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Earthquake Risks and Land Prices: Evidence from the Tokyo Metropolitan Area

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Abstract: Land prices may reflect a premium compensating for earthquake risks in that risk-averse agents tend to avoid land with a high degree of danger posed by earthquakes. The current paper empirically addresses that issue using a hazard map compiled for the entire region by the Tokyo Metropolitan Government in 1998. It finds strong evidence for the impact of earthquake risks on land pricing; land prices are substantially lower in risky areas than in safe areas even after controlling for other possible effects on land pricing. That impact became more evident in the 1990s than in the 1980s, indicating that households and firms were becoming more sensitive to earthquake risks. In addition, this paper carefully examines the consistency of the estimated magnitude of earthquake risk premiums within a framework of the expected utility hypothesis, thereby proving an extremely strong aversion toward a given unit of earthquake risks.

Keywords: earthquake risks, risk aversion, land pricing, hazard map.
JEL classification: R14, R22, G11.

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1. Introduction

Risk aversion of households and firms toward earthquake risks may be inferred from real estate data in two ways. First, land prices may reflect a premium compensating for earthquake risks in that risk-averse agents tend to avoid land with a high degree of danger posed by earthquakes. Second, house rents may reflect information on degrees of earthquake-resistant quality of construction in that risk-averse agents prefer solidly built structures. This paper empirically examines the first issue, while our companion paper (Nakagawa et al. [2004]) addresses the second issue.

There have been few empirical studies concerning the effects of earthquake risks on land pricing in the field of urban and regional economics. Among exceptions, Beron et al. [1997] compare residential prices in the San Francisco Bay Area between, before, and after the Loma Prieta Earthquake of 1989. Their study suggests that residents in this area had revised the assessment of earthquake risks after the earthquake occurred. Brookshire et al. [1985] is close to our study in terms of empirical approach. They find significant impacts on land pricing from the disclosure of a hazard map by the State Government of California. In addition, they show that the estimated decline of land prices due to earthquake risks is quite consistent with what is implied for risk-averse behavior under expected utility theory.

This paper empirically analyzes how land prices reflect earthquake risks using a hazard map compiled for the entire region by the Tokyo Metropolitan Government in 1998 (Bureau of City Planning [1998]). Controlling for other possible effects on land pricing based on existing empirical literature of land pricing, we test statistically how the land prices reported officially by the National Land Agency [1980 through 2001] (Koji-Chika or Published Land Prices) are influenced by the earthquake risk implied by the above hazard map. In addition, adopting a simple theoretical model, this paper carefully examines the consistency of the estimated magnitude of earthquake risk premiums within an expected utility framework.

We summarize our findings as follows. We found strong evidence for the effect of earthquake risks on land pricing; land prices are lower in risky areas than in safe areas even after controlling for other possible effects on land pricing. More concretely, the price of the riskiest areas is discounted against that of the safest by around 10 percent. Such an effect became more prominent in the 1990s than in the 1980s, suggesting that households and firms became more sensitive to earthquake risks. Our numerical investigation based on a simple theoretical model suggests that economic agents such as households and stockholders show an extremely strong aversion toward a given unit of earthquake risks.

These findings have important implications for disaster prevention policy. Given a profound aversion toward earthquake risks on the side of economic agents, there is ample room for both central and local governments to adopt market-oriented approaches, thereby giving agents an incentive to control disaster risks more effectively. Such market-oriented policy instruments include disclosure of information concerning natural disaster risks, public assistance to private insurance markets, and subsidies for mitigation expenses. In addition, ex-ante benefits of disaster prevention policy may be calculated accurately by observing an increase in land prices due to such policy measures.

This paper is organized as follows. Section 2 briefly describes the hazard map compiled by the Tokyo Metropolitan Government. Section 3 presents empirical specification and reports estimation results. Using a simple theoretical framework, Section 4 attempts to interpret the estimated impact of earthquake risks on land pricing according to expected utility theory. Section 5 concludes.

