Hedonic Evaluation of the Amenity of Paddy Fields : A Case of the Hyogo Prefecture in Japan

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1. Introduction

Recently in Japan, much attention has begun to be paid the importance of the externality of the agriculture and forestry on the neighboring areas, and the number of studies evaluating the economical value in monetary term is increasing. In particular, the studies using Hedonic Method in evaluating the amenity of the agriculture and forestry land have played a major role in this field. The hedonic method is based on a capitalization hypothesis that an environmental factor affects land prices. For example, the agriculture and forestry land near a residential area providing green scenery and open space provides a comfortable residential environment; this environmental factor can raise land prices.

Specifically, the hedonic method estimates the shadow price of the environmental factors throughout a regression analysis (rent regressed on a vector of the several factors that affect the value of land prices) by using the data about rents, the area of agriculture and forestry land, and the other environmental factors at different locations. In applying the hedonic method to the evaluation of the amenity of the agriculture and for-

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estry land, however, there exists various theoretical and methodological problems.

The current study addressed a model selection of hedonic rent function by nonnested test. In a hedonic analysis, it is crucial to specify a model because a unsuitable model leads an unreliable evaluation. In previous studies, the specification of the hedonic rent function was carried out through the trial and error of the researchers, depending only on a few indexes of model adequacy, or in ad hoc manner. However, by applying the concept of a model-building procedure with use of diagnostic tests, which were used in Shinbo and Asano (1993) study, it is possible to specify the model more objectively and more systematically. This procedure was proposed by Pagan and Hall (1983).

When specifying the hedonic rent function, it is difficult to determine functional form of the model. In the past empirical studies in Japan, several functional forms are used, such as simple linear model, log-linear model (e.g., Nishizawa et al., 1991.), quadratic form (e.g., Maruyama et al., 1995), Box-Cox transformation (e.g., Kanemoto et al., 1984), and Least-squares spline (e.g., Asano, 1995). Although there are some studies using several functional forms for the estimation and comparison (e.g., Maruyaml et al., 1995), there exists no objective standard for the comparison among nonnested functional form, when the functional form are nonnested. There are also problems regarding the arbitrariness in choosing variables should be taken into a model. For example, the compositions of the explanatory variables are substantially different from one model to another, and the comparison between the models with different dependent variables, that is, the models with different functional forms is often different from the formulation of dependent variables.

Nonnested tests highlighted in this study make it possible to compare nonnested hypotheses such as the case mentioned above. The advantage of

specifying a model using diagnostic test, such as nonnested test, lies in the point that it makes possible to conclude the specification of the hedonic rent function by a test of statistical hypothesis. With the use of the hedonic method, if the assumptions necessary for the theoretical model are satisfied, the validity of evaluating the external economies of the areas neighboring agricultural areas depends on the validity of the specification of the hedonic rent function.

In the following section we introduce the outline of nonnested test. In section 3, two hedonic rent equations with different specifications are estimated, and in section 4, they are compared by using the nonnested test. At this time, the composition of the explanatory variables is the same between the two equations, but the functional form is different between them. And then we compute the evaluated values of the amenity of paddy fields from the estimated equations, and consider these results.

2. Model Selection by the Use of Nonnested Test

First, let us start with reviewing nonnested tests according to Dran (1993). Suppose the following two non-linear hypotheses:

$$H_0 : y = f(X_0, \beta_0) + u_0 \quad \cdots\cdots(1)$$

$$H_1 : y = g(X_1, \beta_1) + u_1 \quad \cdots\cdots(2)$$

Next, to test these hypotheses , suppose that nesting them within a composite model.

$$H_c : y = (1-\alpha) f(X_0, \beta_0) + \alpha g(X_1, \beta_1) + u \quad \cdots\cdots(3)$$

If $\alpha = 0$, H_0 is confirmed, while $\alpha = 1$ implies H_1. H_0 could be tested by testing $\alpha = 0$ on H_c.

When we estimate the parameter of the model under H_1, we can

calculate the predicted value of y, $\hat{y}_1 = g(X_1, \hat{\beta}_1)$, under H_1. Then the composite model H_c become

$$H_c' : y = (1-\alpha) f(X_0, \beta_0) + \alpha g(X_1, \hat{\beta}_1) + u$$
$$= (1-\alpha) f(X_0, \beta_0) + \alpha \hat{y}_1 + u \quad \cdots\cdots(4)$$

Now, testing $\alpha = 0$ under H_c' by the use of routine t-test is simplest form of nonnested test.

Next, to test on the basis of residual, we rewrite (3) as

$$H_c : (1-\alpha)(y - f(X_0, \beta_0)) + \alpha (y - g(X_1, \beta_1)) = u \quad \cdots\cdots(5)$$

$y-f$ and $y-g$ are u_0 and u_1, respectively. Using it, we rewrite (5) as

$$y = f(X_0, \beta_0) + \theta u_1 + v \quad \cdots\cdots(6)$$

where $\theta = \frac{-\alpha}{1-\alpha}$. Then, testing $\alpha = 0$ in (5) is equivalent to testing $\theta = 0$ in (6). Error term u_1, which is random variable, is unobservable, so it is necessary to provide an observable proxy. We replace it by an estimated residual. According to the formulation of estimated residual, there are two procedures for testing nonnested hypotheses. One is the J-test; the other is the JA-test. The J-test is obtained by replacing u_1 by

$$\hat{u}_1 = y - g(X_1, \hat{\beta}_1) \quad \cdots\cdots(7)$$

$\hat{u}_1$ is the residual when estimating the equation (2). And the JA-test is obtained by replacing u_1 by

$$\hat{u}_{01} = \hat{y}_0 - g(X_1, \beta_1^*) \quad \cdots\cdots(8)$$

$\hat{y}_0$ is the predicted value when estimating the equation (1). β_1^* is obtained by regressing $\hat{y}_0$ on $g(X_1, \beta_1)$. $\hat{u}_{01}$ is the residual when regressing $\hat{y}_0$ on $g(X_1, \beta_1^*)$.

