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Incorporating Land Characteristics into Land Valuation for Reconstruction Areas

: A Case Study of Kobe City around the Great Hanshin–Awaji Earthquake in 1995

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Abstract

This article, based on a case study of Kobe city just before and after the great earthquake, examines the necessity and effectiveness of incorporating variables that represent the characteristics of local societies, such as income and social wealth, into an analysis of land price differences using the hedonic hypothesis. The authors conclude that income levels may contribute to the land price difference between localities and suggest including these characteristics in the compensation process for reconstruction and development projects planned in the area just after the great earthquake.

Keywords: hedonic hypothesis, land valuation, the Great Hanshin–Awaji Earthquake

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1. Purpose of this Study

To carry out a city planning project, plan formulators and constructors are required to (1) adjust land ownership with landowners, (2) provide compensation if ownership is transferred, and (3) set the reduction rate of site areas during land readjustment. When all of the problems are integrated into the trade-offs among plan formulators/constructors, landowners and leaseholders during the adjustment of land ownership, the basic issue becomes land valuation.

In general, land valuation for a city planning project is carried out by two methods. One is the cost approach in which calculation is performed on the basis of project cost. The other is to compare land prices with information from completed transactions in the area (the sales comparison approach). However, the two indices generally disagree. That is, there is no guarantee that the injection of project cost will be evaluated on the market. As the quality of city planning increases, external economic factors become increasingly influential; as a result, the possibility of disagreement between the land values given by the two methods increases.

In the reconstruction projects after the Great Hanshin–Awaji Earthquake, in some cases where high-standard urban roads had been authorized in city plans and large-scale municipal parks were planned, consensus building among interested participants became difficult. This was because of a deviation between the reduction rate of the site area, which is based on the expected land price increase assumed by the plan formulator using the estimated project cost as an index, and the reservation price assumed by the landowner.

Such situations are to be expected in actual city planning projects. Land valuation is expected to provide basic information used to realize consensus building, while adjusting land rights among the relevant parties during the city planning project. Accordingly, land-valuation results should be of a standard precision, and should be stable and universal.

In particular, in the city planning area, due to reasons such as the change in the comparative advantage of the area as a whole along with changes in expected returns in the future, the market condition deviates from the equilibrium condition. Furthermore, if individual related acts such as building a consensus are assumed, not only the space structures but also the social structure of the target area must be considered simultaneously, and detailed information gathering is required. In particular, in order to use land price information as a basis for the adjustment of land ownership, the stability and universality of the information supplied by the planning authority are important in realizing a consensus (Figure 1).

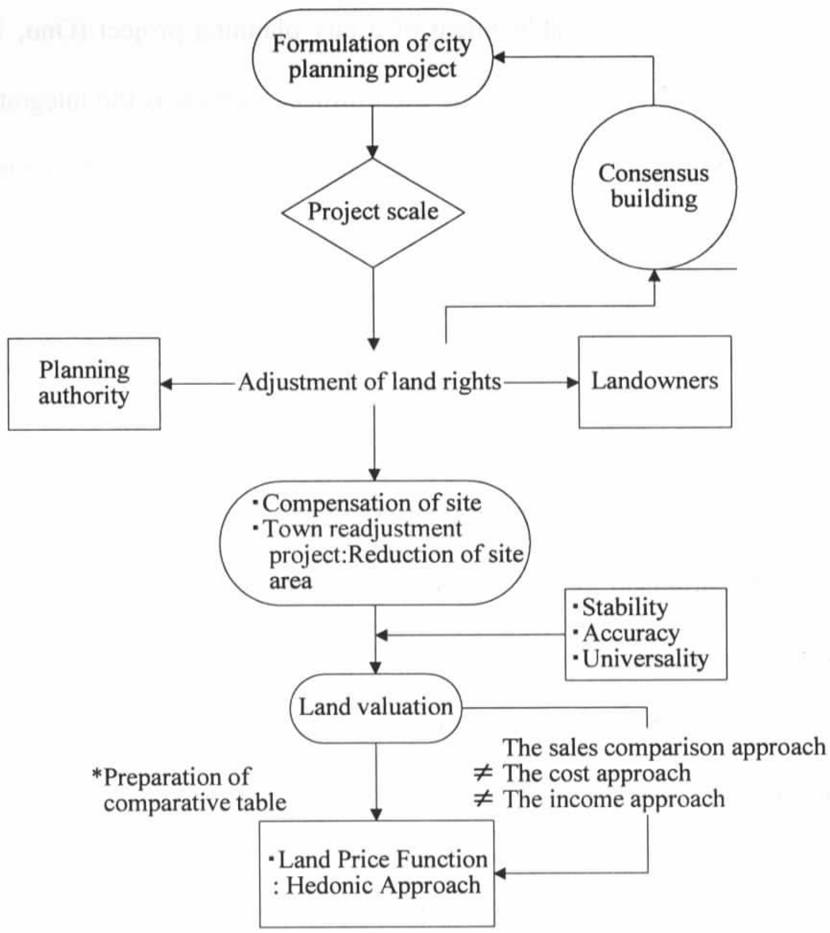

Figure 1. Relationship between formulation of city planning and land valuation

Formulation of city planning project, consensus building, project scale, planning authority, adjustment of land rights (ownership), landowners and leaseholders, compensation of site, town readjustment project, reduction of site area, land valuation, stability, accuracy, universality, preparation of comparative table, the sales comparison approach ≠ the cost approach ≠ the income approach, land price function.

In postdisaster reconstruction projects, the land market condition deviates from the equilibrium condition due to the disaster. Furthermore, the land market then starts to converge toward the equilibrium condition in which a new image of the site in the future is assumed, after the establishment of a city planning project (Ono, 1989). In addition, the fairness of a single reconstruction project, as well as the integration of the project with other projects as a whole to include several project areas should be secured. Accordingly, both the temporal stability of the project progress, and spatial stability that expands over several projects should be ensured concurrently.

The reconstruction project is, in one sense, disaster restoration, but it is also a huge development project, as history indicates. If the target area is an existing urban area, it is a complete redevelopment project. For the aim of directing the urban structure to be a publicly desirable one, it is natural that public funds be injected; therefore, intervention accompanying ownership transfer and compensation will naturally occur for the land that is the property of individuals.

