CSIS Discussion Paper.104 (The University of Tokyo)

Estimation of Redevelopment Probability using Panel Data*

-Asset Bubble Burst and Office Market in Tokyo-

Chihiro SHIMIZU†
Koji KARATO‡

28. January.2010

Summary

Purpose: When Japan's asset bubble burst, the office vacancy rate soared sharply. This study targets the office market in Tokyo's 23 special wards during Japan's bubble burst period. It aims to define economic conditions for the redevelopment/conversion of offices into housing and estimate the redevelopment/conversion probability under the conditions.
Design/methodology/approach: The precondition for land-use conversion is that subsequent profit excluding destruction and reconstruction costs is estimated to increase from the present level for existing buildings. We estimated hedonic functions for offices and housing, computed profit gaps for approximately 40,000 buildings used for offices in 1991, and projected how the profit gaps would influence the land-use conversion probability. Specifically, we used panel data for two time points in the 1990s to examine the significance of redevelopment/conversion conditions.
Findings: We found that if random effects are used to control for individual characteristics of buildings, the redevelopment probability rises significantly when profit from land after redevelopment is expected to exceed that from present land uses. This increase is larger in the central part of a city.
Research limitations/implications: Limitations stem from the nature of Japanese data limited to the conversion of offices into housing. In the future, we may develop a model to generalize land-use conversion conditions.
Originality/value: This is the first study to specify the process of land-use adjustments that emerged during the bubble burst. This is also the first empirical study using panel data to analyse conditions for redevelopment.
Key words: hedonic approach, random probit model, urban redevelopment, Japan's asset bubble
Paper type: Research paper

JEL Classification : C31 - Cross-Sectional Models; Spatial, R31 - Housing Supply and Markets

---

* This research is a part of the project entitled: Understanding Inflation Dynamics of the Japanese Economy, funded by JSPS Grant-in-Aid for Creative Scientiic Research (18GS0101), headed by Tsutomu Watanabe. During the study, we received relevant comments from Yoshitsugu Kanemoto, Fukuju Yamazaki, Yoshihisa Asada and Yasushi Asami. We also received indispensible research data from the Bureau of Planning at the Tokyo Metropolitan Government. We sincerely thank them for their help.
† Associate Professor, International School of Economics and Business Administration, Reitaku University
Hikarigaoka2-1-1, Kashiwa-city, Chiba, 277-8686 Japan , Tel. +81-(0)4-7173-3439, Fax. +81-(0)4-7173-1100,
e-mail: cshimizu@reitaku-u.ac.jp
‡ Associate Professor, Faculty of Economics, University of Toyama

1. Study Objectives

Sharp real estate price hikes and declines, or the formation and bursting of real estate bubbles, have brought about serious economic problems in many countries.

Japan in particular experienced fast real estate price hikes and declines between the mid-1980s and mid-1990s. The hikes were described as the largest real estate bubbles in the 20th century. After the bubble burst, Japan saw a long economic slump labelled a “lost decade”. What happened in the Japanese real estate market in the bubble formation and burst process? How did the microstructure of the real estate market change amid the large macro fluctuations of real estate prices?

While speculative real estate transactions were repeated in urban areas during the so-called bubble period, undesirable land-use conversions came under fire. In a typical case, urban centre houses were converted into small office buildings called “pencil buildings”. Even in suburban areas, large office buildings and commercial facilities were constructed.

After the bubble burst, vacancy rates soared for many office buildings with massive real estate assets left idle, even in central Tokyo with the highest economic concentration in Japan.

An economic explanation of the phenomenon is that the distribution of land resources was distorted within the metropolis, bringing about strong inefficiencies. When inefficiencies exist in the land-use market, conversion/redevelopment is required to achieve a new equilibrium. This means that land-use inefficiencies are resolved through conversion to optimize the distribution of resources anew.

Earlier studies analysed land-use adjustment processes, treating them as urban redevelopment problems and specifying conditions for redevelopment.

The dynamic urban redevelopment model by Wheaton (1982) assumes that housing stock developed at one point in time exists at multiple time points. Capital costs emerge at the development point and are sunk at other points. Therefore, rents after the development are different from those upon the development and are based on housing stock after the development. Redevelopment is implemented when post-redevelopment rent income minus capital costs for the redevelopment is projected to exceed the level based on the existing housing stock.

Rosenthal and Helsley (1994) used an empirical analysis to verify Wheaton’s conditions for redevelopment. Using a structural probit model considering a selection bias, they found that housing redevelopment is implemented when the price of the land for the redevelopment is projected to exceed the existing land price plus housing capital destruction costs.

Munneke (1996) used the Rosenthal and Helsley empirical analysis framework for commercial real estate. This study also indicates that the redevelopment probability rises as land prices after redevelopment are projected to increase from present levels. McGrath (2000) conducted an empirical analysis of commercial real estate by considering redevelopment conditions while taking into account soil pollution risks of land for redevelopment.

These studies used data at a given point in time for analyses. They apparently targeted snapshots of the Wheaton model as temporary economic conditions to consider the advisability of redevelopment conditions. These empirical analyses are based on cross-section data at a point in time and may fail to identify individual characteristics of lands or buildings in a city.

