area of housing floor per person is used as a dependent variable alternatively in the analysis of Columns (3) and (5).）

Contrary to the result of the OLS estimation, the coefficients of land price on crime rate in the cross-sectional IV estimation are -3.912 and -3.980, and the coefficients in the panel-data IV estimation are -0.215 and -0.245.

The Wu-Hausmann Test rejects the null hypothesis that crime rate is not endogenous. The Cragg Donald Test rejects the null hypothesis that instrumental variables are weakly identified and that they are underidentified at the level of 1%. The Sargan Test indicates that there are not more instrument variables than endogenous variables except in the case of IV analysis in Column (3) of Table 5.[8]

In the estimation, we used distance from police boxes and voluntary member ratio as

[8] We also estimate fixed effects of panel data to compare the coefficient of Panel IV estimation. The coefficient is -0.0241, which implies crime rates have negative effects on land prices, but the Hausmann Test shows the difference in coefficients between fixed effect and random effect is not systematic. We adopt panel-data IV estimation to avoid the correlation of crime rates with fixed effect.

excluded instrumental variables. The estimation results show that the coefficient of crime rate on distance from police boxes is significantly positive and that the coefficient of crime rate on voluntary members ratio is significantly negative. We also estimate the coefficient of crime rate on the voluntary members rate in previous year to evade the effect of crime rate on next year's voluntary members rate to take the possibility that crime rate may have the positive effect on the voluntary members rate into the consideration. The result coincides with the presumption that the weaker the capacity of police boxes to prevent crimes is, the longer the distance from the property to police boxes is, and that a large number of voluntary members are effective to prevent crimes. The coefficient of crime rate on the voluntary members rate in the previous year is negative, which means that voluntary members rate has the negative effect on crime rate in the next year as shown in Table6.

The crime rate also has significant coefficient explanatory variables such as income group ratio, unburnable building ratio, or land use ratio.

High-income households may become targets for property criminals. As expected, the estimated coefficient of the crime rate on the ratio of high-income groups is positive. The coefficients of crime rate on the ratio of households with over 15 million yen in annual income is 1.398 (Z=13.70) in Column (2)' of Table 6. Low-income criminals tend to commit crimes in their neighborhoods and low-income households are not well prepared for the danger of property crimes, because they have insufficient financial resources to spare on preventing crimes. The result of the analysis of Column (2)' of Table 6 is that the coefficient of the ratio of low-income group amounts to 0.280 (Z=6.40), showing that a low-income ratio area raises the crime rate.

We also use size of house as an alternative variable. The estimated coefficient of crime rate on the average of the housing floor area in neighborhood is significantly positive in Table 6 (Columns (3)' and (5)') because larger houses also can be targets of burglaries.

An area with a high ratio of burnable wooden rental apartments is not only dangerous in the event of an earthquake but also in terms of property crimes, because criminals can hide from police and residents in an area filled with burnable houses and narrow roads. The City Planning Bureau of Tokyo Metropolitan Government designates dangerous areas in the event of an earthquake, where many old wooden rental apartments stand along narrow roads. Koide (2005) warns that there are a lot of property crimes in the designated area, which is caused by the above prediction. The result of an analysis of Table 6 also shows a positive coefficient of crime rate at below a 50% unburnable ratio and a negative coefficient of crime rate on owner-occupied rate at a significant level, which means a neighborhood with many rental apartments faces the threat of property crimes.

As regards land use, in the area with a higher ratio of roads, the crime rate tends to be higher because many criminals tend to travel along trunk road to find suitable places to burgle. Poyner (1983) warns that residing in an area along a trunk road is a crime risk. The result of the analysis of Table 6 also shows that the coefficient of crime rate on the ratio of road area is positive.

In a neighborhood with a lot of commercial or office buildings, the crime rate rises. According to Colquhoun (2004), in places near downtown areas, young criminals tend to gather and commit property crimes. The coefficient of crime rate in the regression of the ratio of commercial or office use is positive in the analysis of Table 6.

We try to analyze the effect of felonious or violent crimes by IV panel analysis as shown. The coefficient is -0.143, which implies that the crimes such as murder, arson, rape, assault or bodily injury also has the negative effect on land price as shown in Table 7. The coefficient is smaller than that of burglaries and we could premise the residents in the Tokyo Metropolitan are not as keen to the danger of felonious or violent crimes as that of burglaries.