Here, if reconstruction that takes account of social characteristics unique to each area is pursued, the most important issue for promoting the smooth progress of the project is whether effective treatment can be carried out in each area and whether fair treatment can be carried out between areas.

Therefore, it is extremely important to establish a land price function in which local characteristics are considered in detail. In general, when land price or ground rent is analyzed by the hedonic land price function, an equilibrium market is assumed (Morisugi *et al.*, 1986; Hidano *et al.*, 1992). Many previous studies targeted areas of high demand where the population conglomerates, and did not consider the differences in the income level and preferences of the land buyers between the study areas. In addition, Hayashiyama *et al.* (1994) demonstrated the dependence of excessive estimates on buyers' preferences by numerical calculation for the case when households of various social backgrounds exist in the same area.

Other than the case of large-scale housing redevelopment projects in which a single stratum of society in a suburb is assumed, the formation of a local community on the basis of the history of the area fosters an individual character and unique economy in the area. At the same time, a tense relationship with economical uniformity exists, which leads to the development of the regional characteristics of the area.

In this study targeting Kobe city, which suffered severe damage in the Great Hanshin–Awaji Earthquake, as the restoration area, we estimate the land price function to be taken into consideration for the restoration project. The land market deviates from the equilibrium condition due to the sudden population decrease and the increase in the number of attracted businesses. Moreover, the adjustment of ownership among many relevant parties is required.

2. Information about Land Price and Related Indices

2.1 Land Price Function Model

When the land price function is used in a city planning project, note that the interpretation of the results may differ depending on the type of land price information used. The types of land price information are roughly categorized into two: a land price based on actual transactions, and that assessed by specialists such as real-estate appraisers (*e.g.*, land prices posted by the National Land Agency and standard prices posted by prefectural and city governments). Therefore, analysis using appraisal values as explained variables is equivalent to clarifying the decision-making process of a real-estate appraiser. In addition, it is expected that the decision-making process is accompanied by errors, and that such errors differ depending on the price range and local characteristics (Ono and Shimizu, 1996).

Since appraised values are determined by referring to actual transactions and there is a time delay before obtaining them, such information may be insufficiently responsive under the condition of a changing market structure immediately after postdisaster restoration. When the market is not in equilibrium, it is possible that the transitional phase of the land price structure will differ depending on the area in the city. As in the case of Kobe city, when the reconstruction period differs among areas and when the characteristics of each area after the earthquake are expected to change, an understanding of the area-dependent change is required.

In this study, in order to determine the land price function considering local characteristics, paying attention to the type of information obtained (authenticated value or actual trading price), the land price function in Kobe city before and after the earthquake is defined as

$$PL_{itd} = f(locat, syt, site, pub, (eath), (trs), calt)\ tsv + \varepsilon$$

PL_{itd}: land price of area i, time period t, and type of data d; *i*: area (1: Higashinada, Nada, Chuo, 2: Hyougo, Nagata, Tarumi, Suma, 3: north, west), *t*: time period (1: before earthquake, 2: after earthquake), *d*: type of information (1: transaction value, 2: appraised value), *locat*: convenience, *syt*: institutional constraint, *site*: site condition, *pub*: urban foundation, *eath*: earthquake characteristics, *trs*: transaction state, *calt*: local characteristics, *trv*: time correction, ε: error.

Table 1. List of estimated/explanatory variables for land price function

Variables(Symbol)	Contents
Convenience (*locat*)	● Closeness to central business district (CBD): spatial distance (100 mm) from the nearest station to Sannomiya station (Kobe city), Honmachi station (Midosuji Line) or Himeji station (Himeji city), and temporal distance (transit time, minutes) are calculated and used as independent variables, ● distance along road (m) between each study point to the nearest station
Institutional restrictions (*syt*)	● floor-area ratio (%), ● building-to-land ratio (%), ● city planning dummy: regulated area dummy (regulated area: 1, other area: 0), prospective housing land dummy (prospective housing land: 1, other: 0), ● mixed land use dummy: (when factories and stores coexist within 500 m of the study point: 1, other cases:0)
Environment of the site (*site*)	● acreage (m2), measured acreage is used if it exists, if not, posted acreage is used, ● small-scale housing land dummy: land with area less than 40 m2 (land used for small-scale isolated house) considering the possibility of building a house: 1, other: 0, ● road width in front of the site (m), ● pavement dummy: the road in front of the site is paved: 1, other: 0, ● irregularly shaped site dummy: shape other than square or rectangle: 1, square or rectangle: 0
Urban foundation (*pub*)	● sewerage dummy, with sewerage system: 1, other: 0, ● city gas dummy: with city gas: 1, other: 0, ● private road dummy: the road in front of the site is a private road: 1, other: 0, ● national road dummy: the road in front of the site is a national road: 1, other: 0
Earthquake characteristics (*eath*)	●postearthquake dummy: information obtained after Jan. 17, 1995: 1, other: 0, ● earthquake damage dummy: if the site has been damaged according to residential map published by Zenrin: 1, other: 0, ● priority reconstruction area dummy, if the site is designated a priority reconstruction area: 1, other: 0
transaction state (*trs*)	● buyer dummy: buyers are classified into individuals or corporations (which are further divided into real estate agents and public institutions), if the buyer is an individual: 1, other: 0, same as below, ● seller dummy: sellers are classified into individuals and corporations (which are further divided into real estate agents and public institutions), if the seller is an individual: 1, others: 0, same as below
time adjustment (*tsv*)	● start of housing construction: the number of houses newly built, total number of houses (depending on ward; monthly), ● information concerning population: population, population density, number of households, density of households (depending on ward; monthly)
local characteristics (*cav*)	◎ characteristics depending on ward: ● ward dummy, for example, for Higashinada ward, if the study site is in Higashinada Ward: 1, other: 0, dummies are prepared similarly for wards such as Nada, Hyogo, Nagata, Suma, Tarumi, Kita, Chuo and Nishi
	◎ characteristics depending on train lines, ● line dummy: the line on which the nearest station from the study site exists is selected and a line dummy is prepared. When several stations on different lines are close to the study site, select the station closest to the site. For example, Hankyu dummy, is used when the nearest station from the study site is on the Hankyu line: 1, other: 0, The division of the area according to train lines is based on the Metropolitan District Traffic Census, Code Book in Kinki Area (Center for Transport Economy Research)
	◎ unique local characteristics: ● high-class residential area: If more than two people that pay a large amount of tax (based on individual data prepared by The National Tax Administration Agency) live in the corresponding site (block in town), the site is assumed to be a high-class residential area. high-class residential area: 1, other: 0, ● shopping dummy, if the study site is in a shopping area according to the residential map published by Zenrin and if the site can be used as area: 1, other: 0.