In this study we observe rental office and housing rents and building use conversions, define economic conditions for the redevelopment/conversion of buildings and estimate the redevelopment/conversion probability under these conditions. Specifically, we use panel data for buildings at two time points in the 1990s to examine the significance of conditions for converting offices into housing while controlling effects of individual characteristics.

The following are reasons for our focus on the switch from the office to the housing market. First, profit from offices is generally higher than that from housing in urban centres. Therefore, small houses are usually bundled for office buildings. The conversion of offices into housing apparently occurs after landowners acknowledge land-use failures and closely examine profitability of land when it is used for office buildings and for housing.

Second, we can ignore variables of urban planning constraints in the office-to-housing conversion case. We are interested in the probability of land-use conversion in the case where profit gaps emerge between land uses. In residential zones, however, urban planning constraints frequently prevent housing lands from being used for other purposes, but no legal regulations exist to affect the conversion of office buildings into housing in urban planning areas where such buildings exist. Therefore, land-use conversion can depend on economic reasons alone.

Finally, we can ignore land intensification costs. In urban areas, housing lands are frequently fragmented. High costs for their intensification have frequently impeded land-use conversions and land mergers. However, any such costs may not necessarily have to be considered for the conversion of office buildings into housing.

For the three reasons above, we looked at the office market of Tokyo's special wards, which are known to be some of the most concentrated cities in the world, and compared profit from offices with that from housing and estimated how the profit gap influenced the land-use conversion probability. The estimation covered the decade between 1991 and 2001. By covering such a long period, we can expand our research into a panel data analysis. Therefore, we can extract unobservable characteristic differences among lands or buildings as individual effects.

This is another advantage of the estimation.

Furthermore, the period covers the peak and burst of the real estate bubble that began in the second half of the 1980s. Our research into changes in the microstructure within the city following these developments may be very significant for macroeconomic as well as urban policies.

2. Conditions for Redevelopment and Econometric Model

Here, all reasonable landowners are assumed to choose land uses that can generate the highest profit given the efficiency of the land market. This study targets Tokyo's special wards, featuring high urban concentration, and establishes a model limiting land uses to offices and housing to simplify the problem[1]. Specifically, this study observes the conversion of offices into housing during real estate price drops after the bubble burst in the early 1990s and analyses economic conditions that prompt landowners to eliminate or redevelop buildings for the conversion of offices into housing.

This can be depicted through landowners' land development behaviours. Capital K and constant land area $\overline{L}$ are invested to produce a building with a total floor space of Q. This can be indicated by the production function of $Q = F(K, \overline{L})$. In a bid to construct a new building, the landowner destroys the existing building at a cost of c per floor area. Given the discount rate i and the rent R^R for floor area Q, the maximized profit per land area for the new building for housing can be indicated by the following equation:

$$\max_K r^R = \frac{R^R F(K, \overline{L}) - iK - c\overline{Q}}{\overline{L}} . \tag{1}$$

If the total floor area of the existing office building is $\overline{Q} = F(\overline{K}, \overline{L})$, profit per land area from the office building in the absence of redevelopment is $r^C = R^C \cdot (\overline{Q}/\overline{L})$. Therefore, an incentive for the redevelopment emerges for the $r^R - r^C \geq 0$ case:

$$R^R F(K, \overline{L}) - iK - c\overline{K} - R^C \overline{Q} \geq 0 \ . \tag{2}$$

---

[1] In the actual land market, land-use regulations exist to control land-use externalities. While strong regulations exist for plants and urban farmlands, regulations are weak concerning the conversion of offices into housing, even with regulations in regard to building standards. Therefore, we believe that the assumption here is realistic.

If the production function is specified as $F\left(K,\overline{L}\right)=AK^{\alpha}\overline{L}^{\beta}$, the optimization condition in Equation (1) is indicated by $R^{R}\left(\partial F\left(K,\overline{L}\right)/\partial K\right)=i$. Therefore, the redevelopment condition (2) can be rewritten as follows.

$$\Delta=(1-\alpha)R^{R}Q-\left(R^{C}+c\right)\overline{Q}\geq 0 \tag{3}$$

With this condition, we use the binary choice model with panel data to analyse empirically whether the redevelopment decision can be explained by a differential between profits before and after the redevelopment. The estimation model is as follows

$$\begin{aligned}\widetilde{\Psi}_{it}&=\gamma\Delta_{it}+u_{it}\\ u_{it}&=\delta+\mu_{i}+\varepsilon_{it}\end{aligned}\qquad i=1,2,\cdots,n\quad t=1,2 \tag{4}$$

where u_{it} indicates the error component, δ represents coefficient of the common constant term, μ_i denotes each group's random effect, ε_{it} is a random variable according to the standard normal distribution assuming an average of zero and a variance of 1. The relevant land unit may be redeveloped in the $\widetilde{\Psi}_{it}>0$ $(\Psi_{it}=1)$ case or left to continue with the present use in the $\widetilde{\Psi}_{it}\leq 0$ $(\Psi_{it}=0)$ case. Therefore, the redevelopment probability can be indicated by the following equation.

$$\Pr(\Psi_{it}=1)=\Pr\left(\widetilde{\Psi}_{it}>0\right)=\Pr(\varepsilon_{it}>-\gamma\Delta_{it}-\delta-\mu_{i})=\Phi(\gamma\Delta_{it}+\delta+\mu_{i}) \tag{5}$$

The equation (5) may be maintained provided the density function depicting the Φ distribution function is symmetrical around zero. When a land unit is redeveloped because its projected rent is larger than the combination of its present rent and redevelopment costs, γ is expected to exceed zero. Hereafter, we use a panel probit model to estimate Parameter β and the random effect (based on Baltagi, 2008).