2. On the Disclosure of Earthquake Risks by the Tokyo Metropolitan Government

While the Tokyo Metropolitan Government has compiled an earthquake hazard map by disclosing several kinds of indexes of earthquake risks about every five years since 1975, it released the most elaborate earthquake hazard map on almost a seven-digit postcode basis for the entire metropolitan area except for western rural areas in March 1998 (Bureau of City Planning [1998]). These data have been available through the website of the Tokyo Metropolitan Government since 1998.

The construction of the above earthquake risk index in the 1998 version is not an assessment of damage by a specific predicted earthquake. It is rather an assessment of the comparative vulnerability among finely divided regions (on the seven-digit postcode basis) in terms of (i) potential damage to buildings due to initial earthquake shocks, (ii) potential damage to buildings due to consequent fires, (iii) potential human injuries due to initial earthquake shocks, and (iv) potential human injuries due to consequent fires. Each index classifies degrees of riskiness according to five ranks, from Rank 1 (safest) to Rank 5 (riskiest).

Our study uses the 1998 version of the risk index of construction damage due to initial earthquake shocks (the building collapse risk). A major reason why we adopt the building collapse risk among the four indexes is that this index mainly considers (a) the quality of the ground structure, and (b) earthquake-resistant properties of constructions built on an implicated area. More concretely, the risk index is low if the ground of an affected area is solid, or if robust constructions are built on an affected area. Among 2893 divided areas, 1257 areas belong to Rank 1, 1003 to Rank 2, 466 to Rank 3, 131 to Rank 4, and 36 to Rank 5.

The other three indexes take into consideration not only ground and building structures, but also area congestion. In other words, the other indexes regard degree of congestion as a risk factor. Area congestion, however, often accords with regional concentration, and sometimes has a positive impact on land pricing. Accordingly, when adopting these risk indexes as an explanatory variable in regression, a negative impact of earthquake risks on land pricing may be offset by a positive externality of regional concentration. Conversely, congestion in urban districts may trigger negative externality on land pricing. In the latter case, such interaction of earthquake risk measures with degrees of congestion may yield seemingly negative impacts of risk indexes on land pricing. We thus use the first index in order to avoid such apparent offsetting effects on land pricing.

As mentioned above, the 1998 version of the earthquake risk index is superior to the previous three versions in terms of wider regional coverage with finer meshes, and is based on more thorough site investigation. On the other hand, we cannot compare the 1998 version directly with the previous versions; therefore, it may be difficult to check directly the time-series stability of the index of construction damage due to initial earthquake shocks, in particular a time-series shift of the index caused by a change in building structure in an affected area.

Some circumstantial evidence, however, suggests that the index has been quite stable over time. First, the distribution of building structures in each area concerned has not changed substantially during the past fifteen years. For example, the share of wooden houses in each of the regions classified by cities or wards has not shown any significant shift since 1983. More precisely, the difference in the share ratio between 1998 and 1983 is within one percent. Second, rough geographical matching of the risk index of the 1998 version with that of the previous versions also indicates the time-series stability of the index reported by the 1998 version. For example, sixty out of the eighty-three areas that are ranked as Rank 5 in the 1998 version are classified in the same rank in the 1993 version. We therefore assume the time-series stability of the 1998 index in the following estimation procedure.

3. Data and Estimation Results

3-1. Data

Following a standard hedonic pricing approach, we regress land prices on possible factors including the index described above of earthquake risks. As data points of time, we choose the years 1980, 1985, 1990, 1994, 1996, 2000, and 2001. A major reason for this choice of sample points is to check whether land pricing in Tokyo was influenced by the occurrence of the Great Hanshin-Awaji Earthquake in January 1995, which was the last incidence of a calamitous earthquake in the urban area in Japan before 2004.

This study uses the land price reported officially by the National Land Agency (the Published Land Prices, or the Koji-Chika) as a dependent variable. More precisely, it adopts a natural logarithm of a land price as a dependent variable. The Koji-Chika data set is the most comprehensive available in terms of both time-series continuity and geographical coverage. The number of surveyed samples in the Tokyo Metropolitan Area is 1467 (the year 1980), 1484 (1985), 1589 (1990), 2526 (1994), 2841 (1996), 2870 (2000), and 2833 (2001) respectively.