The descriptions of and preparation methods for explanatory variables are summarized in detail in Table 1. In addition to factors such as convenience, institutional constraint, site conditions and urban foundation considered in the authenticated values according to the transaction case comparison method, earthquake characteristics are added after the earthquake. Local characteristics are also added to examine the local structure. In analyzing transaction cases, indices to carry out time correction are added to consider transaction states and to adjust for successive and dynamic market characteristics.

The data used in this study include 1370 transactions for residential purposes, traded between December 19, 1993 and June 30, 1996, and 1467 appraisal value samples of land for residential purposes (posted land price and standard land price between 1994 and 1996). The number of transaction values is comparable to that of appraisal value, and they were collected during almost the same time period.

2.2 Classification of Type of Land Price Information and Related Indices

Table 2 summarizes land price information and related indices categorized depending on the type of land price information (appraisal value or actual trading price) and the time period (before or after earthquake).

The comparison of each statistical value indicates that the dispersion in values is large for those obtained on the basis of real trading. This can be interpreted as follows: in the case of posted land prices and standard prices, standard sites are assumed in each area, and the land price for the site is appraised.

Table 2. Summary of analysis variables categorized by type of information and time period

			Average	Minimum	Maximum	Standard Deviatuion
Land Price (円／㎡)	B.E	appraisal value	251,053	15,000	790,000	124,535
		sales price	273,945	28,653	862,107	133,488
	A.E	appraisal value	239,905	15,000	635,000	113,816
		sales price	270,522	30,245	784,211	122,142
acreage (㎡)	B.E	appraisal value	219	51	1,302	145
		sales price	162	20	1,903	182
	A.E	appraisal value	223	51	1,302	158
		sales price	134	23	1,125	117
road width in front of the site (m)	B.E	appraisal value	6	2	20	2
		sales price	6	2	30	4
	A.E	appraisal value	6	2	20	2
		sales price	6	2	25	3
floor-area ratio (%)	B.E	appraisal value	145	60	300	58
		sales price	154	80	400	62
	A.E	appraisal value	145	60	300	59
		sales price	178	60	400	78
distance (m) from each study site to nearest station (m)	B.E	appraisal value	1,593	100	14,000	1,668
		sales price	1,369	3	8,099	1,100
	A.E	appraisal value	1,677	100	14,000	1,838
		sales price	1,284	1	5,600	1,078
temporal distance from nearest station to Sannomiya station (minute)	B.E	appraisal value	28	0	72	13
		sales price	28	7	71	11
	A.E	appraisal value	29	0	72	13
		sales price	26	0	68	11
temporal distance from nearest station to Osaka CBD (minute)	B.E	appraisal value	66	36	111	13
		sales price	65	39	109	13
	A.E	appraisal value	66	36	111	14
		sales price	64	39	107	12

Number of samples, appraisal value before earthquake: N=821, sales price before earthquake: N=962, appraisal value after earthquake: N=646, sales price after earthquake: N=408, Total number of samples: N=2,837
B.E:before earthquake,A.E:after earthquake

For example, a transaction of a site for small-scale housing lists an acreage as small as 20 mm^2, whereas the minimum acreage given based on the authenticated value is 51 mm^2. The maximum authenticated distance from the nearest station is 14,000 m, whereas it is 8,099 m in transactions. In land trading, it is assumed that the land is actually used, and therefore examples of transaction may not exist for land with characteristics that are not regarded as merits in trading.

The public authenticated values, such as posted land prices and standard land prices, are indices for a standard-sized site with standard conditions. This confirms that such indices are averages.

2.3 Land Price And Related Indices Depending On Area Classification

In this section, the scheme of the area is targeted as local characteristics and the city area is divided into three areas for comparative study.

Area 1 developed after World War II. Higashinada-ku is a new city area that came into being after Uosakimura was consolidated into Kobe city by municipal merger. An exclusive residential area was formed, partly on the assumption that commuting to Osaka is possible. Chuo-ku, including Sannomiya and Motomachi, has the characteristics of a new urban center since the city center has moved eastward since World War II. In general, Area 1 is an area where new accumulation is observable. Area 2 has the characteristics of old accumulation. Area 3 is an emerging residential area far from the city center.