3. Data

3.1. Land uses and use conversions

This study uses the building-based GIS (geographical information system) polygon data from a land and building use survey by the Bureau of Planning of the Tokyo Metropolitan Government to observe how buildings that existed in 1991 were redeveloped and converted by 1996 and 2001. The number of office buildings in 1991 stood at 40,516, excluding those used for both stores and housing. Figure 1 indicates their distribution.

Of the 40,516 office buildings that existed in 1991, 2,607 were redeveloped or converted into housing by 1996, with the remaining 37,909 buildings used still for offices. Of office buildings that existed in 1996, 3,576 were redeveloped or converted into housing by 2001. The remaining 36,940 office buildings remained as offices. Details of the panel data are described in Section 4.3.

3.2. Office and housing rents

Office rent R^R and housing rent R^C must be specified to estimate the model in the previous section. We used rent data provided by the National Federation of Real Estate Transaction Associations, known as Zentakuren, for the period between January 1991 and December 2004. The data covered 13,147 rent contracts during the period.

Meanwhile, we used “*Weekly residential listing magazine—Rental Homes*” from Recruit Co. to collect housing rent data[2]. From the data in the magazine, we selected data that were deleted because contracts had been concluded. Rent prices upon their deletion from magazines represent first offers in the reverse auction process where landlords send house quality and rent information through magazines and continue to cut rents until they find tenants. These figures can be characterized as the highest prices for tenants, but may be taken as market prices because few tenants successfully negotiate reductions in rents from offered levels[3]. Between 1991 and December 2004, there were data on 488,348 rents. Office and housing rent databases are shown in Table 1 and a statistical summary in Table 2.

Each database covers a 14-year period in which bubbles formed and burst, including volatile rent data. The average office rent was 4,851 yen per square metre with a standard deviation of 1,925 indicating strong volatility. The average housing rent was 3,248 yen per square metre with a standard deviation of 824[4].

We use the above data to estimate floor rents. Office rents are determined through business location, based on the convenience of business communications and employees’

[2] Steel apartments account for most rental housing stock. Because our study was designed to compare housing with office buildings, however, we limited data for our analysis to RC (reinforced concrete) and SRC (steel reinforced concrete) buildings.
[3] On a weekly basis, Recruit monitors whether contracts are concluded on advertised rents and how rents failing to meet tenant requests are lowered. As a result of monitoring, it has been found that final rent levels offered just before their deletion from the magazine are equal to contract levels (as confirmed with data from the period 1996 to 2001).
[4] Office rents ranged from the minimum at 1,815 yen to the maximum at 13,310 yen and housing rents from 600 yen to 13,300 yen. Both rents were distributed in the same area.

commutation as well as workplace conditions such as space. Because the data for this study cover 14 years from 1991 to 2004, we make next pooling regression model as follows:

$$\log R_{it}^{O} = x_i^{O}{}'\theta^{O} + d_i^{O}{}'\delta^{O} + v_{it}^{O} \tag{6}$$

where R_{it}^{O} stands for office rent per unit of floor area for property *i* at time *t*, x_i for the vector of property *i* characteristics (including floor space, distance to the nearest station, age, proximity to an urban centre, and a regional dummy variable), θ^{O} for the relevant implicit price vector, d_i^{O} for a time dummy variable vector that takes the value of 1 at time *t* and 0 at any other time, δ^{O} for the time effect vector, and v_{it}^{O} is the disturbance term.

Housing rents are assumed to be based on commutation convenience, indicated by proximity to the urban centre, the distance to the nearest station, building age, structure and other characteristics such as window and door aspects. Prices of one-room apartments mainly for singles, compact houses for DINKS (double income no kids) and other small families, and family-type houses for large households are structurally different. Housing preferences for small households including singles and DINKS are different from those for large households including parents and their children. Therefore, their bid prices are structurally different (Shimizu et al., 2004). The model is given in next equation:

$$\log R_{it}^{H} = x_i^{H}{}'\theta^{H} + d_i^{H}{}'\delta^{H} + v_{it}^{H} \tag{7}$$

where R_{it}^{H} stands for the housing rent per unit area for property *i* at times *t* and x_i for the vector of property *i* characteristics (including space occupancy, age, distance to the nearest station, time to the urban centre and a regional dummy variable).

3.3. Capital share and destruction costs

To specify Δ_{it} for profit differential in equation (4), we must estimate capital share α for floor space production and cost c (per unit area) for the demolition of the existing building. However, the land and building use survey by the Bureau of Planning at the Tokyo Metropolitan Government that we use for this study include no data on capital investment or demolition costs while indicating changes in use.

