Hedonic and Repeat Sales Rent Indices for the Rental Apartment Market in Tokyo's 23 Wards

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Abstract

The hedonic method, which arrives at a final value by decomposing a property into constituent characteristics that are valued independently and then summing these values, and the repeat sales method, which uses prior sale prices of the same property, are the two main methods used to create indices of housing prices and market rent. A representative example of the former is the Residential Property Price Indices. A representative example of the later is the S&P/Case-Shiller Home Price Indices.

Some previous studies have compared these two methods. For instance, Shimizu et al.(2010) compared a condominium price index created by the hedonic method with one created by the repeat sales method, and determined that repeat sales indices are impacted by aging degradation of properties, and lag from the reverse of the condominium price trend compared with the hedonic indices.

In this paper, the study group used a data set of rental apartments in Tokyo's 23 Wards, Japan, contributed by At Home Co., which provides real estate market information. Generally, apartments' market rent is stable compared to condominium prices, which are affected by business fluctuations. On the other hand, Fujii et al.(2012) pointed out that each *madori* (a typical Japanese room category) has a unique market in Tokyo's 23 Wards. Additionally, they indicated that market rent for particular *madori* are affected by business fluctuations around the Lehman shock. For *madori*, we created market rent indices by both the hedonic and repeat sales method. As is previous studies about price indices, we confirmed that repeat sales indices are impacted by aging degradation of properties, and repeat sales indices lag at turning point of the rent trend compared with the hedonic indices.

1. Introduction

There are two primary methods used to compute price indices for housing purchases and rentals—the hedonic method (e.g., Rosen, 1974) and the repeat sales method (e.g., Bailey et al., 1963; Case and Shiller, 1989). A typical example of the former is the residential property price indices that the G20 countries are developing in accordance with international guidelines for the creation of such indices. A representative example of the later are the S&P/Case-Shiller home price indices, which are the most widely used indices for housing price trends in the U.S.

The hedonic method enables various attributes of a property to be controlled for the purpose of analysis, thereby allowing the creation of finely tuned indices for specific applications. Since all transaction data are subject to analysis, the method is considered to yield highly efficient analysis. In contrast, the repeat sales method generates indices by comparing the prices of the same property over time, as it undergoes repeated transactions. It is a simple method of estimation because it does not require any information about the attributes of a property, and it is characterized by a high reproducibility of index values.

A number of previous studies have compared the two methods in terms of their ability to calculate housing price indices. For example, pointed out the problem of sample selection bias that occurs due to the fact that the quality of the properties that undergo repeated sale varies across the entire housing market, affecting the movement of the price index. Shimizu et al. (2010) calculated price indices with both the hedonic and repeat sales methods, using sales data for two major property categories in the Japanese housing market—second-hand condominiums and detached houses. They found that at market inflection points—most notably at times of market recovery—price indices calculated with the repeat sales method tend to exhibit greater lag than price indices calculated with the hedonic method.

In contrast, few comparative studies have been conducted on the two pricing methods for rent indices. Since repeat "sales" are a fundamental feature of the rental apartment property market, the problem of sample selection bias should be of little significance. Also, since housing rents are less sensitive to economic climate fluctuations than housing purchase prices, we might reasonably expect the lag at points of market inflection to be less for rent indices than for property price indices.

In a previous study, Fujii et al. (2012) used the hedonic method to show that unique markets exist for each of the room type categories used to designate Japanese residences in the property market (hereinafter referred to by the Japanese term *madori*). Furthermore, they found that the global financial crisis of 2008 caused very significant changes in the rent index for specific *madori* across Tokyo's 23 wards. In the present study we utilize rental apartment data from one of Japan's leading residential property information providers, At Home Co., Ltd., to compute rent indices for various *madori* in Tokyo's 23 wards, using both the hedonic and repeat sales methods. We also assess the usefulness of repeat sales indices.

2. Data

2.1 Rental apartment data

The rental apartment data was provided by At Home Co., Ltd., a company that provides real estate information services to consumers and business solution services to the real estate companies. The data encompasses approximately 1.67 million sample points covering the period from January 2004 to December 2013 from Tokyo's 23 wards. From this we utilized for our analysis 251,142 sets of data that included rental price and other items of information from the time of contract conclusion for the hedonic method, also 79,769 sets of data that are observed same units more than twice for the repeat sales method. Details of the collected data are shown in Table 1, which describes the *madori* categories and Table 2, which gives basic statistics for each *madori*.

Table 1. Descriptions of each *madori* category

<table>
<tr><th>madori</th><th>Description</th><th>Area of unit
(Average ± σ)</th><th colspan="3">Units for</th></tr>
<tr><td>1R</td><td>One room with kitchen area included</td><td>14 m2 – 30 m2</td><td rowspan="4">Singles</td><td rowspan="2"></td><td rowspan="5"></td></tr>
<tr><td>1K</td><td>1 bedroom and a kitchen</td><td>18 m2 – 30 m2</td></tr>
<tr><td>1DK</td><td>1 bedroom, a dining room, and a kitchen</td><td>26 m2 – 38 m2</td><td rowspan="5">Couples</td></tr>
<tr><td>1LDK</td><td>1 bedroom, a living room, a dining room, and a kitchen</td><td>37 m2 – 58 m2</td></tr>
<tr><td>2K</td><td>2 bedrooms and a kitchen</td><td>27 m2 – 39 m2</td><td rowspan="5"></td></tr>
<tr><td>2DK</td><td>2 bedrooms, a dining room, and a kitchen</td><td>37 m2 – 48 m2</td><td rowspan="4">Families</td></tr>
<tr><td>2LDK</td><td>2 bedrooms, living room, and dining room with a kitchen</td><td>48 m2 – 78 m2</td></tr>
<tr><td>3DK</td><td>3 bedrooms, a dining room, and a kitchen</td><td>49 m2 – 61 m2</td><td rowspan="2"></td></tr>
<tr><td>3LDK</td><td>3 bedrooms, a living room, a dining room, and a kitchen</td><td>55 m2 – 101 m2</td></tr>
</table>