This Koji-Chika data set is based on the land prices assessed by the certified real estate appraisers. The real estate appraisers usually pay attention to market prices quoted in the neighborhood in assessing these land prices; in this sense, the market assessment of possible risk factors including earthquake risks may be reflected in the Koji-Chika data (the data of the Published Land Prices).

The Koji-Chika data report a land price per square meter after controlling for price impacts of land shapes (more irregular, more discounted) and accessibility to a public road (further from a public road, more discounted). The average land prices per square meter in the Tokyo Metropolitan Area were 269,000 yen (the year 1980), 654,000 yen (1985), 2,249,000 yen (1990), 1,193,000 yen (1994), 782,000 yen (1996), 592,000 yen (2000), and 565,000 yen (2001).

Among explanatory variables, we construct a dummy variable based on the index, described above, of earthquake risks reported by the Tokyo Metropolitan Government in 1998. Considering the small sample sizes of risky areas, we classify Rank 1 as the lowest risk, Rank 2 as the middle risk, and Ranks 3, 4, and 5 together as the highest risk. Excluding the lowest risk dummy from a set of explanatory variables, coefficients on the middle risk dummy and the highest risk dummy indicate a percentage price difference from land with the lowest risk. Because we reasonably expect the time-series stability of the risk index as discussed before, we use the same risk index as an explanatory variable for each year.

Following existing literature of a hedonic pricing approach applied in Japanese cities (for example, Gao and Asami [2001], Kanemoto and Nakamura [1986], and Kanemoto et al. [1996]), we adopt the following variables as explanatory variables, thereby controlling for possible effects on land pricing: road distance to the nearest station, legally required bulk ratios (ratio of total floor area to site area), dummy variables of gas supply, water supply, and sewage availability, and legal restriction on land uses. Accurate information as to these explanatory variables is conveniently available from the Koji-Chika data set of each year. In addition, we calculate the time distance from the nearest station to Tokyo Station according to the train timetable of the year 2000,[3] and add it to a list of explanatory variables. The time distance to Tokyo Station is often regarded as a measure of commuting convenience in the Tokyo Metropolitan Area.

Finally, we include, as explanatory variables, dummy variables of both a city (ward) and the nearest commuter line. A major reason for the inclusion of these dummy variables is that the Tokyo Metropolitan Area is distinctly segmented according to income classes. Consequently, in which city (ward) and along which line of railroad a household lives is likely to imply which economic class one belongs to. Hence, the convenience and amenity of an area of concern depend largely on both in which city (ward) and along which commuter line a household lives.

3-2. Estimation results

[Table 1. inserts here]

Table 1 reports the estimation results for each sample point of time. All estimated coefficients on time

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[3] For this purpose, we use software provided by VAL Institute (http://val.co.jp).

distance to Tokyo Station, road distance to the nearest station, and legally required bulk ratios (ratio of total floor area to site area) show reasonable signs and statistical significance at the level of 1% over time. Although only the estimation result based on the year 2001 is reported in Table A, the estimated coefficients on dummy variables associated with residential environment and amenity are also consistent with those of existing literature in terms of signs and significance.[4]

With respect to the effects of earthquake risks, land pricing does not differ significantly between land with the lowest risk and with the middle risk. On the other hand, all estimated coefficients on the highest risk dummy are significantly negative. A closer look at these estimation results tells us that land with the highest risk was discounted mildly against land with the lowest risk (by 5% to 7%) in 1980 and 1985, while it was discounted substantially (by more than 10%) in 1990, 1994, and 1996. The estimated price difference narrowed slightly to around 9% in 2000 and 2001.