Therefore, we use another data set to estimate α and c. *Nihon no Toshi Saikaihatsu* (Japan’s Urban Redevelopment) by the Urban Renewal Association of Japan records construction plans and costs for buildings redeveloped between 1982 and 2001. It includes 107 cases in Tokyo. Based on this source, Table 3 indicates the descriptive statistics for the total floor space of redeveloped buildings, real construction costs calculated with the consumer price index (100 for the base year of 2000) and the total site area.

We use data in Table 3 to logarithmically transform the Cobb–Douglas Production Function $Q = AK^{\alpha}L^{\beta}$ to estimate parameters. Here, Q stands for the total floor space, K for construction costs and L for the site area size. Respective dummy variables for special wards of Tokyo are introduced to control for individual regional effects. Years for completion are used as trend variables to control for time effects. Table 4 indicates ordinary least squares estimation, which allow us to compute the capital share of floor space production at $\alpha = 0.390$.

A fact-finding survey on building expansion, reconstruction and refurbishment (by the Ministry of Land, Infrastructure, Transport and Tourism) has reported the average building destruction cost as 14,394 yen per square metre. If the yield on the benchmark 10-year government bond issue is used as a discount rate at time of completion, the demolition cost at a given point in time is defined as c = discount rate ×14,394 yen.

4. Estimation Results

4.1. Rent functions for office and housing uses

Table 5 indicates estimation results for office and housing rent functions. Regarding the office rent function, age, or number of years since construction, was estimated at –0.093 and the distance to the nearest station at –0.219. As for age, the rent per square metre was estimated to decline by 9.3% every year. Although the decline appears too fast, the age variable apparently accounts for fast economic and technological deterioration of old office buildings amid the advancement of office buildings (for adaptations to office automation equipment, higher ceilings and earthquake resistance) and building methods (for features such as columns). Given the average age of 16 years for buildings in our analysis, we believe that the tendency may be strong.

Distance to the nearest station indicates how business communication and workers' commutation is convenient.

Regarding the housing rent function for the standard compact type, age is estimated at –0.070, distance to the nearest station at –0.034, the First-floor dummy(Table.1) at –0.042 and proximity to the urban centre at –0.066. All of these variables are negative, consistent with the general tendency, but space occupancy is given as –0.197 in contrast to a positive figure for the office rent model. We must pay attention to the sign difference. Here, the constant term dummy and the cross term are also observed.

Among constant term dummies, the one-room dummy is estimated at +0.706 and the family-type dummy at –1.581. Regarding cross terms between the one-room dummy and the variables, space occupancy is estimated at –0.263, distance to the nearest station at –0.011, age at +0.025 and time to the urban centre at –0.040. The estimation results indicate that the tendency to avoid age for the one-room type is weaker than for the compact type. One-room apartment residents may give priority to convenience rather than environment, demonstrating strong preferences for shorter distance to the nearest station and a shorter time to the urban centre.

For the family-house type, space occupancy is estimated at +0.043, distance to the nearest station at +0.004, age at –0.002 and time to the urban centre at –0.035. Family-type house residents have stronger preferences than compact or one-room house residents for newer and wider buildings. If +0.004 of the cross term is taken into account, the distance to the nearest station is then –0.030. This tendency indicates that residents in relatively wide rental condominiums give less priority to traffic convenience than do one-room and compact house residents. This suggests that better residential environments for houses are associated with longer distances to the nearest station. In Tokyo's special wards, railway stations and their vicinities feature greater convenience and commercial concentration while lacking greenery, playgrounds or security. At locations that are more distant from railway stations, the natural environment, park development and security may be better. This may be interpreted to mean that households in larger houses might have given priority to natural environmental quality rather than convenience associated with shorter distances to railway stations.

Therefore, family-type house residents who demonstrate stronger preferences for better residential environments are expected to be less sensitive to distances to railway stations than one-room or compact house residents.

4.2. Condition for profit gaps

The above office and housing rent function parameters are used to measure theoretical rents for buildings in our analysis. Building data identified through the GIS polygon include use, floor-space ratio, area, number of floors, building shape and geographic coordinates. Including time effects, these data are included to compute theoretical (predicted) office and housing rents for each building in 1996 and 2001.

First, we computed theoretical rents, compared theoretical office and housing rents and confirmed the distribution of buildings that should be converted into housing for higher rents. The distribution of buildings for which housing rents would be higher than office rents is given for

1991, 1996 and 2001 (Figures 2, 3 and 4). In 1991, there are few buildings for which housing rents were higher than office rents, but such buildings proliferated year by year as bubbles burst. Particularly, clear distribution biases were confirmed. Such rent or profit gaps do not lead immediately to building use conversions because these are accompanied by demolition and reconstruction costs. If land-use conversions are expected to improve profit even with these costs taken into account, incentives for conversions may be effective. If land-use conversions are temporarily projected to improve profit at a certain point, however, they may not necessarily be implemented. Because real estate properties are durable investment goods, land-use conversions may not be implemented unless net profit is expected to improve even with costs taken into account for a certain period of time. Therefore, we computed five-year average profit gaps[5] and took destruction and reconstruction costs into account in the following way. Here, we use the capital investment share ($\alpha = 0.390$) and the marginal destruction cost (c = discount rate × 14,394 yen) to compute $\Delta_{i,1996}, \Delta_{i,2001}$. These panel data are given in Table 6.