We use the dummy variable which equals 1 if crime rate is more than certain level (from 0.01 to 0.6) to examine the effect of the crime rate when it exceeds certain point. The results are shown in Table 8. The coefficient of the dummy variable that is 1 when crime rate exceeds 0.01 is larger than when crime rate is 0.2 or 0.3 which is around the average of crime rate. It means that crime rate has negative effects on land price, when crime rate does not exceed far lower level than the average, such as 0.01.

We also analyze the effect of crime rates in several submarkets of Tokyo Metropolitan Area by using 4 ways.

We analyze not only the coefficients of crime rate in the segmented areas, but also the efficiency of analysis by using F test as regards with the residuals of IV-panel analysis, and the results are shown in table 9.

The results show that the coefficient of crime rate is negative in each submarket. The F-test shows us that the division by geographical way and the division by the regulation of floor area ratio are not efficient.

Tanaka and Asami (2005) point out that the Japanese residents do not prefer specific area and that geographical submarket can't be formed. On the other hand, they state that the 'characteristic space' divided by location characteristics such as time to nearest station can form the submarket. The result of the analysis can prove the statement.

The result also implies that in the residential areas where the travelling time is from 30-40 minutes from the Tokyo station, or walking time is 7-12 minutes from the nearest station, the effect of crime rate on land price is larger than the other areas and which means that residents get stronger damage on their preference to their location when they encounter the burglars in such better place to live.

(2) Estimation Results of Propensity Score Matching Method

We use instrumental variables such as distance from police box and voluntary members rate to estimate the effect of crime rate in IV analysis or panel IV analysis, but there is some problem if we select appropriate instrument variables. We also conduct a Propensity Score Matching analysis, because we try to testify the validity of the hypothesis high crime rate have negative effect on land price. The method is completely different from the hedonic approach, and it is the way of the estimation of treatment effect by comparing treated and control samples which are similar in their factors except crime rates.

As mentioned in 3. (2), we define treated as more than 0.20 crimes per 100 households in the neighborhood (0.20 is a medium of total samples), and we estimate the Propensity Score by probit analysis using location characteristics, neighborhood characteristics, distance from police boxes and voluntary members ratio. We use rich and informative dataset to explain the Propensity Score to support the conditional independence assumption. The result of probit analysis is shown in Table 10 and a description of the Propensity Score is given in Table 11. We tested to confirm that the average propensity score of treated and control units and the means of each characteristic do not differ between treated and control units. In the analysis, the Balancing Hypothesis is satisfied. We also estimate the propensity score under the standard that D=1 means the crime rates are more than the figure 0.01 to 0.8.

The estimation result obtained by the Propensity Score Matching Method is shown in Table 12. The standard error is estimated through a bootstrap estimation. *ATT* shows generally significant negative coefficients, which means that property crimes have a negative impact on land prices, and agrees with the result of the IV estimation. Table 13 shows that the ATT figures are different among several analysis under different standards of *D=1*, and that the ATT shows negative effects of crime rate. The result shows that the negative effects of crime rates are apparent regardless of the level of crime rates.

5. Conclusion

Estimating OLS and IV clarified that property crimes rate play a role in decreasing land prices regardless of local inhabitants and land-use situation. According to the estimated results, land price will fall around 1% in the event of a 10% rise in property test scores.[9] The inhabitants who do not suffer from break-in burglaries directly can suffer

[9] In the case of panel IV analysis, it is exp(-0.245*0.403*0.10)－1≒-0.00995. 0.403 means crimes per 100 households in 2005.

from the land price fall effect, which is a disadvantage in terms of loss of safety from crimes. It is thought that the loss of land price reflects the intention of a resident to pay for safety. The estimation is useful to encourage measures to prevent property crime and ensure the effectiveness of measures. For example, a detached house owner in the Tokyo Metropolitan Area whose house site amounts to 112 square meter (It is the average of housing site in the City of Tokyo, Kanagawa, Chiba and Saitama Prefecture) has about 55 million yen of the housing land, because the average land price per square meter 537,111 yen. That means the average house owner suffers the loss of 550thousand yen when crime rate is rising. In other words, it is economically rational that the house owner should pay about 550 thousand yen to guard against crimes if he hopes to evade crime rate rising by 10%. The Tokyo Metropolitan Government tries to improve the safety from crimes and has spent a lot of money on the policy of keeping the peace in the residential area. The estimation can be applied when the policy makers estimate the cost and benefit of police authority or safety keeping activity.