The observed time-series behavior of the estimated coefficients on the risk dummies suggests that the enhanced effect of earthquake risks on land pricing was not motivated directly by either the incidence of the Great Hanshin-Awaji Earthquake in 1995 or the disclosure of the elaborate hazard map in 1998. Instead, the pricing impact of earthquake risks was more evident from the beginning of the 1990s.

Some circumstantial evidence may explain the above time-series behavior. First, both firms and households have become more sensitive to earthquake risks since the mid-1980s. According to a household survey conducted by the Tokyo Metropolitan Government (Bureau of Policy and Information [1984, 1995]), for example, 85.8% of surveyed households expressed anxiety toward earthquake risks in 1995, but only 73.3% did so in 1984. A wider price difference between safe areas and risky areas may be attributed to such growing recognition of earthquake risks among households and firms. It follows from this conjecture that the price of safe areas soared more rapidly than that of risky areas at the period of dramatic increases in land prices during the late 1980s, thereby more evidently reflecting differences in degrees of earthquake risks.

A slight decline in price differentials between safe and risky areas from the late 1990s may reflect the immediate impact of the 1995 incidence of the Great Hanshin-Awaji Earthquake on urban planning. The earthquake produced devastating damage in the Hanshin Area, the second largest urban area in Japan, and triggered comprehensive development of disaster prevention measures in the Tokyo Metropolitan Area. These measures helped to reduce the vulnerability of densely built-up areas to civil disasters. Thanks to these measures, prices of previously risky areas might have improved to some extent.

As a final remark, we discuss the possibility that the earthquake risk dummy may pick up effects other than an earthquake risk factor, and generate a seeming relationship with land pricing. In particular, the risk dummy may act as proxy for environmental variables such as amenity and convenience. We argue

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[4] As far as the coefficients on these dummy variables are concerned, the estimation results of the other years are basically the same as those of the year 2001.

against such a possibility for the following reasons.

First, if it were the case, the estimated coefficient on the risk dummy should be substantially negative even in 1980 and 1985, and there would be no reason for any difference in risk impacts between the 1980s and the 1990s. It is then rather difficult to justify the enhanced effect of the risk dummy during the 1990s without due consideration of growing recognition of earthquake risks among households and firms.

Second, our well-prepared list of explanatory variables is able to control for environmental effects on land pricing to a large extent. Variables of road distance to the nearest station and time distance to Tokyo Station can act as proxy for degrees of commuting convenience. As is well recognized in existing literature, dummy variables of cities (wards) and commuter lines can control for residential environmental factors and segmentation effects due to income classes (see Table A).

Third, a degree of congestion in an affected area is likely to be an endogenous variable and may interact with environmental variables. As mentioned in the previous section, however, the risk index we use for estimation procedures is potential damage due to initial earthquake shocks, and unlike the other three risk indexes does not consider any congestion aspect directly in measuring risks. Therefore, it is hard to imagine that the risk measure used triggers such interaction, thereby yielding a seemingly negative relationship with land pricing.

Fourth, as Nakagawa et al. [2004] demonstrate, the above earthquake risk measure is negatively related to rent pricing in interaction with the robustness of rented houses. That is, the rent of fragile apartments differs more significantly from that of robust ones in the areas classified as Ranks 3, 4, and 5 than in those classified as Ranks 1 and 2. It would be hard to imagine that environmental factors other than earthquake risks interact with construction robustness in such a manner. Thus, those estimation results suggest that this measure can capture earthquake risks rather than overall environmental factors.

4. Consistency of Estimated Risk Impacts within Expected Utility Framework

The previous section has demonstrated that earthquake risks have statistically significant effects on land pricing in the Tokyo Metropolitan Area. That is, land prices are discounted by around 10% given the highest degree of earthquake risk. This section examines to what extent such an estimated magnitude of earthquake risks on land pricing is justifiable within a standard framework of expected utility theory.

4-1. Simple theoretical framework

Suppose that a monotonically increasing and concave utility function U is defined on the level of household wealth. An earthquake occurs with probability π. A direct loss on a construction built on implicated land is denoted by s. A household is endowed with total wealth including human capital W. For some reasons, such as the incompleteness of natural disaster insurance, S out of W remains uninsured against earthquake risks.