Δ represents a profit gap, or a difference between office and housing rents. According to the 1991 descriptive statistics, the number of buildings subjected to redevelopment/conversion came to 2,607, accounting for 6% of the total. The profit gap for redevelopment cases is compared with that for non-redevelopment cases as $\Delta(\Psi = 1) > \Delta(\Psi = 0)$. This indicates that the gap is larger for redevelopment cases. In 2001, redevelopment/conversion covered 3,576 buildings or 3% of the total. The profit gap was larger for redevelopment cases. Estimation results in Table 5 indicate that both office and housing rent indices declined between 1991 and 2001. The profit gap in the period was negative. Even in the period, opportunity costs for avoiding redevelopment indicates that the profit gap for buildings subjected to redevelopment was larger than that for those left unchanged.

4.3. Random probit model estimation results

Table 7 displays results of the random probit estimation using the above data for Equation (4). The estimated coefficient of the profit gap is significantly positive, indicating that the probability of redevelopment increases when profit from redevelopment is expected to rise. σ represents the standard error of the random effect. $\rho = \sigma^2 / (1 + \sigma^2)$ is the correlation coefficient for $\mu_i + \varepsilon_{it}$ and $\mu_i + \varepsilon_{is}$, indicating the degree of panel-level dispersive elements' contributions to the dispersion of the entire model. The estimators of a random effect are significantly different from pooling estimation results, since the standard errors of correlation coefficient ρ in brackets

[5] We used the 1986–1990 average gap between office and housing rents for the 1991 analysis, the 1991–1995 average for the 1996 analysis and the 1996–2000 average for the 2001 analysis.

are sufficiently small. The Wald statistic tests the null hypothesis that the estimated coefficient of Δ is zero. The null hypothesis is rejected.

We also defined the following regions to find redevelopment effect gaps among the regions:

Region 1: Chiyoda, Chuo and Minato Wards

Region 2: Shinjuku, Bunkyo, Taito, Shinagawa and Shibuya Wards

Region 3: Sumida, Koto, Ota, Meguro, Nakano, Toshima, Arakawa, Setagaya, Suginami, Nerima, Itabashi, Kita, Adachi, Katsushika and Edogawa Wards

Samples were divided into the three regional groups for estimation. Estimation results are shown in the second, third and fourth rows of Table 7. For region 1 in the second row, the conversion probability is estimated only for the central Tokyo region covering Chiyoda, Chuo and Minato Wards. Region 2 in the third row and region 3 in the fourth row surround the central region. For all samples, estimated coefficients of profit gaps are positive and significant with standard errors being sufficiently small. Estimated coefficients in regions 2 and 3 are larger than those in region 1, indicating that offices in the non-central regions would have a greater probability of being converted into housing than those in the central region under the same profit conditions.

Spikes and plunges in office rents in the 1990s boosted the office vacancy rate to deteriorate the profitability of office buildings in the non-central regions more sharply than in the central region. A factor behind the deterioration was that houses were aggressively converted into offices under strong expectations of higher office rents amid swelling bubbles in the 1980s. We assume that land use was changed again to compensate for the past-development failure. Eventually, our analysis has empirically demonstrated the assumption.

5. Conclusion

In this study, we observed rental office and house rents and building use conversions, defined economic conditions for the redevelopment/conversion of buildings, and estimated the redevelopment/conversion probability under these conditions. While earlier studies have been limited to single time-point cross-section analyses, this study has used panel data at two time points in the 1990s to examine the significance of the redevelopment/conversion conditions while controlling for effects of individual land/building characteristics. This examination is the key contribution of this study. By limiting our analysis target to the conversion of offices into housing, we have measured the pure effects of profit gaps on land-use conversion without the need to consider land use and other legal regulations.

The 1990s saw a fast shrinkage of land and rental office and housing markets in the Japanese economy. Office rents declined faster than housing rents amid the economic downtrend in the decade, indicating that landlords might have paid huge opportunity costs by maintaining office buildings. In particular, office rent spikes and plunges were sharp in the central Tokyo region. Rapid changes in economic conditions may have prompted economic units to alter their operations. Our analysis, where samples were divided into three regional groups, indicated that growing profit gaps triggered redevelopment more strongly in the non-central regions than in the central region.

Many industrial countries have experienced phenomena indicating that economic confusion resulting from the generation and burst of real estate bubbles can develop into serious economic problems. A real estate market recovery is frequently accompanied by land-use conversions and takes considerable time. In the bubble period, land intensification and land-use conversions may be conducted proactively, distorting the distribution of resources. It is not an exaggeration to say that no true real estate market recovery may come unless such resource distribution distortions are corrected. The correction might easily be expected to take more time amid real estate price declines than amid spikes. Japan’s real estate price decline after the bubble period, described as the “lost decade”, took a long time and caused an extended economic slump. Slow land-use conversions to correct market distortions may have been a factor behind the prolonged slump.

Our study focused on land-use conversions that emerged to correct distortions in distribution of resources amid dynamic real estate market volatility including the generation and burst of bubbles and specified factors affecting such conversions. In the most typical land-use conversions, however, houses generating low income may be converted into offices yielding a relatively high income. As a matter of course, we must consider the conversion of houses into offices as well as the reverse to generalize the land-use adjustment process. We would like to address this question in the future.