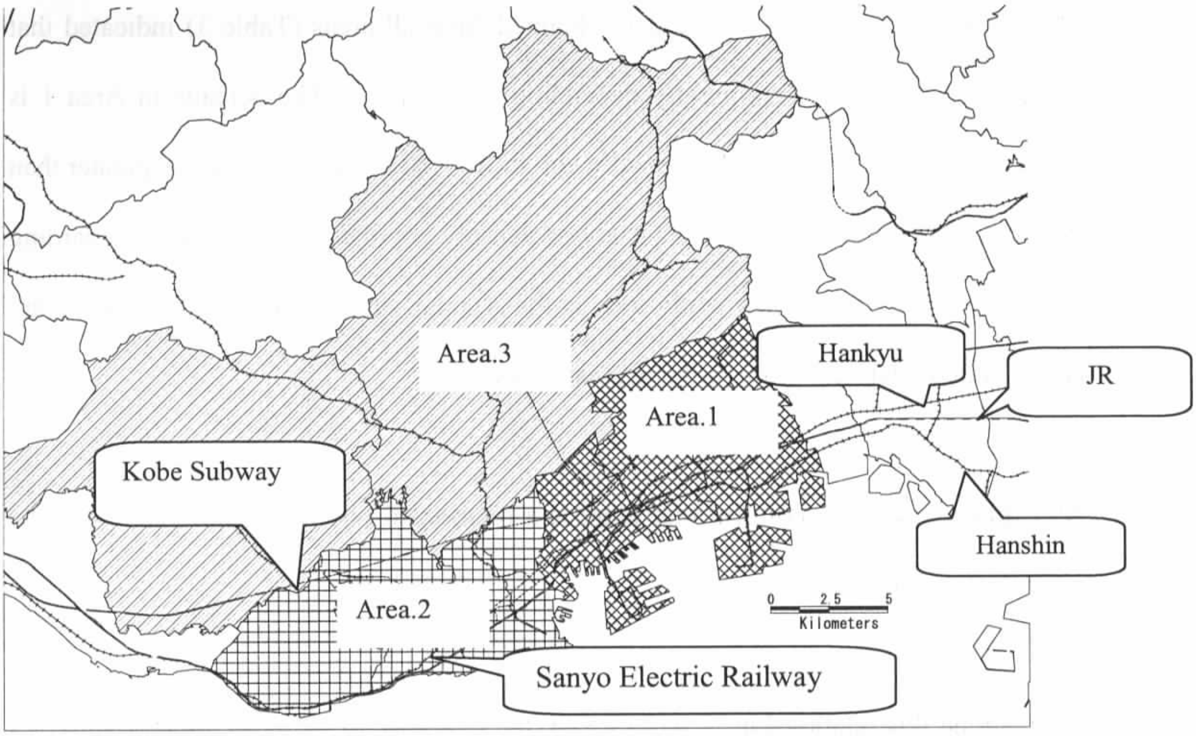

Figure 2. Classification of areas and railway lines: Kobe city

Table 3. Analysis variables for each area

		Average	Minimum	Maximum	Standard Deviatuion
Land Price (Yen／㎡)	Area1	420,603	84,770	862,107	111,411
	Area2	251,048	30,245	676,356	82,531
	Area3	158,039	15,000	403,538	55,166
acreage (㎡)	Area1	183	20	1,903	186
	Area2	157	21	1,481	114
	Area3	238	27	1,739	189
road width in front of the site (m)	Area1	6.2	2.0	30.0	3.5
	Area2	5.5	2.0	30.0	3.0
	Area3	5.7	2.0	25.0	2.4
floor-area ratio (%)	Area1	192	80	400	58
	Area2	165	60	400	59
	Area3	107	60	300	45
distance (m) from each study site to nearest station	Area1	763	60	2,500	491
	Area2	1,409	1	5,800	1,108
	Area3	2,125	3	14,000	2,037
temporal distance from nearest station to Sannomiya station	Area1	16	0	36	6
	Area2	26	9	38	6
	Area3	39	17	72	14
temporal distance from nearest station to Osaka station	Area1	50	36	66	7
	Area2	65	44	88	7
	Area3	76	57	111	14

＊Number of samples:Area1(N=622),Area2(N=1,326),Area3(N=889)

The statistical comparison of the data obtained from all areas (Table 3) indicated that the land-price level differs greatly depending on the area. The acreage in Area 1 is larger than that in Area 2, and the road width in front of the site in Area 1 is greater than that in Area 2, indicating that Area 1 is less densely populated than Area 2. Regarding the distance (m) from each study site to the nearest station, the sites in Area 1 are concentrated relatively close to the nearest station.

As explained, we can confirm that there is a relationship between land prices and the main explanatory variable.

To examine this relationship in more detail, the relationship between dummy variables representing local characteristics and area classification is examined (Table 4). From the table, the characteristics of the three areas are clearly evident.

First, in Area 1, dummy variables for urbanization-regulated areas and prospective residential land are zero. The availability rates of sewerage and city gas, and the pavement rates are high in Area 1, indicating that the area is highly urbanized. Also, Area 1 has an exclusive residential area and its rating as a residential area is relatively high. In addition, the extent of earthquake damage in this area was high, and it is to be expected that the land price structure significantly changed after the earthquake.

In Area 2, similar to the case of Area 1, urbanization has proceeded; however, the number of small-scale residential sites is large and the rate of mixed land use is relatively high, indicating that the land use in Area 2 is mixed in a complicated manner.

In Area 3, an urbanization-regulated area and prospective residential land are included in this area, and the penetration rate of sewerage and city gas is low. Consequently, it is considered that urbanization has been delayed compared with that of Areas 1 and 2.

Table 4. Distribution of dummy variables in three areas

dummy variable	Total number of samples		Area1	Area2	Area3
	Number of samples	percentage	percentage	percentage	percentage
sewerage	2,490	87.8%	100.0%	100.0%	61.0%
city gas	2,033	71.7%	96.9%	77.5%	45.3%
pavement	2,580	90.9%	89.2%	89.4%	94.5%
road in front of the site (national road)	9	0.3%	0.6%	0.4%	0.0%
road in front of the site (private road)	329	11.6%	7.9%	16.8%	6.4%
small-scale residential land	54	1.9%	2.1%	3.0%	0.1%
irregularly shaped site	163	5.7%	5.1%	5.5%	6.5%
exclusive residential	63	2.2%	10.1%	0.0%	0.0%
mixed land use	49	1.7%	1.6%	2.8%	0.2%
prospective residential land	5	0.2%	0.0%	0.1%	0.4%
regulated area	96	3.4%	0.0%	0.0%	10.8%
site damaged in earthquake	196	6.9%	14.5%	7.8%	0.2%
priority reconstruction area	26	0.9%	1.3%	1.4%	0.0%
along Hankyu line	259	9.1%	41.6%	0.0%	0.0%
along Hanshin line	191	6.7%	30.7%	0.0%	0.0%
along JR	932	32.9%	19.6%	44.1%	25.3%
	N=2,837		N=622	N=1,326	N=889

On the basis of the analytical results described above, analysis using a Chi-squared automated interaction detector (CHAID)[1] was carried out using area classification as the explained variable and dummy variables as explanatory variables in order to examine the structural differences in the three areas in greater detail. Dummy variables are adopted in the order of sewerage dummy, city gas dummy, pavement dummy, and

[1] The Chi-squared automated interaction detector or CHAID, is an automated interaction detector based on the $\chi 2$ value.

private road dummy. Therefore, it became evident that a significant difference in infrastructure was observable among the three areas.

However, the number of selected dummy variables is not sufficiently high in areas having the characteristics explained above, and therefore, the above variables are prospective candidate explanatory variables to be used in the model .