The estimation shows that police boxes and number of voluntary group members inhibit property crimes. The analysis also shows that a residential area with many low-income households, and with a lot of burnable buildings, faces the threat of property crimes.

The results also imply that policy measures to increase police boxes or voluntary group members are effective for decreasing crimes. Policy measures that pay attention to low-income households or redeveloping urban areas will also be effective for creating safer cities.

As mentioned before, the Tokyo Metropolitan Government try to improve the safety and the government put an emphasis on rearing voluntary group activities. The Metropolitan Police Authority also assists the formation of the groups and retired policemen help such activities. The estimation also shows such activities are effective in decreasing crimes, therefore it shows the policy of the government is effective.

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Figure 1 Geographical distribution of burglaries and locations of police boxes in the 23 wards of Tokyo (2005)

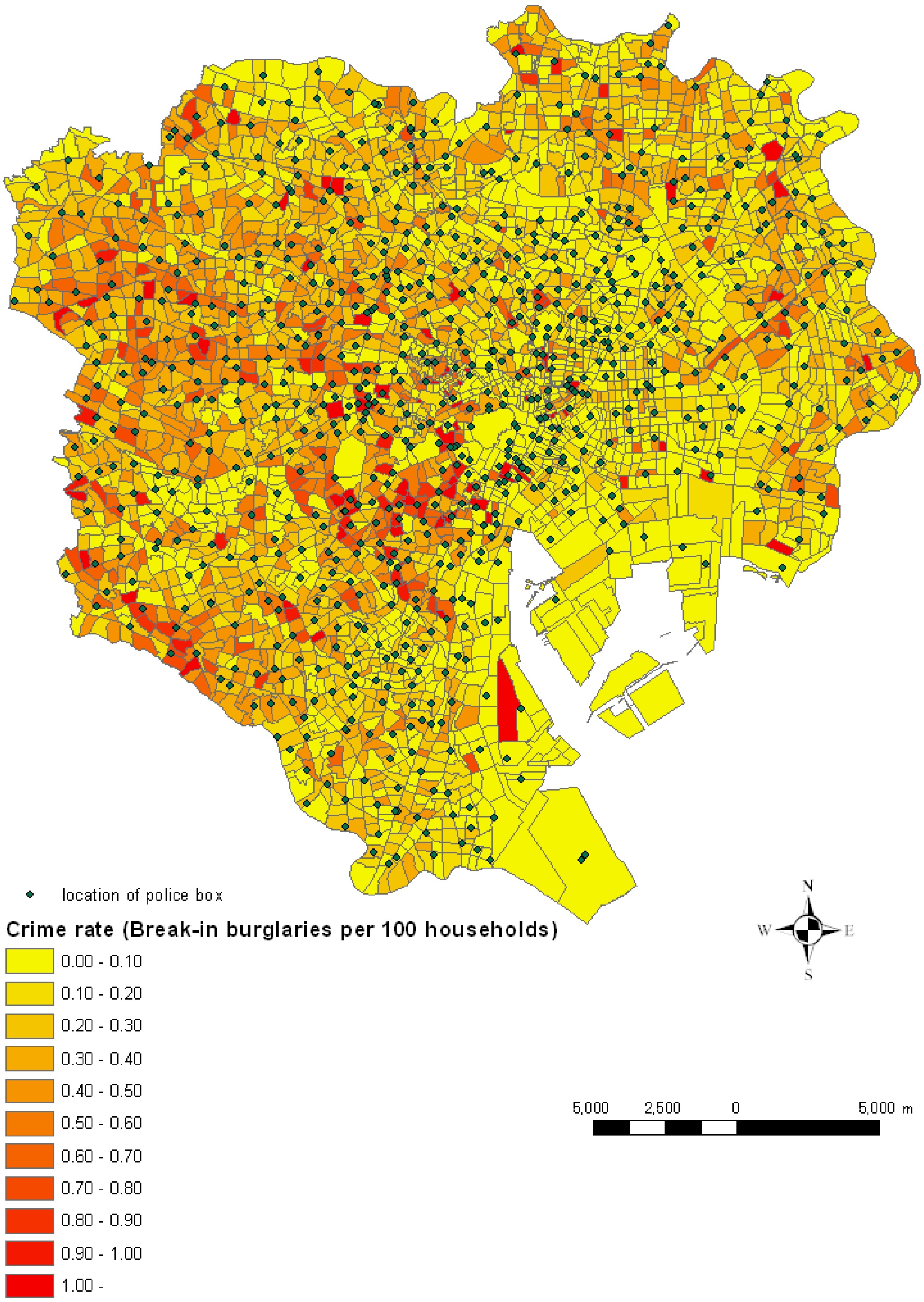

Table 1 Explanation of Data

Variables	Description	Source
Dependent Variables		
Land price（Yen）	Land Price researched	Tokyo Real Estate Foundation
Explanatory Variables		
Walking time (Min)	Walking time to the nearest station	Yahoo! Map
Travel time (Min)	Travel time from nearest station to Tokyo Station	Yahoo! Travel
Regulation on building area ratio	The regulation on ratio of building area to total site area	City Planning in Tokyo Metropolitan Area
Regulation on floor area ratio	The regulation on ratio of building area to total area	
Regulation on land use ratio	The ratios of the following zoning areas ・Exclusively Residential Zone for Low-rise Buildings （Class1, 2) ・Exclusively Residential Zone for Medium-and High-rise Buildings (Class1,2) ・Residential Zone (Class1,2) ・Semi-Residential zone	
Land use ratio	The ratios of areas of following forms of land use to total area of neighborhood ・Residential use ・Commercial use ・Industrial use ・Farm and agricultural use ・Road ・Park	City Planning Bureau, Tokyo Metropolitan Government
Home ownership rate	The rate of owner occupied households	National Census
Unburnable ratio	The ratio of unburnable floors to all building floors	City Planning Bureau, Tokyo Metropolitan
Household income distribution ratio	The ratios of households within the following annual household income groups ・- 3 million yen ・ 3 million - 5 million yen ・ 5 million - 7 million yen ・ 7 million - 10 million yen ・10 million - 15 million yen ・15 million yen-	UDS