References:

Baltagi, B.H. (2008), *Econometric Analysis of Panel Data* 4th ed., John Wiley & Sons Ltd.

McGrath, D.T. (2000), "Urban industrial land redevelopment and contamination risk", *Journal of Urban Economics*, 47, 414–442.

Munneke, H.J. (1996), "Redevelopment decisions for commercial and industrial properties", *Journal of Urban Economics*, 39, 229–253.

Rosenthal S.S. and Helsley, R.W. (1994), "Redevelopment and the urban land price gradient", *Journal of Urban Economics*, 35, 182–200.

Shimizu, C., Nishimura K.G., and Asami, Y. (2004), "Search and vacancy costs in the Tokyo housing market: An attempt to measure social costs of imperfect information", *Regional and Urban Development Studies*, 16, 3, 210–230.

Wheaton, W.C. (1982), "Urban spatial development with durable but replaceable capital", *Journal of Urban Economics*, 12, 53–67.

Table 1. Rent Data Outline

Symbols	Variables	Contents	Unit
WK	Distance to nearest station	Time to the nearest station (walking and bus).	minutes
ACC	Accessibility to central business district	Average of railway travel time in daytime to the most crowded 40 stations in 1988 weighted by the number of passengers at the stations*.	minutes
FS	Floor space/ square metres	Floor space	m^2
TA	Total floor space/ square metres	Total floor space	m^2
BY	Number of years after construction	Period between the date when the data are deleted from the magazine and the date of construction of the building.	year
BS	Balcony space/ square metres	Balcony space (as shown in *Jutaku Joho* magazine).	m^2
NU	Number of units	Total number of units in the condominium.	unit
RT	Market reservation time	Period between the date when the data appear in the magazine** for the first time and the date when the data are deleted	date
MC	Management cost	Management fee.	YEN/ month
WD	Walk dummy	Whether the travel time includes time on bus 1, not including time on bus 1 but including time on bus 0.	(0,1)
FF	First-floor dummy	The property is on the ground floor 1, on other floors 0.	(0,1)
HF	Highest floor dummy	The property is on the top floor 1, on the other floors 0.	(0,1)
SD	South-facing dummy	Windows facing south 1, other directions 0.	(0,1)

SD2	South-facing dummy2	Fenestrae facing south, south west or south east 1, other directions 0.	(0,1)
TK	Ferroconcrete dummy	Steel reinforced concrete frame structure 1, other structure 0.	(0,1)
KD	Housing Loan Corporation dummy	Eligible for Housing Loan Corporation loan 1, not eligible 0.	(0,1)
LDj (j=0,…,J)	Location (Ward) dummy	*j th administrative district 1,* other district 0.	(0,1)
RDk (k=0,…,K)	Railway line dummy	*i th railway line 1, other railway line 0.* (10 railway lines appeared in the magazine)	(0,1)
TDl (k=0,…,L)	Time dummy (monthly)	*k th month 1,* other month 0.	(0,1)

* Shinjuku station is the busiest station. The busiest 40 stations include main terminal stations of the Yamanote Line such as Shinagawa, Ikebukuro and Shibuya as well as Yokohama, Kawasaki, Chiba, Omiya and Kashiwa stations. We have established a 73,920 railway line network database, which is worked out of 1,848 stations that appeared in the magazine for the 40 stations. This database is updated every six months.

** *Weekly residential listing magazine* by Recruit Co.

Table 2. Descriptive Statistics of Office and Housing Rent Data

	Office		Housing	
	Average	Standard deviation	Average	Standard deviation
Rent (yen/m^2)	4,851.48	1,925.12	3,248.26	824.90
Contractual space (m^2)	264.02	309.87	41.03	20.63
Distance to Tokyo centre (minutes)	12.46	6.25	10.53	7.17
Number of years after construction (years)	16.19	10.29	9.26	7.28
Distance to station (minutes)	4.13	2.91	6.76	3.89
Total floor space (m^2)	3,426.36	4,520.41	–	–
Number of observations=	13,147		488,348	

Table 3. Redevelopment Data (Number of observations at 107)

		Average	Standard deviation	Minimum	Maximum
Q	Total floor space (m^2)	42,327.9	49,338.5	1,536.0	360,600.0
K	Real construction cost (million yen)	198.4	222.2	2.9	1,042.6
L	Site space (m^2)	7,311.7	6,827.9	626.0	48,729.0

Source: *Nihon no Toshi Saikaihatsu* (Japan's Urban Redevelopment) Vol. 1–6, Urban Renewal Association of Japan. The real construction cost was calculated by deflating nominal values with the consumer price index for which the base year is 2000.

Table 4. Floor Space Production Function

	coef.	t-value
Constant term	24.140	2.673
log K	0.390	10.704
log L	0.670	15.077
Annual trend	−0.011	−2.396
Ward dummy	Yes	
Adj. R^2	0.959	

Note: The annual trend indicates an estimated coefficient of the trend term representing the time of completion.