Given the above setup, a risk-averse household assesses a direct loss of an earthquake (s) using the marginal rate of substitution between a state prior to an earthquake and a state where an earthquake occurs. That is,

$$q = \frac{\pi U'(W-S)}{U'(W)} s, \tag{1}$$

where $U'(g)$ denotes a marginal utility.

Since U is monotonically increasing and concave, $U'(W-S) > U'(W)$ holds. Hence, $q > \pi s$ obtains from equation (1). This implies that the earthquake loss assessed by a risk-averse household q is greater than an expected loss or an actuarially fair value πs. A difference between q and πs corresponds to a premium compensating for an earthquake risk.

Taylor-expanding equation (1) around W by the first order leads to

$$q = \left(1 + \gamma \frac{S}{W}\right) \pi s, \tag{2}$$

where a parameter γ indicates the degree of relative risk aversion, and it is defined as $-\frac{U''(W)W}{U'(W)}$.

Equation (2) demonstrates that the magnitude of the risk premium ($\gamma \frac{S}{W}$) depends on both the degree of relative risk aversion and the extent to which household wealth is exposed to earthquake risks. Because the above q is defined in a flow term, the present value of future premium flows is equal to $\frac{q}{r}$, where r is a period rate of interest. Accordingly, a land price P_L with an earthquake risk is discounted by $\frac{q}{r}$. In other words, the price of land with an earthquake risk differs from that without one by $\frac{q/r}{P_L}$.

4-2. Simple calibration

Calibrating the land-pricing model based on equation (2), this subsection examines whether the estimated magnitude of decreases in land prices due to earthquake risks is consistent with what is implied by expected utility theory. We here assume that a land price discount due to earthquake risks $\frac{q/r}{P_L}$ corresponds to the price difference between land with the highest risk and land with the lowest risk. More concretely, we suppose that $\frac{q/r}{P_L}$ equals 9.6% based on the estimation of the year 2000.

The following assumptions are made for the other parameters. The annual real interest rate is assumed to be the average mortgage rate adjusted by the consumer price index for the sample period between 1987 and 1999. That is, r is 3.52%. Considering that an earthquake with a magnitude of higher than 6.9 has occurred every twenty years on average since the beginning of the seventeenth century, we assume that the upper bound of the annual occurrence of catastrophic earthquakes is equal to 5% per year. We also calibrate the cases with earthquake occurrence 1%, 2%, 3%, and 4% per year.

A damage of construction s is calculated as follows. Based on the estimates from Yoshida and Chun [2001], the average value of household residence in Tokyo was 7,030,000 yen in 1993; adjusted by the residential price index, it was 7,072,000 yen in 1999. According to a survey entitled *A Report of Estimated Damages in Case of Earthquake with Hypocenter Directly Below Tokyo* compiled by the Tokyo Metropolitan Government in 1997 (Tokyo Metropolitan Disaster Prevention Council [1997]), the difference in a construction damage ratio (the ratio of physical losses relative to the value of residential assets) between land with the lowest risk and land with the highest risk is 28.9%. Therefore, a damage of construction s is equal to 2,042,000 yen (7,072,000 x 0.289). Finally, according to *The Family Income and Expenditure Survey* conducted by the Agency of General Affairs in 1999 (Agency of General Affairs [1999]), the average value of land owned by households in the Tokyo Metropolitan Area (P_L) is 33,873,000 yen.

[Table 2. inserts here]

Substituting the above assumptions into equation (2), Table 2 reports the calibrated value of $\frac{S}{W}$, or the calculated extent to which household wealth is exposed to earthquake risks for the range of relative risk aversion γ between 2 and 10.[5] If the estimation of impacts of earthquake risks on land pricing is consistent with a framework of expected utility theory, then $\frac{S}{W}$ should be between zero and one. Conversely, if the calibrated value of $\frac{S}{W}$ is greater than one, then households demand excessively large premiums for taking earthquake risks. In other words, the observed risk premium is too large to be consistent with the underlying theory.