Furthermore let us review the P-test according to MacKinnon (1992).

Using the first-order Taylor-Series approximation to $f(X_0, \beta_0)$ around $\beta_0 = \hat{\beta}_0$, we rewrite the equation (4) as

$$y = f(X_0, \hat{\beta}_0) + \hat{\mathbf{x}}(\beta_0 - \hat{\beta}_0) + \text{higher-oredre terms} + \alpha(g(X_1, \hat{\beta}_1) - f(X_0, \hat{\beta}_0)) + u \quad \cdots\cdots(9)$$

where $\hat{\mathbf{x}}$ is a vector of derivatives of $f(X_0, \beta_0)$ evaluated at $\beta_0 = \hat{\beta}_0$. Taking $f(X_0, \hat{\beta}_0)$ over to the left-hand side of (9), replacing $\beta_0 - \hat{\beta}_0$ by **b**, combining the higher-order terms with error term u, and putting it v, we obtain

$$H_c : y - f(X_0, \hat{\beta}_0) = \hat{\mathbf{x}}\mathbf{b} + \alpha(g(X_1, \hat{\beta}_1) - f(X_0, \hat{\beta}_0)) + v \quad \cdots(10)$$

Then, the left-hand side of this equation is equivalent to the residual when estimating the equation (1). Testing $\alpha = 0$ in the equation (10) is called the P-test.

3. Estimating Hedonic Rent Function

The main source of land price data for this study was obtained from the Land Price Research, carried out by National Land Agency of Japan in 1992. We used the average land prices by city or town in the Hyogo Prefecture (91 cities and towns). The Land Price Research provides more detailed data for each city and town, which is more desirable in theory to use. The reason for using the average land prices was that the data of environmental factors necessary for evaluating the externality of agricultural land (e.g., the area of paddy field neighboring each survey point) was not available, but that many kinds of data which we needed were available in the data based on the average land prices of each city and town.

The variables used for the estimation of the hedonic rent function is presented in Table 1. The reason for providing many variable is that it was necessary that we consider several attribute of cities and towns in order to

decompose the factors determining land prices. This is because the land price data used in this study were based on each city and town. And actually on our empirical work, we investigated these variables as well as several transformations of variables, such as, logarithm and the ratio of population or area. Furthermore, as the variable of the environmental factor which affect land price, we selected area of paddy field, TNB.

Table 1 Variable List used for Hedonic Analysis

No.	Variable	Content of Variable	Unit	Year	Source
0	LP	average price of residential site	yen/m²	1992	[1]
1	RNT	rent (=lp × discount rate(interest rate))	yen/m²	1992	[1]
2	ARA	total area	km²	1992	[1]
3	TNB	land area according to the kind of land : paddy field	ha	1992	[1]
4	HTK	land area according to the kind of land : upland field	ha	1992	[1]
5	TKT	land area according to the kind of land : residential land	ha	1992	[1]
6	SRN	land area according to the kind of land : forest land	ha	1992	[1]
7	MKB	land area according to the kind of land : pasture and grassland	ha	1992	[1]
8	FTA	forest land area	ha	1992	[1]
9	FTB	growing stock of trees (thousand cubic meter)		1992	[1]
10	CP 1	area of city planning area	ha	1992	[1]
11	CP 2	area of urbanization area	ha	1992	[1]
12	CP 3	area of urbanization control area	ha	1992	[1]
13	ZNA	total area of area classified according to use of the land	ha	1992	[1]
14	ZN 1	area of restrictive construction area Ⅰ	ha	1992	[1]
15	ZN 2	area of restrictive construction area Ⅱ	ha	1992	[1]
16	ZN 3	area of residential area	ha	1992	[1]
17	ZN 4	area of neighboring commercial area	ha	1992	[1]
18	ZN 5	area of commercial area	ha	1992	[1]
19	ZN 6	area of semi-industrial area	ha	1992	[1]
20	ZN 7	area of industrial area	ha	1992	[1]
21	ZN 8	area of exclusive industrial area	ha	1992	[1]
22	OFN	number of city government employees		1992	[1]
23	GIA	revenue(ordinary accounts of city government): total value	million yen	1992	[1]
24	GI 1	revenue(ordinary accounts of city government): local taxes	million yen	1992	[1]
25	GI 2	revenue(ordinary accounts of city government): local allocation tax	million yen	1992	[1]
26	GI 3	revenue(ordinary accounts of city government): local government dept	million yen	1992	[1]
27	GOA	expenditure(ordinary accounts of city government): total value	million yen	1992	[1]
28	GO 1	expenditure(ordinary accounts of city government): welfare	million yen	1992	[1]
29	GO 2	expenditure(ordinary accounts of city government): hygiene	million yen	1992	[1]
30	GO 3	expenditure(ordinary accounts of city government): agriculture, forestry and fisheries	million yen	1992	[1]
31	GO 4	expenditure(ordinary accounts of city government): fire defence	million yen	1992	[1]
32	GO 5	expenditure(ordinary accounts of city government): education	million yen	1992	[1]
33	TXA	local tax revenue by tax item: total	million yen	1992	[1]