Table 5. Office and Housing Rent Function Estimation Results

Method of Estimation	OLS			
Dependent Variable	*OR*: Rent of Office (in log)		*RC*: Rent of Condominium (in log)	
Property Characteristics (in log)	Coefficient	t-value	Coefficient	t-value
Constant	8.374	181.483	0.253	–24.999
FS: Contractual space	0.190	59.102	–0.197	–141.297
BY: Number of years after construction	–0.093	–24.174	–0.070	–259.324
WK: Distance to nearest station	–0.219	–46.556	–0.034	–70.827
ACC: Time distance to Tokyo centre	–0.112	–25.362	–0.066	–117.539
TA: Total floor space	0.051	16.932	–	–
SRC: SRC building dummy	0.199	34.020	0.013	29.494
D1F: First-floor dummy	–	–	–0.042	–76.386
DR1: One-room dummy	–	–	0.706	94.008
DRF: Family-type dummy	–	–	–1.581	–125.536
Cross-Term Effect by Property Characteristics				
DR1×FS	–	–	–0.263	–123.852
DR1×WK	–	–	–0.011	–14.917
DR1×BY	–	–	0.025	63.409
DR1×ACC	–	–	–0.040	–74.509
DRF×FS	–	–	0.403	137.089
DRF×WK	–	–	0.004	4.966
DRF×BY	–	–	–0.002	–3.705
DRF×ACC	–	–	–0.035	–46.599
Ward (city) Dummy	Yes		Yes	
Railway/Subway Line Dummy	Yes		Yes	
Time Dummy	Yes		Yes	
Adjusted R square=	0.608		0.758	
Number of observations=	13,147		488,348	

Table 6. Panel Data Outline

Year	Variable	Unit	Number of observations	Average	Standard deviation	Minimum	Maximum
1996	R^R	Yen	40516	8399	2836	2837	26542
	R^C	Yen	40516	4720	765	3018	6451
	Δ	Million yen	40516	−10.91	55.11	−2712.34	−0.01
	Ψ	–	40516	0.06	0.25	0	1
	Δ (Ψ = 1)		2607	−2.25	7.07	−153.73	−0.01
	Δ (Ψ = 0)		37909	−11.51	56.90	−2712.34	−0.01
2001	R^R	Yen	40516	6402	2162	2163	20232
	R^C	Yen	40516	4808	779	3073	6570
	Δ	Million yen	40516	−7.19	37.66	−1878.82	0.02
	Ψ	–	40516	0.09	0.28	0	1
	Δ (Ψ = 1)		3576	−1.44	4.21	−101.27	0.00
	Δ (Ψ = 0)		36940	−7.75	39.38	−1878.82	0.02

Note: R^R indicates a rent after redevelopment and R^C a rent for a case without redevelopment.

Table 7. Probit Estimation of Redevelopment Probability

	All samples	Region 1	Region 2	Region 3
Δ	0.3181	0.0576	0.4447	0.3407
	(0.0093)	(0.0058)	(0.0250)	(0.0219)
Constant	−13.5617	−5.7765	−9.3597	−9.7961
	(0.4317)	(0.1630)	(0.5139)	(0.6578)
σ	10.5011	2.9883	7.6478	8.0016
	(0.3327)	(0.0903)	(0.4046)	(0.4998)
ρ	0.9910	0.8993	0.9832	0.9846
	(0.0006)	(0.0055)	(0.0017)	(0.0019)
Number of obs.	81032	30110	19898	30468
Individual number of groups	40516	15055	9949	15234
Wald (chi squared)	1160.1	98.8	315.3	242.8
	[.000]	[.000]	[.000]	[.000]
Log likelihood	−15071.5	−2567.9	−3792.0	−8043.3

Note. In parentheses are standard errors. Explained variables are binary variables: 1 for redevelopment cases and 0 for non-redevelopment cases. ρ is the correlation coefficient of the error structure including random effects. Wald represents a test static (chi squared at freedom degree of 1). Numbers in brackets indicate the probability.

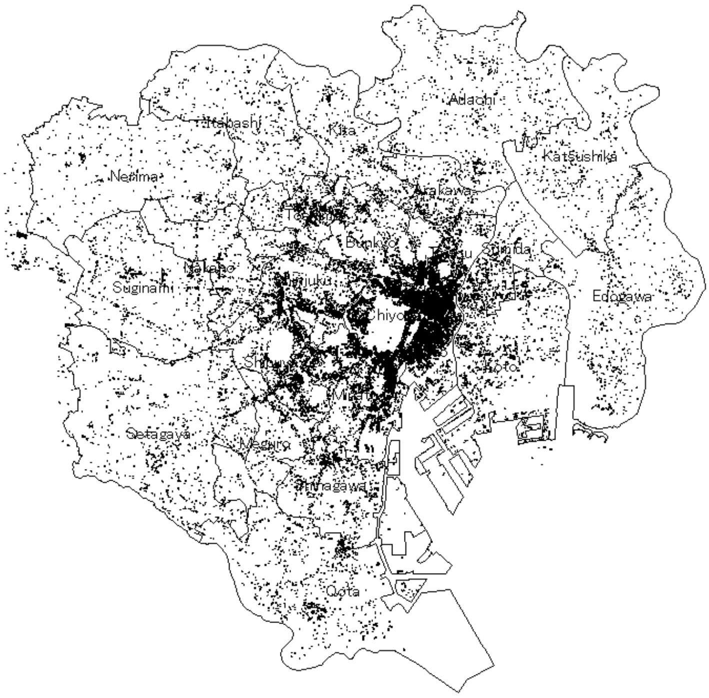

Figure 1. Office Buildings (1991)