Table 2. Descriptive statistics

	Variable	Hedonic					Repeat Sales				
		Obs	Mean	Std.Dev	Min	Max	Obs	Mean	Std.Dev	Min	Max
ALL	logprice	251,142	11.45	0.42	9.62	14.29	79,769	11.45	0.42	9.80	13.91
	Months		132.69	121.12	0.00	630.00		134.54	112.22	0.00	611.00
	Unit size		32.82	16.68	8.21	237.74		32.13	16.07	8.23	232.60
	Required time to station		6.61	3.90	1.00	36.00		6.53	3.84	1.00	28.00
	Access to the CBD		26.66	8.83	0.00	50.00		26.32	8.79	0.00	50.00
	Number of stories		6.43	5.38	1.00	60.00		6.42	5.15	1.00	60.00
1R	logprice	47,986	11.23	0.33	9.62	13.21	16,794	11.23	0.34	9.80	12.95
	Months		157.58	121.61	0.00	623.00		161.31	115.06	0.00	611.00
	Unit size		21.86	7.48	8.21	83.84		21.81	7.60	8.23	81.20
	Required time to station		6.25	3.62	1.00	30.00		6.30	3.68	1.00	28.00
	Access to the CBD		26.42	8.65	0.00	49.00		26.15	8.57	0.00	49.00
	Number of stories		5.88	4.46	1.00	60.00		6.01	4.57	1.00	60.00
1K	logprice	101,294	11.27	0.24	9.90	12.89	31,815	11.27	0.25	10.13	12.61
	Months		95.97	104.86	0.00	606.00		105.77	98.32	0.00	588.00
	Unit size		23.34	4.91	8.25	67.60		23.27	5.06	8.60	58.13
	Required time to station		6.44	3.67	1.00	34.00		6.42	3.62	1.00	28.00
	Access to the CBD		27.13	8.84	0.00	50.00		27.00	8.86	0.00	49.00
	Number of stories		5.61	4.09	1.00	60.00		5.47	4.01	1.00	49.00
1DK	logprice	18,454	11.42	0.29	10.24	12.59	6,079	11.44	0.30	10.37	12.56
	Months		161.61	133.18	0.00	598.00		156.71	125.17	0.00	578.00
	Unit size		31.24	5.70	11.10	64.89		31.42	5.71	13.23	63.93
	Required time to station		6.44	3.76	1.00	28.00		6.40	3.74	1.00	27.00
	Access to the CBD		26.03	8.57	0.00	49.00		25.38	8.48	5.00	49.00
	Number of stories		5.92	4.31	1.00	60.00		6.20	4.40	1.00	60.00
1LDK	logprice	23,525	11.93	0.33	10.82	13.35	7,495	11.96	0.33	10.82	13.25
	Months		86.45	113.16	0.00	596.00		84.33	100.39	0.00	596.00
	Unit size		45.69	8.92	20.20	89.75		45.81	8.74	24.02	89.04
	Required time to station		5.92	3.70	1.00	36.00		5.78	3.65	1.00	24.00
	Access to the CBD		23.56	8.63	0.00	49.00		22.90	8.45	0.00	49.00
	Number of stories		10.06	8.01	2.00	60.00		10.05	6.98	2.00	60.00
2K	logprice	6,541	11.34	0.27	10.13	12.72	1,921	11.38	0.26	10.40	12.52
	Months		253.13	124.11	0.00	630.00		235.91	115.51	0.00	564.00
	Unit size		33.48	5.76	16.00	70.00		34.09	5.85	17.50	68.34
	Required time to station		7.57	4.30	1.00	33.00		7.49	4.23	1.00	25.00
	Access to the CBD		28.06	8.08	5.00	49.00		27.94	8.26	5.00	48.00
	Number of stories		4.14	2.63	1.00	25.00		4.19	2.62	2.00	16.00
2DK	logprice	20,842	11.54	0.24	10.37	12.71	6,640	11.56	0.24	10.82	12.70
	Months		215.56	102.17	0.00	599.00		206.86	93.55	0.00	575.00
	Unit size		42.26	5.64	20.55	72.18		42.53	5.50	21.46	70.60
	Required time to station		7.67	4.47	1.00	36.00		7.58	4.34	1.00	27.00
	Access to the CBD		28.44	8.36	5.00	50.00		28.38	8.22	6.00	49.00
	Number of stories		4.92	3.06	1.00	44.00		4.96	3.05	2.00	24.00
2LDK	logprice	18,577	12.03	0.41	10.95	13.96	5,458	12.06	0.40	11.05	13.86
	Months		130.64	117.14	0.00	607.00		128.60	110.96	0.00	589.00
	Unit size		60.67	13.66	32.00	144.49		60.75	13.55	33.00	142.75
	Required time to station		6.98	4.31	1.00	30.00		6.94	4.20	1.00	25.00
	Access to the CBD		25.57	9.10	0.00	50.00		24.96	8.92	5.00	50.00
	Number of stories		9.57	8.30	2.00	60.00		9.48	7.54	2.00	60.00
3DK	logprice	4,475	11.68	0.21	10.60	12.79	1,259	11.69	0.19	11.08	12.41
	Months		226.59	89.06	0.00	596.00		216.73	85.99	35.00	547.00
	Unit size		55.17	5.92	34.00	95.59		54.91	5.80	35.00	84.25
	Required time to station		7.97	4.74	1.00	28.00		7.58	4.61	1.00	27.00
	Access to the CBD		29.89	8.65	5.00	49.00		29.87	8.56	9.00	49.00
	Number of stories		6.14	3.47	2.00	38.00		6.26	3.40	2.00	17.00
3LDK	logprice	9,448	12.14	0.43	11.08	14.29	2,308	12.16	0.42	11.29	13.91
	Months		152.03	108.07	0.00	584.00		141.79	100.17	0.00	522.00
	Unit size		75.71	20.33	40.85	237.74		75.28	19.54	44.43	232.60
	Required time to station		7.76	4.44	1.00	30.00		7.37	4.38	1.00	23.00
	Access to the CBD		26.86	9.24	6.00	49.00		25.86	9.00	6.00	48.00
	Number of stories		9.53	7.50	2.00	60.00		10.18	7.51	2.00	54.00