Average housing floor area in neighborhood (m^2)	The average of housing floor area per person in the neighborhood	City Planning Bureau, Tokyo Metropolitan
Crime rate	Break-in burglaries per 100 households	Metropolitan Police Authority
Instrumental Variables		
Distance from police boxes	The distance from the nearest police box (including police stations) to a property	Metropolitan Police Authority and GIS
Voluntary members ratio	The ratio of the number of voluntary group members to the population in neighborhood	Metropolitan Police Authority

Table 2 Summary Statistics

Variables	Sample	Average	Std. Dev.	Min.	Max.
Land price (yen/㎡)	18,283	537,111.3	349,087.9	81,818.1	8,666,667
Walking time (min)	18,283	10.807	5.865	1	41
Traveling time (min)	18,283	35.340	8.571	12	54
Regulation on building area ratio (%)	18,283	56.776	5.748	30	80
Regulation on floor area ratio (%)	18,283	192.124	83.068	60	500
Regulation on land use ratio (%)	18,283				
Exclusively Residential Zone for Low-rise Buildings (Class1)	18,283	36.099	48.030	0	100
Exclusively Residential Zone for Low-rise Buildings (Class2)	18,283	1.969	13.894	0	100
Exclusively Residential Zone for Medium-	18,283	27.599	44.703	0	100
Exclusively Residential Zone for Medium, High-rise Buildings (Class2)	18,283	2.576	15.842	0	100
Residential Zone (Class1)	18,283	26.391	44.076	0	100
Residential Zone (Class2)	18,283	3.468	18.297	0	100
Semi-Residential Zone	18,283	1.898	13.646	0	100
Land use ratio (%)					
Residential use	18,283	46.257	13.390	0.915	79.247
Commercial use	18,283	8.434	6.452	0	88.529
Industrial use	18,283	3.613	5.471	0	65.923
Farm or agricultural use	18,283	2.349	4.405	0	32.567
Public building	18,283	8.243	8.410	0	90.506
Road	18,283	19.576	5.119	0.095	48.434
Park	18,262	4.103	6.566	0	75.092
Unused	18,283	2.198	2.453	0	54.132
Home ownership rate (%)	18,283	48.512	12.549	1.373	86.667
Unburnable ratio (%)	18,283	59.983	18.081	12.970	99.980
Household income distribution ratio(%)					
-3 million yen	18,283	28.097	8.260	0	65.371
3-5 million yen	18,283	23.499	6.863	0	50.658
5-7 million yen	18,283	14.336	5.623	0	38.473
7-10 million yen	18,283	14.245	4.744	0	39.581
10-15 million yen	18,283	9.354	3.377	0	28.886
15- million yen	18,283	5.600	3.575	0	24.886
Housing floor area in neighborhood (m^2)	18,283	31.134	4.738	0	61.800
Crime rate	18,283	0.258	0.221	0	2.106
Distance from police (m)	18,283	399.314	192.247	0	1364.29
Voluntary members ratio (%)	18,283	0.926	0.754	0.079	10.464