No.	Variable	Content of Variable	Unit	Year	Source
34	TX 1	local tax revenue by tax item: ordinary taxes	million yen	1992	[1]
35	TX 2	local tax revenue by tax item: city, town inhabitant tax	million yen	1992	[1]
36	TX 3	local tax revenue by tax item: fixed asset tax	million yen	1992	[1]
37	TX 4	local tax revenue by tax item: special land possession tax	million yen	1992	[1]
38	TX 5	local government debt outstanding	million yen	1992	[1]
39	NS 1	number of day nurseries		1992	[3]
40	NS 2	receiving capacity of day nurseries		1992	[3]
41	NS 3	infants enrolled of day nurseries		1992	[3]
42	NS 4	nurses of day nurseries		1992	[3]
43	CG 1	number of kindergartens		1992	[1]
44	CG 2	infants enrolled of kindergartens		1992	[1]
45	CG 3	teachers of kindergartens		1992	[1]
46	ES 1	number of elementary schools		1992	[1]
47	ES 2	children enrolled of elementary schools		1992	[1]
48	ES 3	teachers of elemenntary schools		1992	[1]
49	ED 1	number of lower secondary schools		1992	[1]
50	ED 2	pupils enrolled of lower secondary schools		1992	[1]
51	ED 3	teachers of lower secondary schools		1992	[1]
52	ED 4	number of upper secondary schools		1992	[1]
53	ED 5	students enrolled of upper secondary schools		1992	[1]
54	ED 6	teachers of upper secondary schools		1992	[1]
55	GD 1	post-school status of graduates of lower secondary schools : total graduates		1992	[3]
56	GD 2	post-school status of graduates of lower secondary schools : persons who advanced to schools of higher grade		1992	[3]
57	GD 3	post-school status of graduates of lower secondary schools : persons who advanced to special training schools		1992	[3]
58	GD 4	post-school status of graduates of lower secondary schools : persons who found employment		1992	[3]
59	RD 1	roads : total real length of national highways	m	1993	[1]
60	RD 2	roads : total real length of paved national highways	m	1993	[1]
61	RD 3	roads : total real length of prefectural roads	m	1993	[1]
62	RD 4	roads : total real length of paved prefectural roads	m	1993	[1]
63	AM 1	number of motor vehicles owned		1993	[1]
64	AM 2	number of motor vehicles registered		1993	[1]
65	AM 3	number of light motor vehicles		1993	[1]
66	MD 1	facilities of hospitals		1992	[1]
67	MD 2	number of beds of hospitals		1992	[1]
68	MD 3	facilities of general clinics		1992	[1]
69	MD 4	facilities of dental clinics		1992	[1]
70	MD 5	number of physicians		1992	[1]
71	MD 6	number of dentists		1992	[4]
72	MD 7	number of pharmacies		1992	[1]
73	HS 1	business facilities of envirommental sanitation : lodging facilities		1992	[1]
74	HS 2	business facilities of envirommental sanitation : barber shops		1992	[1]
75	HS 3	business facilities of envirommental sanitation : beauty salons		1992	[1]
76	HS 4	business facilities of envirommental sanitation : laundry shops		1992	[1]

No.	Variable	Content of Variable	Unit	Year	Source
77	HS 5	business facilities of envirommental sanitation : public bath houses		1992	[1]
78	WS 1	diffusion rate of waterworks		1992	[1]
79	WS 2	population of waterworks, simplified waterworks, and exclusive		1992	[3]
80	WC 1	excrement disposal : population in the area unber collection disposal		1992	[1]
81	WC 2	excrement disposal : population with disposal through sewerage manholes		1992	[1]
82	WC 3	excrement disposal : population with self-disposal		1992	[1]
83	WC 4	excrement disposal : population with disposal at disposal facilities		1992	[1]
84	GB 1	garbage disposal : population in the area under collection disposal system		1992	[1]
85	GB 2	garbage disposal : population with self-disposal		1992	[1]
86	GB 3	garbage disposal : population with collection disposal system		1992	[1]
87	GB 4	garbage disposal : self-disposal		1992	[1]
88	GB 5	garbage disposal : total collection of disposal		1992	[1]
89	SW 1	rate of public livelihood aid per thousand population		1992	[1]
90	SW 2	rate of person covered by national pension	%	1992	[1]
91	SW 3	national pension : recipients of contribution system		1992	[4]
92	SW 4	national pension : value which recipients of contribution system received	million yen	1992	[4]
93	SW 5	national pension : recipients of welfare pension		1992	[4]
94	SW 6	national pension : value of welfare pension	million yen	1992	[4]
95	CR 1	penel code crime case known to police per thousand population		1992	[4]
96	CR 2	juvenile offenders arrested of general offences under panel code per thousand population		1992	[4]
97	CR 3	persons killed and injured in traffic accidents per thousand population		1992	[4]
98	FR 1	number of fireman		1992	[3]
99	FR 2	number of fire protection unit member		1992	[3]
100	FR 3	cases of fires per thousand households		1992	[3]
101	HM 1	number of dwellings		1992	[3]
102	HM 2	area of floor space of dwellings	thousand m^2	1992	[3]
103	HM 3	number of dwellings which are subject to taxation		1992	[1]
104	HM 4	area of floor space of dwellings which are subject to taxation	thousand m^2	1992	[1]
105	HM 5	number of dwellings owned by local government (total)		1992	[3]
106	HM 6	number of dwellings owned by profecture government		1992	[3]
107	HM 7	number of dwellings owned by both city and town government		1992	[3]
108	PK 1	area of public parks	ha	1992	[3]
109	PK 2	area of children parks	ha	1992	[3]
110	NHK	number of television subscribers		1992	[3]
111	TPL	number of Shinto shrine, Buddhist temple and church		1992	[3]
112	GST	number of sightseer		1992	[4]
113	HZK	facilities of entertainment and amusement trades		1992	[3]
114	PP 1	total population		1992	[4]
115	PP 2	number of households (total)		1992	[4]
116	PP 3	density of population (per km^2)		1992	[4]
117	PP 4	daytime population		1990	[5]