2.2 Consumer price index

As an indicator of errors in the fluctuation of the hedonic rent index and repeat sales rent index, we used the private rent component of the consumer price index (hereinafter called CPI) for Tokyo's 23 wards, published by the Statistics Bureau of the Ministry of Internal Affairs and Communications, the ministry of the government of Japan. This CPI private rent value is computed based on all rental apartment, including the many properties that continue to be rented without any change in contract and therefore are not easily subject to price revision. For this reason, this value is significantly less sensitive to economic climate fluctuations than the hedonic rent index or repeat sales rent index. However, since the sample population size is very large, we can make use of the CPI private rent value to check for potential bias due to possible underestimation by the formulas used for our hedonic analysis or repeat sales analysis.

3. Model

We calculated the hedonic and repeat sales rent indices using the model below.

3.1 Hedonic model

Our hedonic approach model makes use of a semi-logarithmic transformation linear regression model (Eq.1), with parameters estimated by means of an ordinary least squares (OLS) technique. Table 2 shows details of the variables for each *madori* along with the results.

$$\ln RP_i = a + \sum_m b_m X_{i,m} + \sum_j c_j LD_{i,j} + \sum_k d_k TD_{i,k} + u_i \qquad (1)$$

RP: monthly contractual rent (JPY)

a, *b*, *c*, *d*: constant (intercept) terms and coefficient parameters

X: property attributes (see Table 2)

LD: location dummy (each ward of Tokyo's 23 wards)

TD: time dummy (each month, base is Jan. 2004)

u: error term

Here, the subscript *i* denotes observation. The hedonic rent index RI_{Hed} is calculated using the formula below (Eq.2), featuring the estimated value of the coefficient parameter of the time dummy variable, $\hat{d}$.

$$RI_{\text{Hed}}(t) = \exp\left(\hat{d}_t\right) \times 100 \qquad (2)$$

Note that the hedonic rent index value at baseline (Jan. 2004) is 100. Table 3 describes the explanatory variables and shows the results for all properties; Table 4 shows the results by *madori*.

For some of the *madori*, the sign of the new construction dummy is unnatural, but generally the values are consistent with intuition , and the coefficient of determination values, adjusted for degrees-of-freedom, also indicate generally favorable estimates for all *madori*.

Table 3. Property attributes and estimated results of the hedonic model (Eq. 1) for all observations

Explanatory variable	Description	coefficient	t-value
Constant		11.11090	2241.85
Unit size	Available unit size (square meter)	0.01880	-259.17
Months	Months since the apartment was built	-0.00069	-95.69
Required time to station	Required time to nearest station (minutes)	-0.00658	-36.95
Bus dummy	1 if required to use bus to nearest station, 0 if not	-0.10600	7.50
New construction dummy	1 if new construction, 0 if not	0.00554	-128.88
Access to the CBD	Required time from nearest station to the Tokyo station or the Ohtemachi station (minutes)	-0.00633	-47.68
1st floor dummy	1 if 1st (ground) floor, 0 if not	-0.03780	15.93
Top story dummy	1 if top story, 0 if not	0.01160	101.72
Number of stories	Number of apartment stories	0.00641	-259.17
Structure dummy - Light-Gauge Steel	Wooden(base), Light-Gauge Steel, Steel, Reinforced Concrete, and Steel-Reinforced Concrete	0.01399	11.08
Structure dummy - Steel		0.03567	36.38
Structure dummy - Reinforced Concrete		0.07600	82.45
Structure dummy - Steel-Reinforced Concrete		0.06748	55.07
Adjusted R-square		0.9135	

Table 4. Estimated results of the hedonic model (Eq. 1) by *madori*

Explanatory variable	1R		1K		1DK		1LDK		2K	
	coefficient	t-value	coefficient	t-value	coefficient	t-value	coefficient	t-value	coefficient	t-value
Constant	10.93685	1755.30	10.94003	2939.32	11.09180	954.80	11.24772	915.98	11.12695	333.13
Unit size	0.02536	304.32	0.02349	364.13	0.02089	126.69	0.01751	169.75	0.01875	70.03
Months	-0.00066	-115.32	-0.00064	-177.14	-0.00073	-92.01	-0.00077	-79.20	-0.00073	-51.40
Required time to station	-0.00449	-30.32	-0.00541	-65.07	-0.00642	-28.10	-0.00782	-30.65	-0.00610	-16.81
Bus dummy	-0.08756	-8.50	-0.07626	-13.79	-0.12006	-10.76	-0.15664	-9.02	-0.05351	-5.18
New construction dummy	0.00042	0.25	-0.01260	-16.03	0.01332	5.15	-0.00444	-2.00	-0.00348	-0.43
Access to the CBD	-0.00563	-55.70	-0.00566	-100.44	-0.00678	-40.88	-0.00478	-27.01	-0.00728	-24.77
1st floor dummy	-0.03694	-22.87	-0.02955	-32.80	-0.03911	-14.85	-0.04056	-12.06	-0.01324	-2.90
Top story dummy	0.01063	7.08	0.01701	19.72	0.00799	3.50	0.02466	9.44	0.00812	2.00
Number of stories	0.00737	43.74	0.00819	74.83	0.00797	29.47	0.00452	34.43	0.00802	8.04
Structure dummy- Steel	0.00856	4.52	0.02467	23.47	0.03723	12.04	0.04222	7.20	0.06410	13.46
Structure dummy - Reinforced Concrete	0.03992	22.59	0.05169	48.87	0.07552	24.82	0.10274	19.61	0.08586	17.00
Structure dummy - Steel-Reinforced Concrete	0.02749	10.91	0.03934	24.78	0.05692	13.65	0.09901	17.20	0.08479	9.62
Structure dummy - Light-Gauge Steel	-0.00587	-1.70	0.00332	2.75	0.00174	0.35	-0.02238	-2.93	0.02964	5.02
Adjusted R-square	0.8883		0.8574		0.8652		0.846		0.8227	