Table 3 Change of crimes, distance from police box and voluntary members ratio

	Year	Mean	Std. Dev	Min	Max
Felonious or violent crimes	2005	0.158	0.396	0	8.602
(Crimes per 100 households)	2006	0.167	0.458	0	14.894
	2007	0.155	0.477	0	18.261
	Ave	0.160	0.444	0	18.261
Burglaries	2005	0.320	0.248	0	2.106
	2006	0.259	0.216	0	1.624
	2007	0.190	0.170	0	1.695
	Ave.	0.258	0.221	0	2.106
Distance from Police Box	2005	401.954	193.435	0	1364.290
	2006	397.515	199.177	0	1364.290
	2007	398.346	192.069	0	1364.290
	Ave.	399.314	192.347	0	1364.290
Voluntary Members Ratio	2005	0.802	0.732	0.079	10.464
	2006	0.934	0.660	0.079	10.328
	2007	1.047	0.838	0.108	10.015
	Ave.	0.926	0.754	0.078	10.464

Table 4 The number of police boxes in each ward

	1999	2004	2005	2006	2007
Chiyoda	21	21	21	22	19
Chuou	27	26	26	26	22
Minato	40	41	41	41	34
Shinjuku	40	39	39	39	34
Bunkyo	22	22	22	21	20
Taito	30	30	30	30	27
Sumida	29	28	28	28	23
Koto	28	28	28	28	24
Shinagawa	31	29	29	29	25
Meguro	22	21	21	21	16
Ohta	47	48	48	48	39
Setagaya	45	44	44	45	39
Shibuya	27	27	26	26	24
Nakano	23	22	22	22	19
Suginami	38	39	39	39	34
Toshima	29	28	28	28	24
Kita	29	27	27	26	24
Arakawa	22	22	22	22	17
Itabashi	36	35	35	35	32
Nerima	33	33	33	33	30
Adachi	43	43	43	42	39
Katsushika	34	34	34	34	32
Edogawa	37	37	37	37	35