3. Analysis Of Land Price Structure in Area Affected by the Earthquake

3.1 Estimation of Land Price Function Considering Local Characteristics

The information obtained from the land price function and the spatial unit (?) assumed in the project should agree if the land price information is appropriate for use in the adjustment of ownership in the city planning project. Furthermore, coherence among spatial units over a wide area must be ensured in postearthquake reconstruction projects and we should present information with a high level of generality, in which differences in structure, in terms of spatial axis and temporal axis, are clearly reflected.

To achieve this, the relationship between temporal distance up to the CBD and land prices is obtained, depending on the type of land price information and time period (Figure 3).

The sales prices become more dispersed with increasing temporal distance compared with the appraisal value.

A comparison of land prices obtained from different information sources and before and after the earthquake indicates the authenticated land price is strongly correlated with the temporal distance (correlation coefficient: –0.68 before and after the earthquake).

However, the dispersion of the sales prices is large and the correlation with temporal distance is weaker than that in the former case (correlation coefficient: –0.61 before the earthquake, –0.48 after the earthquake). It is considered that the sales price is determined by more factors than the authenticated land price.

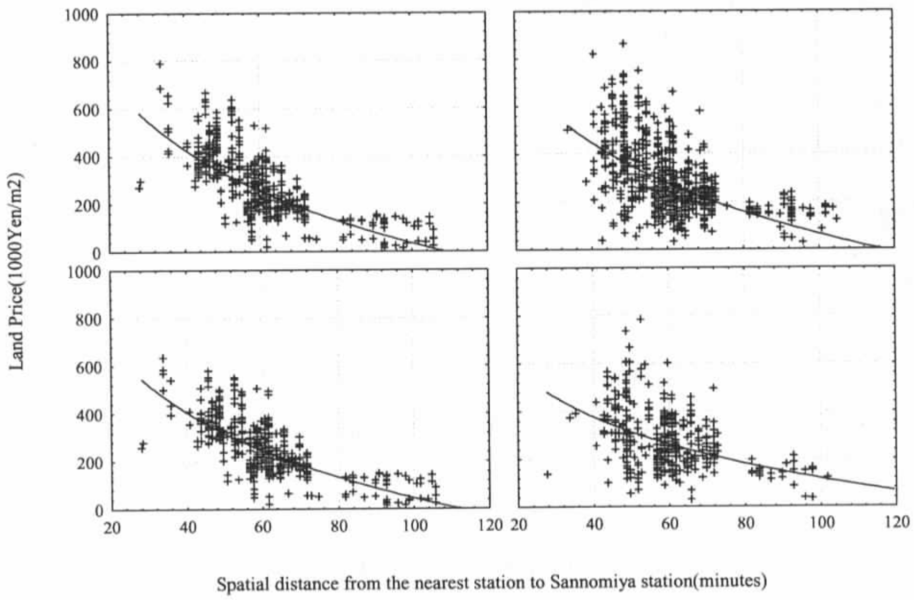

Figure 3. Relationship between land price and temporal distance to the CBD for different parameters

On the basis of the analysis above, we estimate the land price depending on the type of information.

Over the entire area of Kobe city, the structural change before and after the earthquake is considered only in terms of a shift in the land price function, and the postearthquake dummy is included in the analysis. As models of actual trading (convenience, institutional restrictions, environment of the site, time correction), the land price function composed of only fundamental indices in which trading circumstances are taken into consideration (model 1) and the land price function in which local characteristics are also considered in addition to the indices in model 1 (model 2) are assumed (Table 5).

Model 1 is effective for the estimation of the appraisal value. However, it is less suitable for the estimation of the sales price . In contrast, the suitability of model 2, in which local characteristics are also taken into consideration, is significantly better for estimating the authenticated and sales prices, indicating the necessity of considering spatial structure in detail when constructing a model.

Regarding closeness to the CBD, temporal distance is selected rather than spatial distance in both models: the distances to Sannomiya and to Honmachi are selected as variables in the models for appraisal value and sales price, respectively. Depending on the type of information, the selected variable concerning the CBD differs.

For local characteristics, the contribution of the railway dummy, as well as the ward dummy, is obvious. This means that the land price structure differs depending on the railway line. In addition, when the distance to the nearest station is considered more independently in the analysis, the railway line is more developed, and the preferences of residents are reflected in the selection of the location. It is expected that the structure of the land price function is complicated because the sign (+ or –) of the partial regression coefficient for acreage differs between the appraisal value model and the sales price model, and the small-scale residential land dummy is selected only in the sales price model[2].

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[2]Tabuchi (1996) assumed a model using posted land prices, and indicated the presence of scale premia, which also positively influence the land price, as in the case of the appraisal value model in this study. In the actual trading model in this study, partial regression coefficients for both small-scale residential land