Explanatory variable	2DK		2LDK		3DK		3LDK	
	coefficient	t-value	coefficient	t-value	coefficient	t-value	coefficient	t-value
Constant	11.51206	678.23	11.49765	893.62	11.74346	272.75	11.75117	484.61
Unit size	0.01394	103.30	0.01464	180.66	0.01062	40.60	0.01207	147.04
Months	-0.00077	-88.28	-0.00081	-75.60	-0.00069	-31.55	-0.00078	-47.62
Required time to station	-0.00720	-41.64	-0.00816	-32.27	-0.00928	-26.77	-0.00840	-23.95
Bus dummy	-0.08863	-20.34	-0.10277	-12.73	-0.11886	-14.80	-0.11600	-11.72
New construction dummy	0.00119	0.29	0.01681	5.71	-0.14105	-6.51	0.03091	5.73
Access to the CBD	-0.00691	-50.71	-0.00672	-34.54	-0.00861	-28.93	-0.00787	-26.91
1st floor dummy	-0.02902	-13.38	-0.03364	-9.60	-0.02870	-6.09	-0.03306	-6.63
Top story dummy	0.00606	3.22	0.02317	7.94	0.01018	2.42	0.01867	4.31
Number of stories	0.00665	17.45	0.00386	25.49	0.00322	4.24	0.00481	19.63
Structure dummy- Steel	0.02875	10.90	0.05425	7.57	0.03098	2.96	-0.00803	-0.51
Structure dummy - Reinforced Concrete	0.06039	22.52	0.10013	15.49	0.05058	5.10	0.05828	4.07
Structure dummy - Steel-Reinforced Concrete	0.04929	12.58	0.08931	12.89	0.04864	4.30	0.05290	3.59
Structure dummy - Light-Gauge Steel	0.00958	2.91	-0.02564	-2.75	-0.01797	-1.58	-0.04530	-1.87
Adjusted R-square	0.8377		0.8971		0.7775		0.8995	

3.2 Repeat sales model

For our repeat sales model, we used the standard model below (Eq.3), and we estimated parameters using a weighted least squares (WLS) technique.

$$\ln RP_{i,t} - \ln RP_{i,s} = \delta_t TD_{i,t} - \delta_s TD_{i,s} + u_{i,t} - u_{i,s} \quad (3)$$

For a property that is rented in period s and re-rented in period t ($0 \le s < t \le T$)

RP_τ : contractual rent (JPY) at time τ

TD_τ : time dummy variable at time τ

δ_τ : parameter of time τ

u_τ : error term of time τ

The repeat sales rent index RI_{RS} is calculated using the estimated value of the parameter of the time dummy variable $\hat{\delta}$, as in the formula below.

$$RI_{\mathrm{RS}}(t) = \exp\left(\hat{\delta}_t\right) \times 100 \tag{4}$$

As with the hedonic rent index, the value of the repeat sales rent index is 100 at base(Jan. 2004).

4. Estimating rent indices

4.1 Change in rent indices over time

Here, we compare the change over time in the rent indices computed using the hedonic and repeat sales methods with the change in the CPI private rent value. Figures 1 to 10 plot the hedonic rent index and repeat sales rent index (thin lines), as well as 12-month centered moving averages of these indices (thick lines), along with the year-over-year change in index values for the CPI private rent value and by *madori* with January 2004 as baseline. The CPI private rent value is independent of the data classification (*madori*), so note carefully that in the graphs for specific *madori* the CPI private rent curve represents the overall index trends.

Firstly, if we look at changes in the CPI private rent value, we find that it does not change substantially over the period of observation; there is only a slight decline. As explained above, this is consistent with the fact that many rental contracts remained unchanged through the survey period. Since rental prices are normally revised when rental contracts are changed the CPI private rent value remains fairly steady; there is little notable fluctuation.

For all *madori* categories, the hedonic rent index rose appreciably in the "mini real estate bubble" period between 2006 and mid 2008 and then declined from the latter half of 2008 as the impact of the global financial crisis took effect. Then in December 2012, with the change of national government and the expectations surrounding "Abenomics"(the economic stimulus policy of Prime Minister Shinzo Abe), the hedonic rent index levels off or starts to rise in some cases. If we compare the hedonic rent index with the CPI private rent value we might assume that since the values of the different indices start off at the same value they should remain more or less equal over time in the overall model (ignoring differences in *madori*). We note, however, that in the more favorable economic period the hedonic rent index is higher than the CPI private rent value, whereas in the less favorable economic period it closely approximates the CPI private rent value—in other words, the hedonic rent index converges with the CPI private rent value. A notable feature of the hedonic rent index variation by *madori* is that for the smallest 1R and 1K units, which are characterized by a frequent turnover, the values move up and down around the CPI private rent value. In addition, we note that if we compare *madori* of the same number of rooms, the hedonic rent index for the LDK type, which is generally of greater total floor area and more recent construction, shows a significantly greater rise in value.

In the case of the repeat sales rent index, on the other hand, we see no evidence of the “mini real estate bubble” price rise seen with the hedonic rent index. We can, however, discern a drop in rents in the latter half of 2008 due to the impact of the global financial crisis. As for the rise in rent seen with the hedonic rent index from late 2012, the repeat sales rent index reveals a slight correction of the downward trend, but this falls short of indicating any rise in rents.

Table 5 shows the peak values of the hedonic rent index and repeat sales rent index for each *madori*, their trough values from 2008 to 2013, and the difference between these two values. In the case of the hedonic rent index, the earliest peaks occur for 1DK/1LDK in June 2008; the latest peak occurs for 2DK one year later, indicating a lag of 12 months. The overall minimum value for *madori* of 2 rooms or more occurs before the global financial crisis, but after 2008 we find that there is a time lag of 15 months between the time when 1LDK and 2DK rent values bottomed out. In contrast, the repeat sales rent index peaks at the very beginning and reaches its minimum value at the end of the survey period, dropping some 10% over 10 years.