Table 5 Effects of Variables Including Crime Rate on Housing Land Prices

	(1) OLS			(2) IV(Cross-Section-1)			(3) IV(Cross-Section-2)			(4) IV(Panel-1)			(5) IV(Panel-2)		
	Coefficient		T-value	Coefficient		Z-value	Coefficient		Z-value	Coefficient		Z-value	Coefficient		Z-value
Crime Rate	0.059	***	6.63	-3.912	***	-3.33	-3.980	***	-3.57	-0.215	***	-7.73	-0.245	***	-4.98
In case of Voluntary Members Rate -1										-0.761	***	-4.35	-0.744	***	-4.26
Walking Time (log)	-0.148	***	-32.69	-0.208	***	-8.46	-0.126	***	-6.96	-0.153	***	-19.99	-0.108	***	-14.26
Travel Time (log)	-0.199	***	-18.43	-0.018		-0.27	-0.022		-0.28	-0.190	***	-10.05	-0.240	***	-12.68
Regulation on building area ratio	0.440	***	11.02	0.858	***	3.83	0.866	***	3.79	0.452	***	5.89	0.423	***	5.11
Regulation on floor area ratio	0.096	***	18.48	0.050	**	2.15	0.066	***	2.91	0.093	***	12.05	0.105	***	13.44
Land Use ratio(Commercial use)	0.971	***	16.44	1.771	***	6.15	1.360	***	6.18	1.027	***	17.40	0.881	***	6.78
(Industrial use)	-1.553	***	-27.15	-1.876	***	-8.06	-0.679	**	-2.52	-1.554	***	-18.73	-1.251	***	-14.91
(Farm etc.)	-0.866	***	-19.82	-1.288	***	-5.72	-0.320	*	-1.71	-0.868	***	-10.18	-0.337	***	-4.04
(Road)	-0.464	***	-10.97	-0.120		-0.59	0.089		0.38	-0.436	***	-6.35	-0.488	***	-7.06
(Park)	-0.255	***	-9.19	-0.089		-0.57	0.071		0.44	-0.233	***	-5.14	-0.117	**	-2.55
Unburnable ratio (-50%, dummy)	-0.168	***	-21.07	0.075		0.96	-0.046		-0.68	-0.149	***	-11.65	-0.250	***	-20.37
(50%-80%, dummy)	-0.139	***	-19.56	0.004		0.08	-0.022		-0.42	-0.128	***	-12.22	-0.175	***	-17.06
Home ownership rate (%)	-0.054	***	-2.67	-0.055		-0.76	-1.126	***	-4.99	-0.062	**	-2.15	-0.420	***	-13.05
Household income distribution ratio (-3mil.)	-0.751	***	-14.34	0.379		0.98				-0.683	***	-9.99			
(3-5 mil.)	-1.069	***	-15.15	0.994		1.49				-0.944	***	-9.70			
(7-10 mil.)	-1.904	***	-23.19	-1.988	***	-7.27				-1.879	***	-16.22			
(10-15 mil.)	0.686	***	6.43	1.432	***	3.04				0.637	***	4.07			
(15- mil.)	3.310	***	26.41	8.905	***	5.24				3.699	***	20.84			
Ave. housing floor area in neighborhood							0.091	***	6.20				0.042	***	37.38
Year 2006 (dummy)	0.066	***	17.80	-0.175	**	-2.41	-0.180	**	-2.61	0.048	***	14.62	0.046	***	13.77
Year 2007 (dummy)	0.196	***	49.55	-0.316	**	-2.09	-0.326	**	-2.26	0.159	***	24.67	0.155	***	23.63
Constant	14.198	***	198.69	13.409	***	37.71	11.671	***	28.93	14.180	***	132.22	12.780	***	130.33
Sample Size	18,259			18,259			18,259			18,259			18,259		
R^2	77.91(Adj.)			99.59			99.59			76.32			77.29		
Endogeneity Test				243.39 Prob＞F＝0.0000			270.65 Prob＞F＝0.0000								
Weak Identification Test				9.519 (8.68)			13.491 (8.68)								
Overidentification Test				1.643 Prob＞χ^2＝0.1999			5.243 Prob＞χ^2＝0.022								

*Dependent variable is logarithm of housing land price. Regression includes 7 types land use regulation dummies. Unburnable Ratio (-50%) and Unburnable Ratio (50%-100%) are dummy variables that they will be 1 if unburnable rates coincide the condition in the parenthesis. "Year2006" and "Year2007" are also dummy variables that they will be 1 if the researched year is 2006 or 2007 respectively. *(**)[***] is statistically significant at 10%(5%)[1%] level. (It is the same meanings in Table5～9) Z-value is estimated by using robust standard errors.