Table 5. Estimation of land price function depending on type of information

variables	Model 1 (fundamental index)				Model 2 (fundamental index + local index)			
	sales price (total)		sales price (total)		appraisal value (total)		appraisal value (total)	
	coefficient	(t value)	coefficient	(t value)	coefficient	(t value)	coefficient	(t value)
acreage	1.14×10^{2}	8.88			4.02×10	4.66	-4.22×10	-3.17
road width in front of the site	8.82×10^{3}	11.41	4.68×10^{3}	6.41	7.58×10^{3}	14.87	2.62×10^{3}	4.13
floor-area ratio	4.25×10^{2}	12.17	2.51×10^{2}	5.35	2.53×10^{2}	9.56	2.61×10^{2}	6.15
distance to the nearest station	-2.16×10	-19.47	-2.60×10	-9.98	-1.34×10	-16.26	-1.51×10	-5.90
temporal distance to Sannomiya	-4.26×10^{3}	-27.68			-1.47×10^{3}	-10.22		
temporal distance to Osaka CBD			-4.48×10^{3}	-17.95			-1.53×10^{3}	-5.28
sewerage dummy			2.12×10^{4}	2.49				
sewerage and city gas dummy	4.76×10^{4}	7.95	2.31×10^{4}	3.55	4.16×10^{4}	10.21		
pavement dummy					2.74×10^{4}	2.32	1.31×10^{4}	2.30
road in front of the site/national road dummy	1.07×10^{5}	2.45						
road in front of the site/private road dummy	-1.48×10^{4}	-2.24	-2.92×10^{4}	-4.16			-2.21×10^{4}	-3.60
small-scale residential land dummy	—		-4.19×10^{4}	-3.26	—		-3.75×10^{4}	-3.41
irregularly shaped site dummy	—		-2.25×10^{4}	-2.84	—		-1.84×10^{4}	-2.70
Seller:real estate brocker dummy	—		1.77×10^{4}	2.85	—		2.01×10^{4}	3.81
exclusive residential area dummy					8.57×10^{4}	11.14	1.46×10^{5}	8.88
commercial area dummy	1.70×10^{5}	9.81	2.87×10^{5}	11.61	1.44×10^{5}	11.83	2.66×10^{5}	12.61
along Hanshin Railway dummy	—		—		-5.47×10^{4}	-9.33	-6.95×10^{4}	-6.53
along Yamate subway line dummy	—		—		2.32×10^{4}	3.42		
along Seishin subway line dummy	—		—		-1.85×10^{4}	-3.69		
along Kobe-Kousoku dummy	—		—		2.56×10^{4}	3.11		
along Kobe Dentetsu Railway dummy	—		—		-2.41×10^{4}	-5.11	-2.11×10^{4}	-2.27
along Shin-Kotsu dummy	—		—		-3.52×10^{4}	-2.51		
along Sanyo Dentetsu Railway dummy	—		—		1.67×10^{4}	3.88	1.57×10^{4}	1.97
Higashinada-ku dummy	—		—		1.79×10^{5}	30.01	1.91×10^{5}	14.35
Nada-ku dummy	—		—		1.34×10^{5}	22.13	1.43×10^{5}	11.67
Chuo-ku dummy	—		—		1.49×10^{5}	18.99	1.28×10^{5}	7.50
Nagata-ku dummy	—		—		2.20×10^{4}	3.69	-1.79×10^{4}	-1.86
Hyogo-ku dummy	—		—		4.98×10^{4}	6.52	7.15×10^{4}	6.07
Suma-ku dummy	—		—		4.11×10^{4}	7.75	4.45×10^{4}	4.66
Tarumi-ku dummy	—		—		1.29×10^{4}	3.07	2.39×10^{4}	2.88
postearthquake dummy	-1.89×10^{4}	-5.29	-1.42×10^{4}	-2.55	-5.02×10^{3}	-2.11	-1.27×10^{4}	-2.72
the number of houses underconstruction/total	5.16×10	8.13			-1.86×10	-3.87		
Population	1.27×10^{-1}	3.40	3.06×10^{-1}	4.55				
Constant	1.96×10^{5}	13.60	4.57×10^{5}	16.30	1.22×10^{5}	8.43	2.91×10^{5}	12.26
Number of Samples =	1,467		1,370		1,467		1,370	
Adjusted R square=	0.74		0.51		0.89		0.65	

and acreage are negative, indicating that the land price increases to a certain site size, beyond which the land price decreases. In a general authentication evaluation, negative adjustment is carried out for small-scale residential land or sites with an area larger than a predetermined value. Estimated results obtained in this study agree well with the knowledge of experts.

3.2 Change in Land Price Structure Before and After the Earthquake

On the basis of the analytical results explained above, it is expected that the spatial structure and structure for land trading significantly changed after the earthquake, since not only disparity by area is observed, but also the postearthquake dummies are significant in each model (Table 1). The land price function is then estimated on the basis of the type of land price information and time period (before and after the earthquake) to examine the structural change of the land price function (Table 6).

The variable quantities selected in the total-sample model and models before and after the earthquake are not different for the appraisal value model. The effectiveness and the coefficient of determination after adjusted R square (0.89) are of the same order before and after the earthquake. In contrast, in the sales price model, the coefficient of determination after the adjusted R square is 0.65 for the total-sample model, but it was 0.70 before the earthquake and decreased to 0.54 after the earthquake. Also, different variable quantities were selected.

The results of this analysis strongly suggest the possibility that although the structure of the actual land trading price changes after the earthquake, the change is not fully reflected in the appraisal value.

Table 6. Estimation of land price function depending on type of land price information and time period (before and after earthquake)