No.	Variavle	Content of Variable	Unit	Year	Source
118	PP 5	ratio of daytime population to nighttime population	%	1990	[5]
119	PP 6	population 65 years old and over		1990	[5]
120	PP 7	labour force (total)		1990	[5]
121	PP 8	labour force : unemployed		1990	[5]
122	DID	area of Densely Inhabited Districts (DIDs)	km^2	1990	[5]
123	PM 1	movement of population by city and town : pure increase		1992	[1]
124	PM 2	movement of population by city and town : natural increase		1992	[1]
125	PM 3	movement of population by city and town : social increase		1992	[1]
126	PM 4	movement of population by city and town : live births		1992	[1]
127	PM 5	movement of population by city and town : deaths		1992	[1]
128	PM 6	movement of population by city and town : marriages		1992	[1]
129	PM 7	movement of population by city and town : divorces		1992	[1]
130	LV 1	members per household (private household)		1990	[5]
131	LV 2	rooms per household (private households living in dwelling)		1990	[5]
132	LV 3	aera of floor space per household (private households living in dwelling)	m^2	1990	[5]
133	LV 4	area of floor space per person (private households living in dwelling)	m^2	1990	[5]
134	LV 5	private households living in dwelling : total		1990	[5]
135	LV 6	private households living in dwelling : detached houses		1990	[5]
136	LV 7	private households living in dwelling : tenement-house		1990	[5]
137	LV 8	private households living in dwelling : apartments		1990	[5]
138	PRA	net municipal product : total sum	100 million yen	1991	[6]
139	PR 1	net municipal product : primary industry	100 million yen	1991	[6]
140	PR 2	net municipal product : secondary industry	100 million yen	1991	[6]
141	PR 3	net municipal product : tertiary industry	100 million yen	1991	[6]
142	ICA	distribution of citizens' income : total sum	100 million yen	1991	[6]
143	IC 1	distribution of citizens' income : compensation of employee	100 million yen	1991	[6]
144	IC 2	distribution of citizens' income : property income	100 million yen	1991	[6]
145	IC 3	distribution of citizens' income : entrepreneurial income	100 million yen	1991	[6]
146	OFC	establishments by industries		1991	[4]
147	LBR	persons engaged of all industries		1991	[4]
148	ID 1	establishments of manufacturing		1992	[4]
149	ID 2	persons engaged of manufacturing		1992	[4]
150	ID 3	cash earnings of manufacturing	100 million yen	1992	[4]
151	ID 4	value of manufactured goods shipments of manufaturing	100 million yen	1992	[4]
152	CM 1	stores of wholesale trade		1991	[4]
153	CM 2	persons engaged of wholesale trade		1991	[4]
154	CM 3	value of annual sales of wholesale trade	100 million yen	1991	[4]
155	CM 4	stores of retail trade		1991	[4]
156	CM 5	persons engaged of retail trade		1991	[4]
157	CM 6	value of annual sales of retail trade	100 million yen	1991	[4]
158	RS 1	stores of eating and drinking places		1992	[4]
159	RS 2	persons engaged of eating and drinking places		1992	[4]
160	RS 3	value of annual sales of eating and drinking places	100 million yen	1992	[4]
161	AG 1	total farm households		1990	[4]
162	AG 2	full-time farm households		1990	[4]

No.	Variable	Content of Variable	Unit	Year	Source
163	AG 3	part-time farm households : mainly farming		1990	[4]
164	AG 4	part-time farm households : mainly other jobs		1990	[4]
165	AG 5	gross value of agricultural production	10 million yen	1992	[7]
166	AG 6	agricultural income produced	10 million yen	1992	[7]
167	DS 1	distance from Kobe : motor vehicles operation-kilometers	km^2	1990	[8]
168	DS 2	distance from Kobe : one-line destance	km^2	1990	*1
169	D 1	dummy variable : A railway is constructed in the city and town.		1990	*1
170	D 2	dummy variable : A freeway is constructed in the city and town.		1990	*1
171	D 3	dummy variable : A city and a town is in an islands except for Honshu		1990	*1
172	D 4	dummy variable : A city and a town is in Honshu and lies on the Inland		1990	*1
173	D 5	dummy variable : Ashiya city		1990	*1
174	D 6	dummy variable : Land price have fallen by 20% and over last year.		1992	[1]
175	LPM	average change in land price of residential sites	%	1992	[1]

*1 They were inputted referring to [8] and [9]

Source

[1] Statistics of Hyogo Prefecture, 1992. Statistics Div., Policy Planning Department, Hyogo prefecture