Table 6 Factors to Influence Crime Rate

	(2)' IV (Cross-Section-1)		(3)' IV (Cross-Section-2)		(4)' IV (Panel Data-1)		(5)'IV (Panel Data-2)	
	Coefficient	Z-Value	Coefficient	Z-Value	Coefficient	Z-Value	Coefficient	Z-Value
Distance from police (log)	0.009 ***	3.35	0.011 ***	3.84	0.017 *	1.88	0.018 **	2.03
Voluntary members rate	-0.427 *	-1.72	-0.547 **	-2.32	-2.699 ***	-9.46	-2.704 ***	-9.49
Voluntary members rate-1(previous year)					-1.429 ***	-4.26	-1.437 ***	-4.29
Walking time (log)	-0.017 ***	-3.99	-0.007 *	-1.64	-0.017	-1.06	-0.008	-0.48
Traveling time (log)	0.042 ***	4.14	0.054 ***	5.45	0.028	0.70	0.042	1.06
Regulation on building area rate	0.106 **	2.25	0.116 **	2.47	0.091	0.55	0.099	0.62
Regulation on floor area rate	-0.011 **	-2.40	-0.010 **	-2.17	-0.010	-0.60	-0.009	-0.54
Land use ratio (Commercial use)	0.211 ***	5.01	0.139 ***	3.47	0.240 *	1.92	0.165	1.35
(Industrial use)	-0.097	-1.58	0.156 ***	2.87	-0.060	-0.34	0.167	0.95
(Farm etc.)	-0.118 **	-2.51	$-3*10^4$	-0.01	-0.149	-0.81	-0.029	-0.17
(Road)	0.086 **	1.96	0.154 ***	3.63	0.089	0.60	0.156	1.09
(Park)	0.043	1.25	0.055	1.61	0.051	0.53	0.064	0.67
Unburnable rate (-50%)	0.061 ***	8.57	0.056 ***	8.42	0.066 **	2.48	0.057 **	2.29
(50%-80%)	0.037 ***	6.14	0.042 ***	7.61	0.041 *	1.83	0.044 **	2.07
Home ownership rate (%)	-0.003	-0.20	-0.193 ***	-10.81	-0.020	-0.33	-0.204 ***	-3.15
Household income distribution ratio (-3mil.)	0.280 ***	6.40			0.253 *	1.76		
(3-5 mil. yen)	0.510 ***	8.48			0.465 **	2.31		
(7-10 mil. yen)	-0.023	-0.35			-0.024	-0.09		
(10-15 mil.)	0.192 **	1.96			0.170	0.51		
(15- mil.)	1.398 ***	13.70			1.393 ***	3.96		
Ave. housing floor area in neighborhood			0.131 ***	18.47			0.013 ***	6.85
Year 2006 (dummy)	-0.060 ***	-15.27	-0.060 ***	-15.46	-0.059 ***	-20.35	-0.059 ***	-20.36
Year 2007 (dummy)	-0.128 ***	-34.55	-0.128 ***	-34.98	-0.124 ***	-41.98	-0.124 ***	-42.00
Sample Size	18,259		18,259		18,259		18,259	

* Unburnable Ratio (-50%) and Unburnable Ratio (50%-100%) are dummy variables that they will be 1 if unburnable rates coincide the condition in the parenthesis. "Year2006" and "Year2007" are also dummy variables that they will be 1 if the researched year is 2006 or 2007 respectively.

Table 7 Effects of crime rates on land price among various types of crime

Type of Crime	Coefficients of crime rate on land price		Instrumental Variable			
			Distance from Police Box		Voluntary Members	
Felonious or violent crimes	-0.143**	(-2.38)	0.014	(0.79)	-1.884***	(-6.06)
Burglaries	-0.215***	(-4.45)	0.017*	(1.88)	-2.699***	(-9.46)

Table 8 Effects of various types of dummy

Type of dummy	The portion that dummy variable is 1	Coefficient of dummy variable	
Crime rate is more than	0.894	-0.678**	(-2.57)
0.05	0.873	-0.449***	(-3.09)
0.10	0.757	-0.411**	(-2.10)
0.15	0.639	-0.233**	(-2.48)
0.20	0.521	-0.290***	(-2.66)
0.25	0.423	-0.125***	(-4.08)
0.30	0.327	-0.138***	(-4.38)
0.35	0.258	-0.142***	(-4.38)
0.40	0.197	-0.169***	(-4.51)
0.50	0.118	-0.079**	(-2.33)
0.60	0.070	-0.095**	(-2.41)
0.80	0.027	-0.230***	(-3.08)