This observations shows that with repeat sales indices, there is a downward pressure on rental prices that is stronger than the upward pressure, and also that this pressure has a strong influence on the difference in index value changes between the two methods. It can be inferred that this bias is largely due to the drop in the rental price of properties as they get older. The hedonic model expresses the rental price change of all properties from the total data sample that are of the “same quality,” adjusted for the attributes of the property. In the model formula used here, this quality adjustment is made based on the variable for number of months since construction. In contrast, the repeat sales rent index expresses the change in the rental price when the same properties from the data sample are rented multiple times. This supposes that there is no qualitative change in the property over the period in which the multiple transactions occur. For this reason, in the standard repeat sales model used here, it is not possible to distinguish between the effects of simple passing of time and the time since construction (aging degradation), as a result of which, a downward bias occurs due to the influence of the aging of properties.

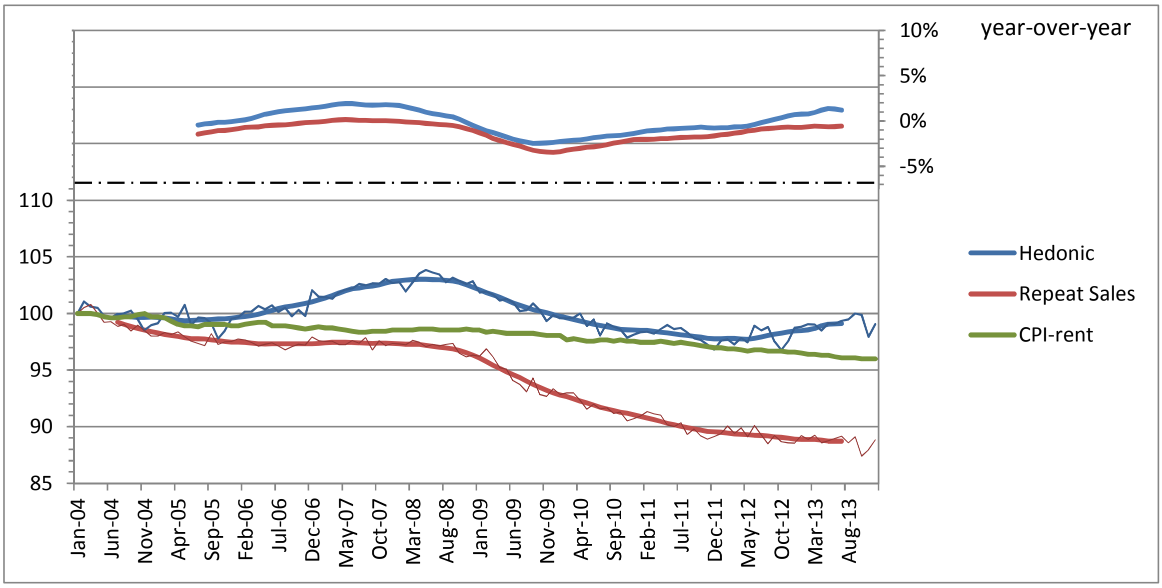