[2] Main Statistical Indicator of Hyogo Prefecture by City and Town, 1992. Statistics Div., Policy Planning Department, Hyogo prefecture

[3] Main Statistical Indicator of Hyogo Prefecture by City and Town, 1993. Statistics Div., Policy Planning Department, Hyogo prefecture

[4] Main Statistical Indicator of Hyogo Prefecture by City and Town, 1994. Statistics Div., Policy Planning Department, Hyogo prefecture

[5] Report of 1990 Population Census. Statistic Bureau, Management and Cordination Agency

[6] Income Produced in Cities and Towns (Net Product) and Citizens' Income (Distribution), 1991. Statistics Div., Policy Planning Department, Hyogo prefecture

[7] Statistics of Agricultural Income Produced, 1992. Statistics and Information Department, Ministry of agriculture, Forestry and Fisheries

[8] Japanease Atlas by Prefecture and Geographical Dictionary, 1990. Jinbunsha

[9] Flowery Hyogo 70 Towns. Association of towns and village in Hyogo Prefecture

As the functional form of our model, we adopted both least-squares spline and Box-Cox transformation, which are flexible and are able to include several kinds of functional forms. Therefore, we transform the variable TNB (area of paddy field) into spline term of cube of TNB, and spline term of logarithm of cubic and squared TNB. The knots of the spline term are determined on the basis of an equal sample method, in which the knots were taken so as to make the number of the samples approximately equal in

each interval.

First, we specified a hedonic rent function with least-squares spline, using of t-statistic, AIC, adjusted R-squared, and especially taking account of appropriate signs of the equation. The result of this estimation is shown in Table 2-1. As the dependent variable of our specified equation, logarithm of rent is selected, and as the explanatory variables, square of logarithm of TNB, cube of logarithm of TNB and spline term SQ0 (which definition is shown in Table 2-1), are chosen.

Secondly, on the basis of this result, we specified the other equation

Table 2-1 Estimation Result of Hedonic Rent Function: Least-Squares Spline of Logarithm

	Variable	Content of Variable	Coefficient	t-statistic
Dependent Variable	RNTL	Logarithm of rent		
Explanatory Variable 1	CONST	Constant term	4.4511	2.568
2	TBL 2	Square of Logarithm of TNB (area of paddy field)	0.20894	1.656
3	TBL 3	Cube of Logarithm of TNB (area of paddy field)	−0.033676	−1.736
4	SQ0	Spline term of Square of Logarithm of TNB (area of paddy field)	0.50878	1.834
5	TXL	Logarithm of TX 2 (city, town inhabitant tax)	1.9315	6.952
6	TXL 2	Square of Logarithm of TX 2 (city, town inhabitant tax)	−0.075058	−4.647
7	AG 1 L	Logarithum of AG 1 (total farm households)	−0.20385	−0.827
8	HTKL	Logarithm of HTK (area of upland field)	0.088733	1.343
9	NS1AL	Logarithm of NS 1/ARA (day nurseries per area)	0.081241	1.910
10	ID4L	Logarithm of ID 4 (value of manufactured goods shipments of manufactuing)	−0.062585	−1.012
11	GSTL	Logarithm go GST (number of sightseers)	0.078677	1.821
12	LPM	average change in land price of residential site	−0.040079	−3.418
13	D 2	Dummy of freeway	0.16434	1.808
14	D 3	Dummy of islands except for Honshu	0.18999	1.331
15	D 4	Dummy of Honshu and Lies on the Inland	0.30944	1.809
16	AM2L	Logarithm of AM 2 (motor vehicles registered)	−0.77584	−2.332
17	HS4L	Logarithm of HS 4 (laundry shops)	0.21176	2.064
		Adjusted R-squared	0.8946	
		Log-Likelihood	−18.8712	
		AIC	0.7971378	

Spline tern of Square of Logarithm of TNB (area of paddy field) is following calculation

$$SQ0 = 0 \quad \text{if } TNB \leqq 121.2551$$
$$= (\ln TNB - \ln 121.2551)^2 \quad \text{if } TNB > 121.2551$$

with Box-Cox transformation, which has the same composition of the explanatory variables as the first equation. We estimated the parameter λ of Box-Cox transformation $X^{(\lambda)}=\frac{x^{\lambda}-1}{\lambda}$ by maximum likelihood estimation. First, we estimated the transformation parameter λ of rent RNT on the basis of a simplified equation that regresses RNT on area of paddy field TNB. Next, using λ, we calculated RNTB, the Box-Cox transformation of RNT. Finally, we estimated the transformation parameter of explanatory variables on the basis of the equation that has RNTB as its dependent variable. The result of this estimation on the equation with Box-Cox transfor-