Table 9 Effect of submarkets

Way of Segregation	Whole Area	By Area	Regulation on floor area ratio	Time to nearest station	Time to Tokyo Station
		Southwest	Under 100% Area	Under 7min Area	Under 30min. Area
	-0.2153***	-0.2442***	-0.225**	-0.070	-0.145***
	(n=18259)	(n=6326)	(n=4523)	(n=5879)	(n=5602)
		Northeast Area	100-200% Area	7-12min. Area	30-40min. Area
Coefficient of Crime Rate on Land Price		-1.902	-0.509***	-0.120***	-0.308***
		(n=3276)	(n=9572)	(n=6903)	(n=7053)
		Northwest Area	200-300% Area	Above 12min. Area	Above 40min. Area
		-1.816*	-0.142**	-0.114	-0.132
		(n=8657)	(n=3591)	(n=5477)	(n=5064)
			Above 300% Area		
			-0.184*		
			(n=597)		
F value		1.000	0.105	0.000	0.000

*"By area" means geographical segregation of Tokyo Metropolitan area.

"Southwest" area means Chiyoda, Minato, Shinjuku, Shinagawa, Meguro, Ohta, Setagaya and Shobuya ward.

"Northeast" area means Chuo, Bunkyo, Taito, Sumida, Kouto, Arakawa, Katsushika and Edogawa ward

"Northwest" area means Nakano, Suginami, Toshima, Kita, Itabashi, Nerima and Adachi ward

Table 10 Estimation of the Propensity Score

	Coefficient	Z-value
Distance from police (log)	0.134***	4.23
Voluntary members rate	-9.416***	-4.19
Walking time (log)	-0.141***	-3.78
Travel time (log)	0.423***	4.19
Regulation on building area rate	0.860**	2.04
Regulation on floor area rate	-0.060	-1.44
Land use ratio (Commercial use)	1.631***	5.09
(Industrial use)	-1.260***	-2.63
(Farm etc.)	-1.744***	-3.68
(Road)	0.948***	2.70
(Park)	0.350	1.37
Unburnable rate (-50%)	0.895***	12.91
(50%-80%)	0.623***	10.89
Home ownership rate (%)	-0.386**	-2.44
Household income distribution ratio(-3mil.)	3.109***	8.24
(3-5 mil. yen)	6.053***	11.37
(7-10 mil. yen)	0.8040	1.25
(10-15 mil.)	4.889***	5.64
(15- mil.)	12.111***	13.21

*Unburnable Ratio (-50%) and Unburnable Ratio (50%-100%) are dummy variables

Table 11 Description of Propensity Score

Percentiles		Profile	
1%	0.166	Smallest	0.052
5%	0.269	Largest	0.904
10%	0.331	Mean	0.521
25%	0.423	Std. Dev.	0.146
50%	0.526	Variance	0.021
75%	0.627	Skewness	-0.215
90%	0.716	Kurtosis	2.677
95%	0.754		
99%	0.802		

Distribution of treated and controls across blocks

Blocks	Score		Total
	0	1	
-0.2	328	110	438
0.2-0.3	751	242	993
0.3-0.4	1,592	838	2,430
0.4-0.5	2,243	1,921	4,164
0.5-0.6	2,072	2,621	4,693
0.6-0.7	1,208	2,179	3,387
0.7-0.8	503	1,480	1,983
0.8-	52	143	195
Total	8,749	9,469	18,283

Table 12 Result of Propensity Score Matching

	Number of Treatment	Number of Control	ATT	Standard Error	T-value
Nearest Neighbor Matching	9514	6089	-0.065	0.011	-6.040
Kernel Matching	9514	8742	-0.021	0.004	-5.601
Stratification Matching	9469	8699	-0.023	0.007	-3.413

Table 13 ATT Value under different sets of Treatment Variable

Type of Propensity Score	The portion that estimated P-score is 1	ATT-value	
Crime rate is more than 0.01	0.895	-0.011	(-0.95)
0.05	0.874	-0.025	(-1.25)
0.10	0.758	-0.043***	(-3.42)
0.15	0.639	-0.043***	(-4.14)
0.20	0.521	-0.065***	(-6.04)
0.25	0.423	-0.059***	(-6.04)
0.30	0.327	-0.062***	(-6.08)
0.35	0.259	-0.066***	(-5.97)
0.40	0.198	-0.072***	(-5.98)
0.50	0.118	-0.083***	(-5.35)
0.60	0.071	-0.076***	(-3.74)
0.80	0.028	-0.055*	(-1.69)