As shown in Table 2, the calibrated value of $\frac{S}{W}$ shows a reasonable range (between zero and one) for most combinations of the probability of earthquake occurrence and the degree of relative risk aversion. The only exceptions, where $\frac{S}{W}$ is beyond one, are the cases with the combination of the lowest probability 0.01 and relatively low risk aversion (less than four); in these cases, the observed premium on earthquake risks is too large to be consistent with expected utility theory.

The above finding suggests that the estimated magnitude of a risk premium is justifiable within a framework of expected utility theory given relatively pessimistic scenarios (scenarios with high π). As Gilboa and Schmeidler [1989] demonstrate theoretically, if there is any ambiguity in the assessment of

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[5] The assumption of the range for γ follows a typical setup of calibration exercises in macroeconomics and asset-pricing theory.

either losses or probabilities, risk-averse agents tend to respond to the most pessimistic scenario among possible scenarios with respect to losses and probabilities. It is indeed the assessment of earthquake risks that involves such ambiguity in the most serious manner. Our finding indicates that households tend to take rather pessimistic scenarios into consideration when presented with such ambiguity in earthquake risk assessment.

5. Conclusion

Using the hazard map compiled by the Tokyo Metropolitan Government in 1998, this paper has empirically examined how earthquake risks are reflected in land pricing. The estimation results show that land with the highest earthquake risk is discounted by around ten percent against land with the lowest risk. Such a tendency in land price discounting was most significant during the early 1990s; these results may reflect the fact that both households and firms have become progressively more sensitive to earthquake risks since the late 1980s.

In addition, using a simple calibration procedure, we have demonstrated that the estimated magnitude of effects of earthquake risks on land pricing is consistent with expected utility theory given a rather pessimistic scenario for probability of earthquake occurrence. This calibration result suggests that the behavior of risk-averse households is in response to pessimistic scenarios in the presence of serious ambiguity in the assessment of earthquake risks.

Our overall findings strongly suggest that agents including households and firms are rather averse toward earthquake risks, and that land prices reflect such risk aversion significantly. If that is the case, public policy such as urban planning and disaster prevention measures should seriously consider risk-averse behavior by households and firms. In other words, market-oriented policy measures, such as disclosing earthquake risks, maintaining orderly insurance and reinsurance for natural disaster risks, and subsidies for mitigation behavior of firms and households, may give risk-averse agents a powerful incentive to protect themselves against earthquake risks. In addition, ex-ante benefits of disaster prevention policy may be calculated fairly accurately by observing increases in land prices due to such policy measures.

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Table 1: Estimation Results of Land Pricing Functions

(Natural Logarithms of Land Prices as Dependent Variables)

Year	1980	1985	1990	1994	1996	2000	2001
Earthquake Risk Index: Rank 2.	0.017	0.009	0.012	-0.003	-0.008	-0.008	0.002
	(0.0207)	(0.0197)	(0.0196)	(0.0135)	(0.0114)	(0.0117)	(0.0122)
Earthquake Risk Index: Ranks 3, 4, and 5.	-0.050*	-0.069**	-0.107***	-0.121***	-0.105***	-0.096***	-0.092***
	(0.0278)	(0.0274)	(0.0273)	(0.0186)	(0.0152)	(0.0159)	(0.0167)
Time Distance to Tokyo Station	-0.274***	-0.255***	-0.294***	-0.283***	-0.298***	-0.339***	-0.227***
	(0.0457)	(0.0488)	(0.0495)	(0.0353)	(0.0295)	(0.0303)	(0.0290)
Distance to the Nearest Station	-0.109***	-0.078***	-0.077***	-0.070***	-0.072***	-0.080***	-0.079***
	(0.0070)	(0.0065)	(0.0067)	(0.0046)	(0.0040)	(0.0042)	(0.0043)
Bulk Ratio (Total Floor Area/Site Area)	0.270***	0.382***	0.484***	0.517***	0.448***	0.435***	0.461***
	(0.0314)	(0.0385)	(0.0394)	(0.0268)	(0.0224)	(0.0237)	(0.0247)
Constant Term	11.125***	10.458***	12.693***	12.179***	11.449***	11.677***	10.766***
	(0.5116)	(0.4701)	(0.3513)	(0.2795)	(0.2995)	(0.2747)	(0.2454)
Adjusted .R^2	0.894	0.919	0.939	0.935	0.926	0.906	0.901
Number of Samples	1467	1484	1589	2526	2841	2870	2833