variables	Appraisal Value Model				Sales Price Model			
	before earthquake		after earthquake		before earthquake		after earthquake	
	coefficient	(t value)	coefficient	(t value)	coefficient	(t valu	coefficient	(t value)
acreage	5.00×10	4.09	2.98×10	2.48	-5.23×10	-3.74		
road width in front of the site	7.66×10^{3}	10.26	7.69×10^{3}	11.31	1.91×10^{3}	2.72	3.05×10^{3}	2.16
floor-area ratio	2.47×10^{2}	6.78	2.54×10^{2}	6.82	3.19×10^{2}	5.88	3.00×10^{2}	4.15
distance to the nearest station	-1.39×10	-11.93	-1.32×10	-11.62	-1.74×10	-6.32	-1.43×10	-2.89
temporal distance to Sannomiya	-1.55×10^{3}	-7.68	-1.38×10^{3}	-7.00				
temporal distance to Osaka CBD					-1.60×10^{3}	-4.90	-2.27×10^{3}	-4.24
sewerage dummy							3.37×10^{4}	3.30
sewerage and city gas dummy	4.18×10^{4}	7.36	4.33×10^{4}	7.56				
pavement dummy	3.54×10^{4}	2.04			1.69×10^{4}	2.59		
road in front of the site/private road dummy					-1.91×10^{4}	-2.70	-3.28×10^{4}	-2.76
small-scale residential land dummy	—		—		-5.46×10^{4}	-4.08		
irregularly shaped site dummy	—		—		-2.03×10^{4}	-2.53		
Seller:real estate brocker dummy	—		—		2.17×10^{4}	3.64		
Buyer:corporate dummy	—		—				4.65×10^{4}	2.57
exclusive residential area dummy	1.07×10^{5}	9.90	6.48×10^{4}	6.11	1.47×10^{5}	8.01	1.36×10^{5}	3.64
commercial area dummy	1.62×10^{5}	10.39	1.31×10^{5}	6.43	2.66×10^{5}	10.97	2.40×10^{5}	5.58
along Hankyu Railway dummy							6.78×10^{4}	3.79
along Hanshin Railway dummy	-4.50×10^{4}	-5.48	-6.05×10^{4}	-7.59	-7.52×10^{4}	-6.01		
along Yamate subway line dummy			2.55×10^{4}	2.56				
along Seishin subway line dummy	-2.15×10^{4}	-3.09	-1.65×10^{4}	-2.36				
along Kobe-Kousoku dummy			2.66×10^{4}	2.43				
along Kobe Dentetsu Railway dummy	-2.70×10^{4}	-4.36	-2.98×10^{4}	-5.16	-1.98×10^{4}	-2.02	-3.59×10^{4}	-2.21
along Sanyo Dentetsu Railway dummy	1.73×10^{4}	2.95	1.32×10^{4}	2.21			3.73×10^{4}	2.59
Higashinada-ku dummy	1.76×10^{5}	22.84	1.51×10^{5}	22.17	1.91×10^{5}	12.86	6.95×10^{4}	3.56
Nada-ku dummy	1.24×10^{5}	16.88	1.04×10^{5}	14.25	1.28×10^{5}	9.78		
Chuo-ku dummy	1.70×10^{5}	13.53	1.45×10^{5}	12.75	1.26×10^{5}	5.54		
Nagata-ku dummy	2.31×10^{4}	3.06			-4.73×10^{4}	-4.06	-8.06×10^{4}	-5.13
Hyogo-ku dummy	5.59×10^{4}	6.64	2.17×10^{4}	2.16	3.35×10^{4}	2.36		
Suma-ku dummy	4.87×10^{4}	5.86	3.85×10^{4}	5.01	6.16×10^{4}	4.79		
Building houses							-4.75×10	-2.28
Population	-2.06×10^{-1}	-2.37	-1.19×10^{-1}	-2.60	-3.20×10^{-1}	-2.19		
Constant	1.50×10^{5}	6.01	1.66×10^{5}	11.88	3.57×10^{5}	10.13	3.54×10^{5}	8.45
Number of Samples =	821		646		962		408	
Adjusted R square=	0.89		0.89		0.70		0.54	

Unlike the general land market, it is possible that circumstances beyond the analytical ability of the real-estate appraiser may arise when evaluating factors in the land market of this unique area, i.e., the earthquake-affected area. Therefore, it is necessary to examine the evaluation method to precisely grasp the dynamically changing circumstances of the land market.

3.3 Estimation of Land Price Function Depends on Area

The structural change was examined using the three area classifications. Since the classification and the other local variables, that is, local dummy variables, are completely independent, mutual comparison is meaningful. Table 7 summarizes the list of coefficients of determination after adjusting the degrees of freedom ($AdjR^2$).

Table 7. List of estimated results of land price function

Estimated land price function		appraisal value ($Adj\ R^2$)	(N)	sales price ($Adj\ R^2$)	(N)
Model1 (only infrastructure)	Total	0.74	1,467	0.51	1,370
	B.E.	0.73	821	0.56	962
	A.E.	0.78	646	0.41	408
Model2 (incorporation of local indices)	Total	0.89	1,467	0.65	1,370
	B.E.	0.89	821	0.70	962
	A.E.	0.89	646	0.54	408
Area1	Total	0.67	330	0.35	291
	B.E.	0.76	181	0.38	215
	A.E.	0.66	149	0.15	77
Area2	Total	0.68	659	0.37	667
	B.E.	0.69	375	0.39	429
	A.E.	0.68	284	0.34	238
Area3	Total	0.87	478	0.35	441
	B.E.	0.86	265	0.34	318
	A.E.	0.88	213	0.43	93

B.E:before earthquake , A.E:after earthquake

According to Table 7, the effectiveness of both the appraisal value model and the sales price model for Areas 2 and 3 is unchanged before and after the earthquake. However, the effectiveness of the sales price model for Area 1 significantly decreased after the earthquake, indicating a structural change in Area 1. As evident in Table 4, this finding is influenced by the earthquake-damage rate in Area 1 being relatively high compared with the other areas. In the city planning project, the land price difference before and after the project is calculated using acreage, road width in front of the site, and floor-area ratio as instrumental variables. Therefore, we focus on such variables in particular, and we show the results of multiple regression analysis according to the type of information and the area, where the structural change before and after the earthquake was examined in detail (Tables 8 and 9).

The partial regression coefficient for floor-area ratio is positive in Areas 2 and 3 for the appraisal value model, but it is negative in Area 1. In contrast, in the sales price model, it is positive in Areas 2 and 3, and is considered an insignificant variable in Area 1. Since the floor-area ratio is generally not fully utilized in residential areas, and the residential environmental standard is high in an area of houses of low height, and in addition, Area 1 contains a typical exclusive residential area, the low floor-area ratio is expected to serve as an index for the residential environment. The fundamental indices for Areas 2 and 3 exhibit similar structures; however, that for Area 1 is unique in that the sign for the partial regression coefficient of the floor-area ratio is different from those of Areas 2 and 3, and that some fundamental indices selected for Areas 2 and 3 are not selected in Area 1.

Next, structural change after the earthquake is examined for each area. The partial regression coefficient of floor-area ratio is negative before the earthquake, but it is not selected as a dummy variable after the earthquake; instead, acreage and road width in front of the site are selected in Area 1 for the appraisal value model. However, no significant change is observed in Areas 2 and 3. In the actual trading model, acreage, road width in front of the site, and floor-area ratio (all of which are fundamental indices) are considered insignificant both before and after the earthquake in Area 1. Acreage and road width in front of the site are not selected as significant variables after the earthquake in Areas 2 and 3, respectively.