Figure 1. Hedonic rent index and repeat sales rent index for ALL

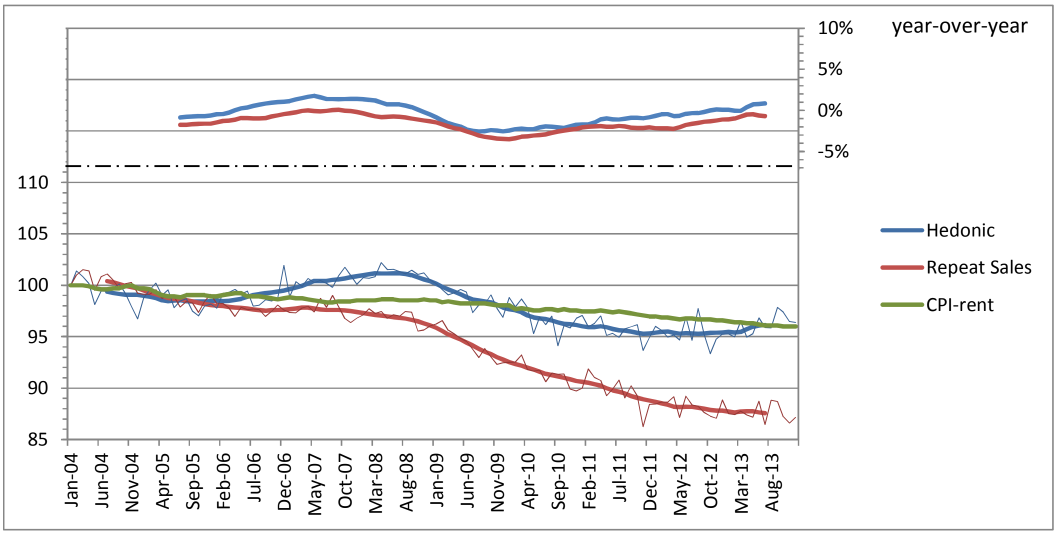

Figure 2. Hedonic rent index and repeat sales rent index for 1R

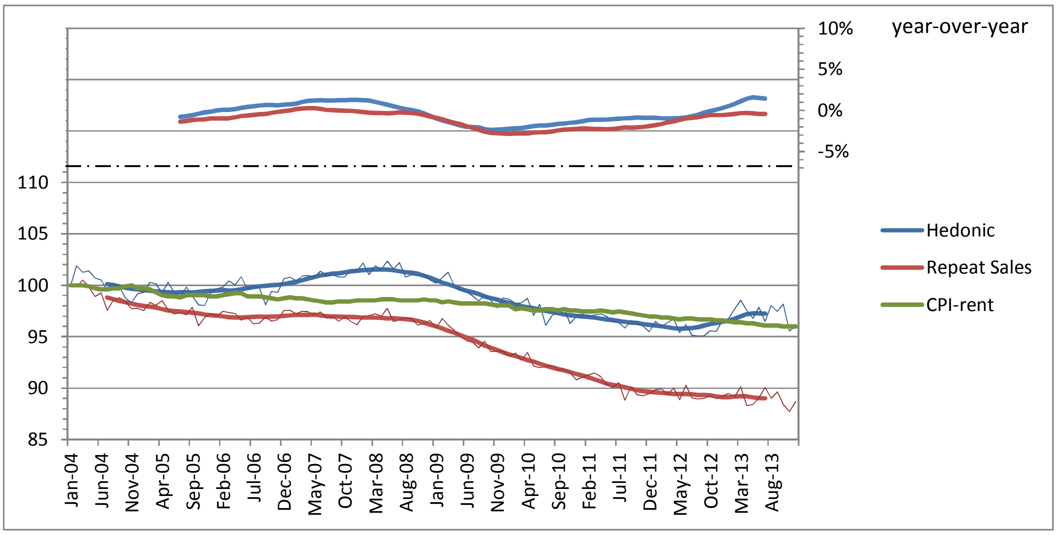

Figure 3. Hedonic rent index and repeat sales rent index for 1K

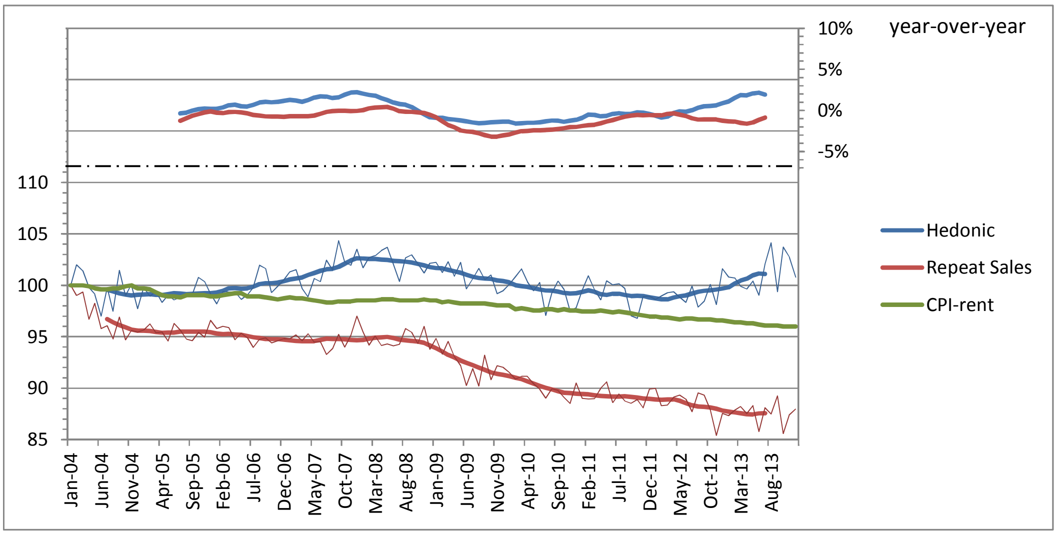

Figure 4. Hedonic rent index and repeat sales rent index for 1DK

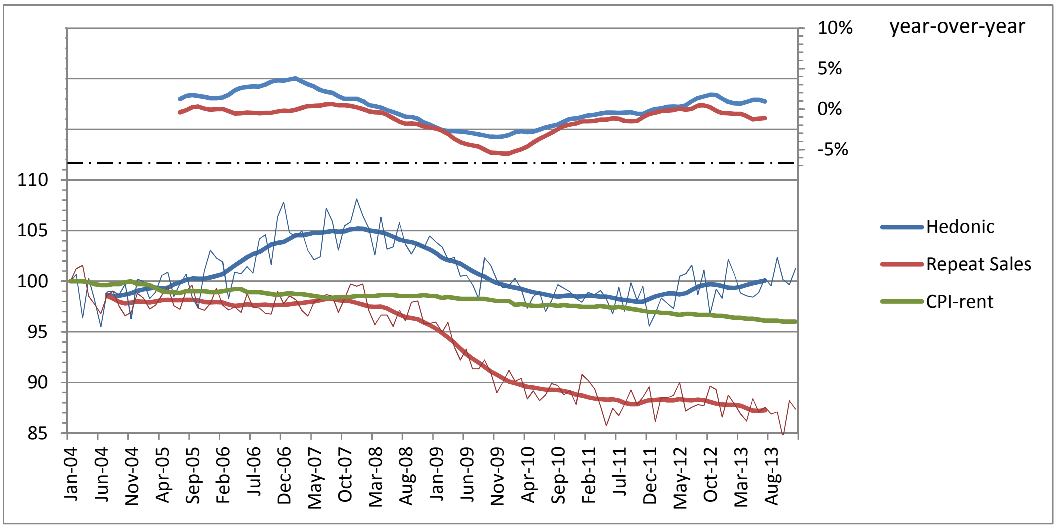

Figure 5. Hedonic rent index and repeat sales rent index for 1LDK

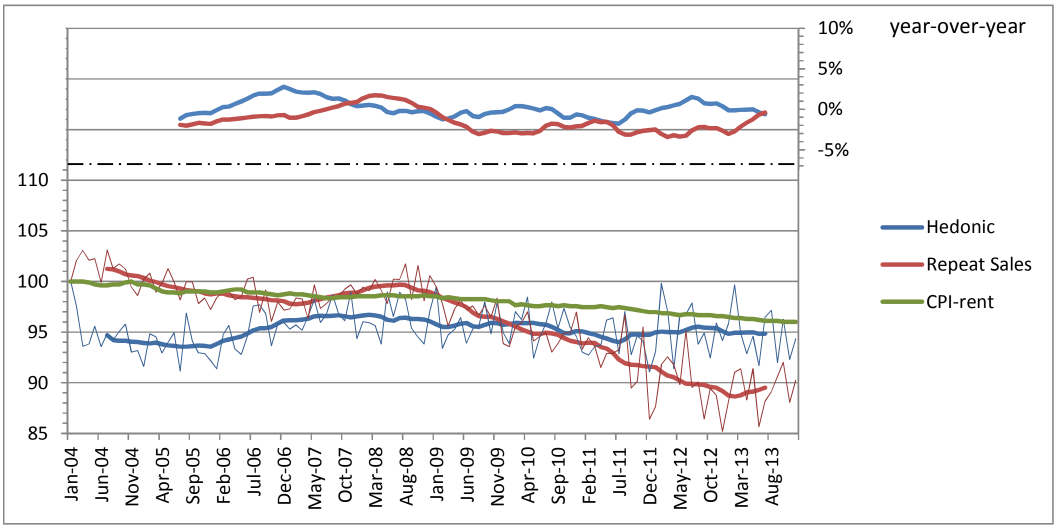

Figure 6. Hedonic rent index and repeat sales rent index for 2K

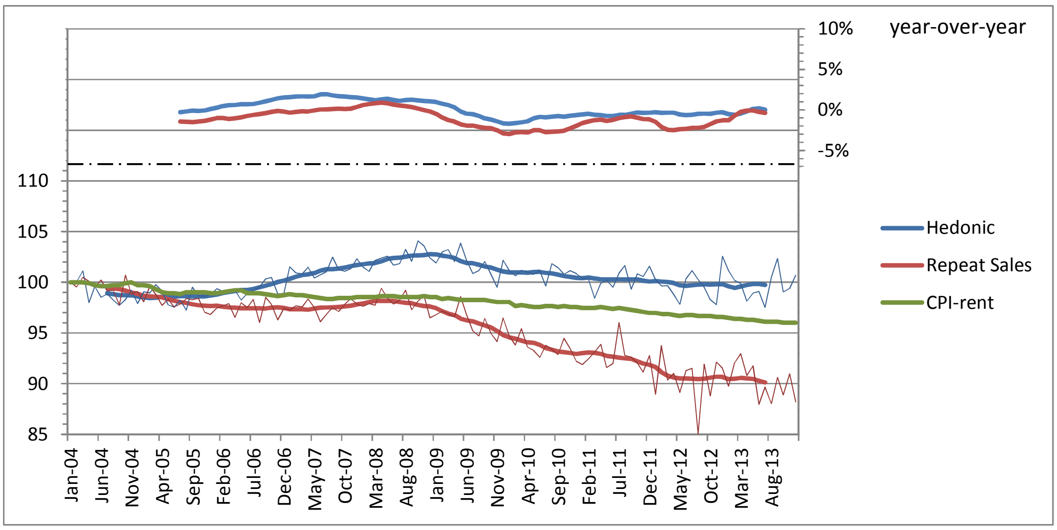

Figure 7. Hedonic rent index and repeat sales rent index for 2DK

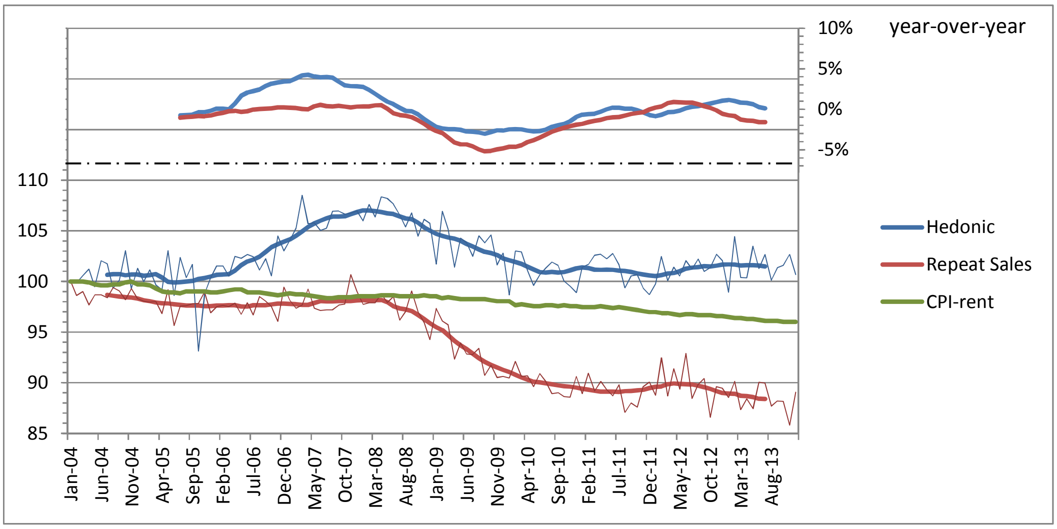

Figure 8. Hedonic rent index and repeat sales rent index for 2LDK

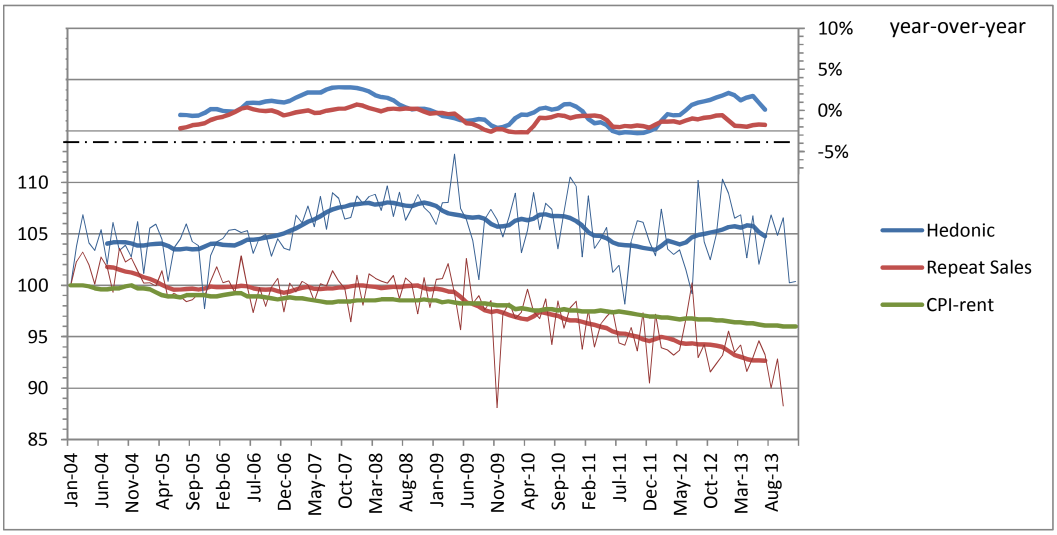

Figure 9. Hedonic rent index and repeat sales rent index for 3DK

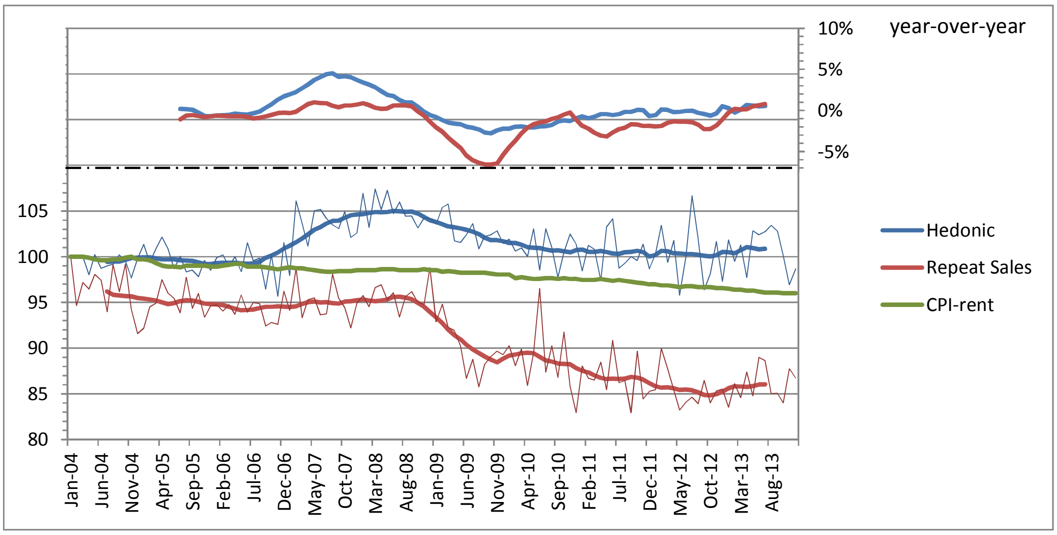

Figure 10. Hedonic rent index and repeat sales rent index for 3LDK

Table 5. Peak and trough values for the hedonic rent index and repeat sales rent index and their differences

	Hedonic			Rereat Sales		
	Peak	Bottom after 2008	Gap	Peak	Bottom	Gap
ALL	Apr-08	May-12	5.301	Jul-04	Jun-13	10.508
1R	Jun-08	Aug-12	5.896	Jul-04	Jul-13	12.815