(1) Numbers in parentheses are standard errors.

(2) ***, **, and * imply the significance level of 1%, 5%, and 10% respectively.

(3) This table does not report any estimates of coefficients on dummy variables of gas, water supply, sewage, legal restriction on land uses, wards or cities, and railroads.

Table 2: Implied Uninsured Wealth Ratio (S/W) Given a Combination of Relative Risk Aversion and Occurrence Probability of Earthquake

γ : Relative Risk Aversion π : Earthquake Probability	2	4	6	8	10
0.05	0.065	0.033	0.022	0.016	0.013
0.04	0.205	0.103	0.068	0.051	0.041
0.03	0.440	0.220	0.147	0.110	0.088
0.02	0.910	0.455	0.303	0.228	0.182
0.01	2.320	1.160	0.773	0.580	0.464

Table A: Estimated Coefficients of Dummy Variables Associated with Residential Environment and Amenity (based on the year 2001 estimation)

Dummy Variables	Estimated Coefficients	Standard Errors
Utility		
Gas	0.078***	(0.0161)
Sewage	0.103***	(0.0272)
District Category		
Category 1 Exclusively Medium-high Residential District	0.082***	(0.0202)
Category 1 Exclusively Low-story Residential District	0.344***	(0.0288)
Category 2 Exclusively Medium-high Residential District	0.057***	(0.0301)
Category 2 Exclusively Low-story Residential District	0.143***	(0.0643)
Neighborhood Commercial District	0.036***	(0.0220)
Industrial District	-0.123***	(0.0501)
Exclusively Industrial District	-0.259***	(0.1203)
Commercial District	0.327***	(0.0265)
Ward/City		
Akiruno	-1.381***	(0.1228)
Inagi	-0.853***	(0.0820)
Hamura	-1.163***	(0.0927)
Katushika	-0.887***	(0.0689)
Edogawa	-0.758***	(0.0612)
Koto	-0.940***	(0.0607)
Minato	-0.142***	(0.0524)
Arakawa	-0.934***	(0.0659)
Kokubunji	-0.611***	(0.0823)
Kunitachi	-0.625***	(0.0870)
Komae	-0.572***	(0.0803)
Mitaka	-0.477***	(0.0732)
Shibuya	-0.146***	(0.0589)
Koganei	-0.611***	(0.0786)
Kodaira	-0.935***	(0.0718)
Akishima	-0.954***	(0.0822)
Shinjuku	-0.213***	(0.0533)
Mizuho	-1.314***	(0.1063)
Suginami	-0.513***	(0.0628)
Setagaya	-0.429***	(0.0626)
Kiyose	-0.965***	(0.0810)
Ome	-1.324***	(0.0764)
Adachi	-1.132***	(0.0623)
Tama	-0.952***	(0.0787)
Taito	-0.819***	(0.0551)
Ohta	-0.573***	(0.0630)
Chuo	-0.113***	(0.0524)
Nakano	-0.529***	(0.0628)
Machida	-1.073***	(0.0663)
Chofu	-0.634***	(0.0723)
Tanashi	-0.740***	(0.0886)
Higashi Kurume	-0.934***	(0.0795)
Higashi Murayama	-1.026***	(0.0766)
Higashi-Yamato	-1.096***	(0.0768)
Hinode	-1.497***	(0.1514)
Hino	-0.955***	(0.0716)
Hachioji	-1.165***	(0.0704)
Itabashi	-0.664***	(0.0626)
Shinagawa	-0.540***	(0.0595)
Fuchu	-0.751***	(0.0765)
Musashi-Murayama	-1.090***	(0.0807)
Musashino	-0.332***	(0.0755)
Fussa	-1.233***	(0.0859)
Bunkyo	-0.548***	(0.0546)