Table 8. Estimation of land price function on the basis of appraisal value

variables	Area1 · B.E (Appraisal) coefficient	(t value)	Area2 · B.E (Appraisal) coefficient	(t value)	Area3 · B.E (Appraisal) coefficient	(t value)	Area1 · A.E (Appraisal) coefficient	(t value)
acreage			1.46×10^{2}	6.23			9.04×10	2.53
road width in front of the site			8.63×10^{3}	9.16	3.96×10^{3}	5.94	3.77×10^{3}	2.03
floor-area ratio	-2.53×10^{2}	-2.51	2.90×10^{2}	5.85	1.82×10^{2}	6.02		
distance to the nearest station	-7.47×10	-8.97	-2.05×10	-9.25	-3.81	-6.14	-6.01×10	-8.04
temporal distance to Sannomiya					-1.18×10^{3}	-12.23	-1.69×10^{3}	-2.20
temporal distance to Osaka CBD	-4.87×10^{3}	-6.19	-1.77×10^{3}	-5.02				
sewerage and city gas dummy			8.78×10^{4}	6.35	2.52×10^{4}	7.82		
pavement dummy			5.48×10^{4}	2.02				
road in front of the site/national road dummy			1.47×10^{5}	3.84				
road in front of the site/private road dummy			-1.38×10^{4}	-2.03				
prospective housing land dummy					-5.69×10^{4}	-11.97		
irregularly shaped site dummy			-5.71×10^{4}	-2.03				
exclusive residential area dummy	8.71×10^{4}	7.02					5.62×10^{4}	4.09
commercial area dummy	2.28×10^{5}	12.76					1.43×10^{5}	5.63
along Hankyu Railway dummy	6.19×10^{4}	4.26						
along Hanshin Railway dummy	-3.65×10^{4}	-3.51					-6.64×10^{4}	-6.26
along Yamate subway line dummy	7.76×10^{4}	4.50						
along Kobe Dentetsu Railway dummy			-3.37×10^{4}	-3.03				
along Sanyo Dentetsu Railway dummy			1.62×10^{4}	3.10				
Nada-ku dummy							-3.87×10^{4}	-4.58
Hyogo-ku dummy			3.32×10^{4}	4.29				
Tarumi-ku dummy			-2.56×10^{4}	-5.30				
Constant	7.28×10^{5}	19.22	1.39×10^{5}	3.24	1.49×10^{5}	22.33	4.43×10^{5}	24.16
Number of Samples =	181		375		265		149	
Adjusted R square=	0.76		0.69		0.86		0.66	

Table 9. Estimation of land price function on the basis of actual trading

variables	Area1·**B.E** (Sales Price) coefficient	(t value)	Area2·**B.E** (Sales Price) coefficient	(t value)	Area3·**B.E** (Sales Price) coefficient	(t value)	Area1·**A.E** (Sales Price) coefficient	(t value)
acreage			-7.28×10	-2.76	-8.55×10	-6.54		
road width in front of the site			3.50×10^{3}	3.36	3.73×10^{3}	4.34		
floor-area ratio			4.96×10^{2}	6.23				
distance to the nearest station	-5.87×10	-3.19	-1.49×10	-3.90	-4.04	-1.97		
temporal distance to Osaka CBD	-4.16×10^{3}	-3.53	-2.51×10^{3}	-4.26	-1.07×10^{3}	-5.43	-4.37×10^{3}	-2.12
mixed land use dummy			3.83×10^{4}	1.97				
small-scale housing land dummy			-5.08×10^{4}	-3.02	-1.52×10^{5}	-4.25		
Seller:real estate brocker dummy	4.27×10^{4}	2.14	2.15×10^{4}	2.24				
Seller:public sector dummy					-4.15×10^{4}	-2.76		
Seller:indibidual dummy					-1.00×10^{4}	-2.41		
exclusive residential area dummy	1.62×10^{5}	6.52					1.30×10^{5}	2.49
commercial area dummy	2.79×10^{5}	6.57	2.73×10^{5}	6.12				
along Hanshin Railway dummy	-5.95×10^{4}	-3.56					-6.71×10^{4}	-2.29
along Seishin subway line dummy					6.84×10^{4}	5.45		
Nagata-ku dummy			-7.00×10^{4}	-7.01				
Suma-ku dummy			3.59×10^{4}	3.82				
Population					-1.43	-2.50		
Constant	6.85×10^{5}	11.32	3.49×10^{5}	7.35	5.46×10^{5}	4.86	6.35×10^{5}	5.90
Number of Samples =	215		429		318		77	
Adjusted R sqaure=	0.38		0.39		0.34		0.15	

Based on the discussion above, when a burden such as the reduction of site area is demanded as compensation for providing infrastructure, such as increased floor-area ratio and expansion/maintenance of roads, it is possible that the actual land price may deviate from the expectations of land owners and leaseholders or land values on the market.

4. Conclusions

We established the following through an analysis of the land price structure.

- The land price structure of Kobe city as a whole cannot be explained on the basis of only location conditions, such as convenience, institutional constraints, site condition and infrastructure. The necessity of considering local characteristics of social structure and spatial structure, such as administration of the ward determined from a historical perspective, railway development concurrent with development of the residential area, and the difference of income levels represented by the exclusive residential area dummy, was demonstrated.

- In terms of effectiveness of the model, the appraisal value model was found to be superior to the sales price model as a result of the analysis based on the type of land price information and time period (before and after the earthquake). However, in the unequilibrated market of the earthquake-affected area, it was difficult to evaluate properly the structural change after the earthquake using the appraisal value.
- For land evaluation in a city planning project, the land price function based on the area and time period (before and after the earthquake) was estimated, focusing on fundamental indices such as acreage, road width in front of the site and floor-area ratio. The results indicate that (1) the level of significance of the floor-area ratio variable differs depending on the area, (2) the variables selected as being significant change depending on the area, and (3) variables selected as being significant in a certain area differ before and after the earthquake.

Based on the above discussions, when the planning authority negotiates with the landowners and leaseholders according to a unified standard, mismatch may occur between the two parties due to differing preferences between the two with respect to planning. Also, the evaluation by the planning authority may deviate from the market evaluation, which is a substitute index used in the decision-making process.

In city planning for a reconstruction area in which the market conditions are dynamically changing, an environment enabling detailed judgment in which the local characteristics are taken into consideration should be provided, in addition to the present land evaluation technique. Therefore, the establishment of an effective method of evaluation that enables residents to clearly understand the effectiveness and fairness of the project is required.

In the future, it will become necessary to use information with high precision that has been obtained utilizing methods such as the geographic information system (GIS), and to adjust land rights (ownership) while amending land evaluation information using factors other than the land market, such as the opinions of residents.

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