Table 2-2 Estimation Result of Hedonic Rent Function: Box-Cox Transformation

	Variable	Content of Variable	Coefficient	t-statistic
Dependent Variable	RNTB	Box-Cox transformation of rent (−0.017754)		
Explanatory Variable 1	CONST	Constant term	5.4634	14.523
2	TNBB	Box-Cox transformation of TNB (area of paddy field) (−0.21330)	0.31747	1.995
3	TX2B	Box-Cox transformation of TX2 (city, town inhabitant tax) (−0.21330)	0.38459	6.045
4	GSTB	Box-Cox transformation of GST (number of sightseers) (−0.21330)	0.043726	1.354
5	HS4B	Box-Cox transformation of HS4 (laundry shops) (−0.21330)	0.075618	2.028
6	ID4B	Box-Cox transformation of ID4 (value of manufactured goods shipments of manufacturing) (−0.21330)	−0.022637	−1.547
7	AG1B	Box-Cox transformation ofAG1 (total farm households) (−0.21330)	−0.46064	−1.860
8	D2	Dummy of freeway	0.031145	1.282
9	D3	Dummy of islands except for Honshu	0.038379	0.987
10	HTKL	Logarithm of HTK (area of upland field)	0.024935	1.464
11	NS1AL	Logarithm of NS1/ARA (day nurseries per area)	0.026301	2.317
12	LPM	average change in land price of residential site	−0.008642	−3.342
13	D4	Dummy of Honshu and Lies on the Inland	0.092921	2.074
14	AM2L	Logarithm of AM2 (motor vehicles registered)	−0.18977	−4.167
		Adjusted R-squared	0.8582	
		Log-Likelihood	94.6471	
		AIC	−1.792158	

In this table, the numerical value in the brackets is the value of transformation parameter of the following Box-Cox transformation:

$$X^{(\lambda)}=\frac{x^{\lambda}-1}{\lambda}$$

mation is presented in Table 2-2. With regard to these two equations, the signs of each explanatory variables are theoretically adequate.

4. Results and Considerations

Let us compare the two equations estimated in the previous section by nonnested test. Firstly, applying JA-test to both equations, the null hypothesis, $\alpha = 0$, was rejected and the alternative hypothesis, $\alpha = 1$, was accepted at a 1 % significance level. Next, applying P-test, the null hypothesis, $\alpha = 0$, was accepted at a 1 % significance level only on the equation with Box-Cox transformation. So, it was found that the equation with least-squares spline functional form was desirable. But the results of JA-test did not have much difference, with regard to P-test; $\alpha = 0$ was rejected and $\alpha = 1$ was accepted on the both equations at a 5 % significance level. These results are presented in Table 3. These results suggest that one model is as adequate as the other model, or one is as inadequate as other one. So, we decide to calculate the evaluated values of amenity of paddy field from both equations.

Table 3 Result of Testing Estimated Hedonic Rent Function by Nonnested Test

Functional Form that was tested $\alpha = 0$	JA-Test	P-Test
Least-Squares Spline of Logarithm	−3.224**	3.210**
Box-Cox Transformation	3.282**	−2.604*

**means level of significance is 1 % and * means 5 %.

The partial derivative coefficient of the hedonic rent function with respect to an environmental factor (in this case, area of paddy field), indicates the money measure of utility change when the environmental factor changes by one unit (see e.g. Johansson, 1987). Therefore, in the case of two estimated equations, we can calculate evaluated value of the amenity of

1 ha paddy field per household by city and town as follows:

(1) In the case of the equation with least-square spline

$$[\text{area of residential land per household}] \times \frac{RNT}{TNB} \times \{2 \times 0.20894 \times \ln TNB + 3 \times (-0.033676) \times (\ln TNB)^2 + 2 \times 0.50878 \times (\ln TNB - \ln 121.2551)\}$$

(2) In the case of the equation with Box-Cox transformation

$$[\text{area of residential land per household}] \times 0.31747 \times RNT^{\{1/(-0.17754)\}} TNB^{(-0.21330-1)}$$

where RNT and TNB show rent and area of paddy field, respectively. The results of this calculation are presented in Table 4.

As a result, the total value of the amenity of paddy fields calculated from the equation with least-squares spline is approximately 27 billion yen; on the other hand, the value from the equation with Box-Cox transformation is approximately 4.5 billion yen. Looking up the values of each city and town, there exist negative values on the cities and towns that have a small area of paddy field. This shows that the equation with least-squares spline is problematic as to its estimation. We think that this is because in our data there exist some cities of Hanshin-kan (this means "between Osaka and Kobe" in Japanese), which have a small area of paddy field, and moreover whose rent is very high. These cities' rent was so high that it was not decomposed into each factor sufficiently in our estimation. So it is thought that the values on the cities and towns that have a small area of paddy field is outliers. Adding up the values only on the cities and the towns that have positive values of the amenity of paddy fields except for Ashiya, this total values became 88 billion yen.

Finally, we computed the average rent of the residential land in Hyogo prefecture, on the basis of it, putting area of paddy field into the above-mentioned computation. We found the relation between the area of

Table 4 The Computation of the Value of the Amenity of Paddy Fields by Cities and Towns in 1992