Hoya	-0.790***	(0.0847)
Toshima	-0.664***	(0.0604)
Kita	-0.690***	(0.0637)
Sumida	-0.925***	(0.0682)
Meguro	-0.439***	(0.0664)
Tachikawa	-0.851***	(0.0703)
Nerima	-0.644***	(0.0616)
Railroad Line		
JR Yokosuka	-0.283***	(0.1219)
JR Yokohama	-0.196***	(0.0578)
Marunouchi (Subway)	-0.156***	(0.0408)
Keio Inokashira	-0.210***	(0.0465)
Keio Takao	-0.189***	(0.0683)
Keio Shinsen	-0.531***	(0.0920)
Keio	-0.247***	(0.0416)
Keio Sagamihara	-0.192***	(0.0555)
Keisei Oshiage	-0.290***	(0.0880)
Keisei	-0.265***	(0.0657)
Keisei Kyuko	-0.344***	(0.0616)
JR Keihin-Tohoku	-0.245***	(0.0462)
JR Keiyo	-0.261***	(0.1399)
JR Kuko	-0.398***	(0.0769)
JR Saikyo	-0.245***	(0.0722)
Odakyu	-0.224***	(0.0445)
Seibu Kokubunji	-0.311***	(0.0732)
Seibu Shinjuku	-0.256***	(0.0412)
Seibu Tamako	-0.238***	(0.0645)
Seibu Tamagawa	-0.204***	(0.0652)
Seibu Ikebukuro	-0.260***	(0.0422)
Seibu Haijima	-0.186***	(0.0504)
Seibu Yurakucho	-0.403***	(0.1647)
Seibuen	-0.323***	(0.1660)
JR Ohme	-0.142***	(0.0515)
JR Joban	-0.295***	(0.0702)
Chiyoda (Subway)	-0.128***	(0.0501)
JR Sobu	-0.332***	(0.0537)
Tama (Monorail)	-0.164***	(0.0616)
JR Chuo	-0.286***	(0.0376)
Tokyu Denentoshi	-0.177***	(0.0788)
Mita (Subway)	-0.284***	(0.0467)
Shinjyuku (Subway)	-0.272***	(0.0550)
Asakusa (Subway)	-0.372***	(0.0478)
Oedo (Subway)	-0.319***	(0.0585)
Arakawa	-0.236***	(0.0712)
Tokyu Shin-Tamagawa	-0.154***	(0.0545)
Tokyu Setagaya	-0.239***	(0.0750)
Tokyu Ohimachi	-0.161***	(0.0543)
Tokyu Ikegami	-0.254***	(0.0570)
Tokyu Mekama	-0.226***	(0.0591)
Tokyo (Monorail)	-0.530***	(0.1247)
Tozai (Subway)	-0.310***	(0.0523)
Tobu Isezaki	-0.182***	(0.0591)
Tobu Kamedo	-0.217***	(0.1159)
Tobu Taishi	-0.219***	(0.0772)
Tobu Tojo	-0.253***	(0.0551)
JR Nanbu	-0.161***	(0.0607)
Nanboku (Subway)	-0.326***	(0.0614)
Hibiya (Subway)	-0.306***	(0.0472)
JR Hakko	-0.233***	(0.0675)
Hanzomon (Subway)	-0.287***	(0.0963)
JR Musashino	-0.227***	(0.0826)
Hokuso	-0.472***	(0.2352)
Yurakucho (Subway)	-0.339***	(0.0400)

(1) ***, **, and * imply the significance level of 1%, 5%, and 10% respectively.

(2) The reference point is an area which is classified as Category 1 Residential District and is located in Chiyoda Ward along the JR Yamanote Line.