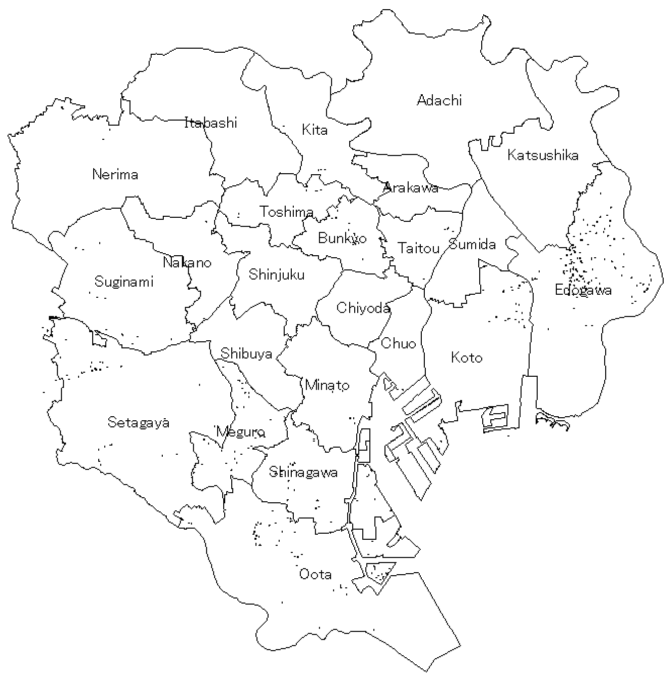

Figure 2. Spatial Distribution of Offices for Lower Rents than Housing Rents in Tokyo's 23 Special Wards in 1995 (Housing rent > Office rent)

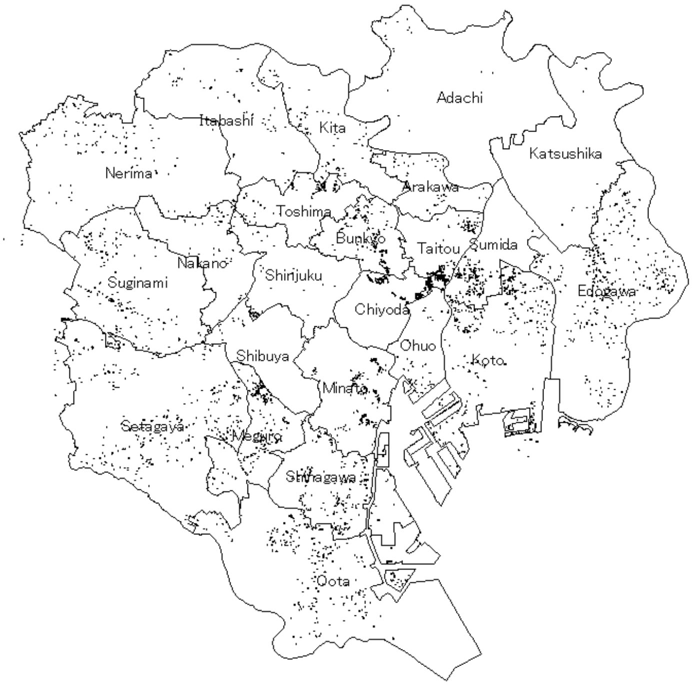

Figure 3. Spatial Distribution of Offices for Lower Rents than Housing Rents in Tokyo's 23 Special Wards in 2000 (Housing rent > Office rent)

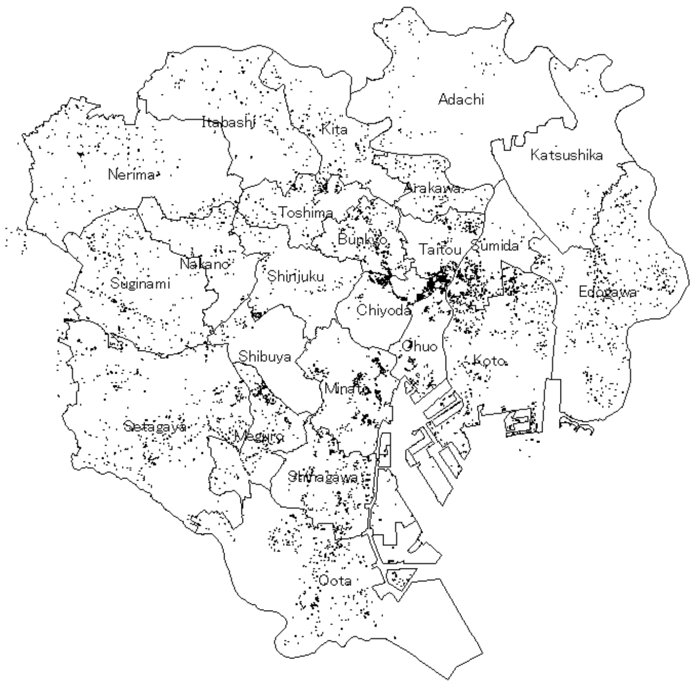

Figure 4. Spatial Distribution of Offices for Lower Rents than Housing Rents in Tokyo's 23 Special Wards in 2004 (Housing rent > Office rent)