No.	Cities and Towns	The equation with Box-Cox transformation		The equation with least-squares spline	
		the value of the amenity of paddy fields per households (Yen)	the total value of the amenity of paddy fields (Yen)	the value of the amenity of paddy fields per households (Yen)	the total value of the amenity of paddy fields (Yen)
1	Ashiya City	5,888,054.28	1,498,177	1,525,695.93	50,929,225,746
2	Awaji Town	323,094.42	225,458	△83,888.95	△212,658,478
3	Kinosaki Town	161,784.63	161,371	△81,473.09	△123,594,670
4	Harima Town	423,992.72	1,133,511	△222,921.47	△2,171,255,098
5	Ikuno Town	97,424.41	231,552	△73,247.74	△139,390,451
6	Amagasaki City	928,191.45	25,184,713	△391,339.22	△74,526,249,224
7	Kawanishi City	812,970.02	8,787,389	△182,827.01	△8,352,451,908
8	Itami City	873,520.45	13,216,536	△153,951.63	△9,935,884,519
9	Yasutomi Town	56,879.93	348,471	△7,944.98	△11,456,658
10	Nishinomiya City	1,769,034.69	40,516,910	△99,048.91	△15,940,436,525
11	Ohya Town	17,751.64	400,440	△1,798.12	△2,808,656
12	Mitsu Town	229,785.21	865,559	△15,224.82	△51,307,628
13	Mikazuki Town	37,465.88	283,969	△1,240.73	△1,296,559
14	Yachiyo Town	22,323.34	399,006	△626.725	△912,511
15	Haga Town	40,073.89	402,349	3,168.14	4,162,930
16	Takeno Town	100,112.59	518,188	10,703.51	17,254,064
17	Kaibara Town	133,638.26	1,021,010	17,181.30	52,402,973
18	Sekinomiya Town	38,805.78	458,931	6,526.49	8,882,556
19	Konda Town	55,663.07	305,765	9,292.52	8,326,101
20	Ohkawati Town	41,789.84	693,023	7,945.46	15,859,127
21	Mikata Town	48,399.57	301,709	9,908.17	8,412,036
22	Takasago City	322,648.00	11,190,615	57,706.34	1,714,109,191
23	Kurodasho Town	48,271.57	813,121	14,143.77	29,008,880
24	Kasumi Town	159,144.81	1,544,756	41,018.60	157,388,368
25	Ibogawa Town	258,781.75	1,423,804	70,504.14	234,285,266
26	Nankoh Town	15,558.11	550,499	7,007.38	8,675,130
27	Asago Town	38,205.50	968,214	15,669.40	33,767,565
28	Takino Town	176,306.47	1,320,553	55,994.33	163,671,437
29	Takarazuka City	1,098,738.38	31,931,262	252,628.40	17,804,491,958
30	Chikusa Town	37,421.06	546,150	15,727.36	18,794,198
31	Higashiura Town	207,352.93	1,203,216	65,857.85	171,164,542
32	Inagawa Town	372,240.02	3,200,950	120,036.12	787,797,023
33	Midori Town	107,711.84	773,582	42,544.86	66,923,070
34	Kanzaki Town	24,456.62	1,025,773	12,707.80	26,355,979
35	Kouzuki Town	46,930.66	858,945	21,307.76	36,968,963
36	Yohka Town	66,473.63	1,818,927	29,754.13	107,828,951
37	Yabu Town	58,563.02	1,302,197	28,470.51	70,976,972
38	Nishiki Town	43,837.83	618,804	23,585.17	26,792,757
39	Hamasaka Town	126,834.83	1,826,116	57,437.00	191,207,758
40	Kohdera Town	199,217.73	3,122,693	85,584.32	480,299,202
41	Kami Town	19,675.12	1,028,614	12,397.15	22,823,146
42	Santoh Town	50,533.83	1,101,421	28,125.96	54,676,860
43	Aioi City	154,957.27	6,842,009	71,105.62	828,167,135
44	Muraoka Town	71,862.23	1,255,452	39,193.50	83,678,120
45	Naka Town	55,992.76	1,916,170	32,604.78	103,324,531
46	Taishi Town	18,132.47	5,638,512	12,374.99	112,958,921

No.	Cities and Towns	The equation with Box-Cox transformation		The equation with least-squares spline	
		the value of the amenity of paddy fields per households (Yen)	the total value of the amenity of paddy fields (Yen)	the value of the amenity of paddy fields per households (Yen)	the total value of the amenity of paddy fields (Yen)
47	Ichinomiya Town	47,343.21	1,777,047	29,519.72	83,393,197
48	Sayoh Town	73,698.05	1,752,521	45,238.29	115,176,688
49	Onsen Town	99,454.63	1,517,261	59,782.29	131,642,056
50	Aogaki Town	48,670.10	1,517,777	33,523.35	73,013,865
51	Sannan Town	58,180.79	2,836,307	40,692.43	153,573,233
52	Hokutan Town	119,010.22	2,902,088	72,382.78	269,915,386
53	Tojo Town	111,332.19	1,557,506	74,313.36	145,208,296
54	Tantoh Town	13,254.46	1,345,249	12,012.64	20,097,143
55	Nishiwaki Town	123,477.45	9,186,855	78,348.15	885,490,743
56	Yumesaki City	118,855.87	4,471,356	77,723.69	422,428,240
57	Akashi City	383,941.47	78,862,316	194,485.76	18,416,245,628
58	Seitan Town	118,327.08	3,150,771	78,237.29	286,974,361
59	Izusi Town	77,687.50	2,542,575	56,785.85	164,962,906
60	Ichinomiya Town	98,347.56	2,597,635	66,569.52	197,245,496
61	Fukusaki Town	168,939.12	4,572,991	109,826.80	571,428,282
62	Shinguh Town	159,225.08	4,080,765	104,345.39	476,858,424
63	Ichikawa Town	48,834.84	3,761,867	39,604.10	161,743,140
64	Nandan Town	173,226.86	6,240,803	111,551.18	721,736,102
65	Wadayama Town	47,840.35	4,761,238	39,025.20	191,886,929
66	Kamigohri Town	102,777.86	5,441,475	74,805.34	401,854,308
67	Tuna Town	190,769.76	5,717,734	123,328.46	672,263,422
68	Akoh Town	250,101.55	16,074,321	157,599.91	2,411,751,362
69	Goshiki Town	115,794.11	3,166,425	84,885.87	248,545,837
70	Ichijima Town	60,015.00	3,078,596	49,929.49	138,354,626
71	Yokawa Town	100,302.52	2,046,934	78,694.55	144,719,278
72	Yamazaki Town	121,060.90	8,401,572	90,260.02	652,579,961
73	Tannan Town	96,414.06	4,473,438	75,274.24	280,396,550
74	Hidaka Town	82,891.85	6,106,992	67,762.95	341,389,749
75	Kasuga Town	58,654.89	4,743,784	50,469.33	175,936,081
76	Sumoto City	219,074.81	20,061,009	143,626.36	2,104,126,160
77	Tatsuno Town	222,508.78	16,741,004	154,694.87	1,770,637,469
78	Hikami Town	105,060.16	7,464,556	84,140.88	429,118,461
79	Mihara Town	119,960.16	7,379,161	90,363.67	408,082,314
80	Yashiro Town	133,717.37	9,956,591	98,779.41	586,749,671
81	Inami Town	222,761.68	14,425,171	152,410.75	1,258,760,402
82	Toyooka City	163,415.89	25,421,100	115,277.38	1,635,440,248
83	Sanda City	400,951.69	47,739,637	232,195.38	5,207,445,773
84	Miki City	147,357.81	51,658,317	94,667.38	2,111,366,599
85	Sasayama Town	64,950.37	15,523,050	48,515.38	323,791,661
86	Ono City	143,976.44	32,267,271	89,624.16	1,148,175,047
87	Kakogawa City	249,584.09	228,131,547	117,203.11	8,906,381,336
88	Kasai City	114,393.34	51,659,819	47,098.87	667,956,107
89	Himiji City	190,219.24	632,076,116	44,919.64	6,745,132,865
90	Kobe City	437,319.36	2,922,277,211	3,305.85	1,849,359,285
		Total Sum	4,462,224,090	Total Sum	27,020,323,796

paddy field in the cities and the towns and the value of the amenity of paddy fields. The results is presented in Figure 1-1 and Figure 1-2.

Except for the part of the small area of paddy field, the graph be-

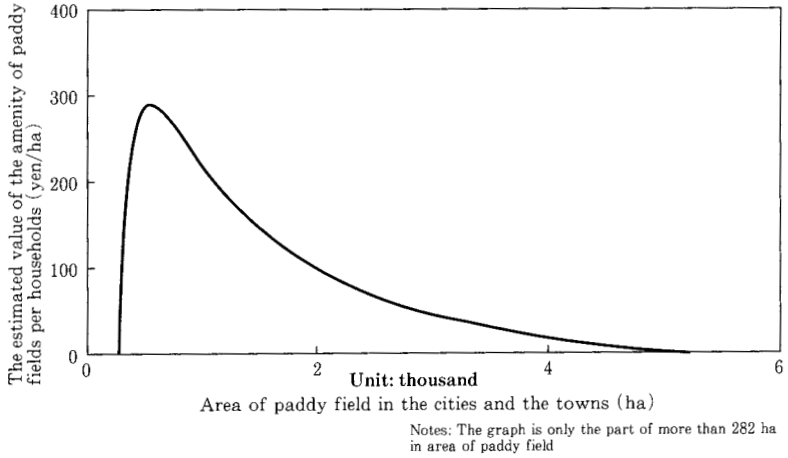

Figure 1 — 1 The relation Between area of paddy field and the estimated value of the amenity of paddy fields
(The computation from the equation with least-squares spline)

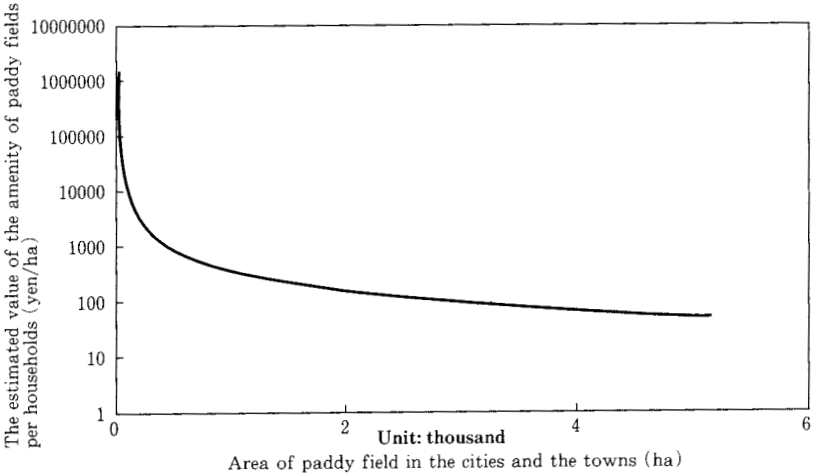

Figure 1 — 2 The relation between area of paddy field and the estimated value of the amenity of paddy fiedls
(The computation from the equation with Box-Cox transformation)

comes falling down to the right. It shows that the value of the amenity of paddy fields per unit declines as the area of paddy field in the city or town increases, i.e. the scarcity of the paddy field decreases. This result agrees with what the theory requires. Looking up the graph of the equation with Box-Cox transformation, the value in the part of the small area of paddy field is overestimated. This result supports the above-mentioned consideration that the rent of some cities in Hanshin-kan, which have a small area of paddy field and whose rent is very high, was so high that it was not decomposed into each factor sufficiently in our estimation.

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