1K	Apr-08	May-12	5.763	Jul-04	Jul-13	9.820
1DK	Dec-07	Mar-12	3.992	Jul-04	May-13	9.253
1LDK	Dec-07	Oct-11	7.231	Jul-04	Jun-13	11.323
2K	Feb-08	Jul-11	2.703	Jul-04	Feb-13	12.619
2DK	Dec-08	Feb-13	3.320	Jul-04	Jul-13	9.335
2LDK	Jan-08	Jan-12	6.492	Jul-04	Jul-13	10.291
3DK	May-08	Jan-12	4.598	Jul-04	Jul-13	9.121
3LDK	Jun-08	Sep-12	4.911	Jul-04	Oct-12	11.361

4.2 Verifying lag

In the results of the current analysis, there is a strong downward bias due to the effect of aging degradation, making it impossible to determine peak and trough values of the repeat sales rent index. In view of this, the following simple, adjusted repeat sales rent index ($RS_{\text{age-adj}}$), was created using the *Months* variable, adjusted for quality using the hedonic model, to enable a comparison of lag.

$$\begin{aligned} RI_{\text{RS-Age\_adj}}(t) &= \exp\left(\hat{\delta}_t\right)\times 100\times \exp\left(-\hat{b}_{Months}(Months_t - Jan.2004)\right) \\ &= \exp\left(\hat{\delta}_t - \hat{b}_{Months}(Months_t - Jan.2004)\right)\times 100, \end{aligned} \tag{4}$$

$\hat{b}_{Months}$: OLS estimator for *Months* variable in Hedonic function (Eq. 1)

$Months_t - Jan.2004$: month(s) at *t* since January 2004 (base point in time)

Table 6 shows the peaks and trough points for the hedonic rent index and $RS_{\text{age-adj}}$ index, for each *madori*, as well as the difference between them. In the case of the overall model the lag between peaks disappears, but the trough for $RS_{\text{age-adj}}$ index occurs 6 months earlier than for the hedonic rent index. In the case of individual *madori*, there is a strong tendency for the hedonic rent index to peak earlier, while conversely there is a strong tendency for the $RS_{\text{age-adj}}$ index to bottom out earlier. This pattern is very evident.

Figure 11 shows the change in index values for the overall model. The graph shows the lagging index of the composite index (hereinafter called CI) of the "indexes of business conditions," which is announced by the Japanese Cabinet Office, to confirm the rate of reversal in a relatively favorable economic climate.

Despite being a convenient method, the $RS_{\text{age-adj}}$ index is very similar in its trajectory to the hedonic rent index, and comparison to the hedonic rent index confirms a systematic downward bias. Even if we take into account the effects of aging degradation to a certain extent, some level of bias still remains. This is an issue that requires further investigation.

Table 6. Peak and trough values for the hedonic rent index and $RS_{age\text{-}adj}$ index and their differences

	Hedonic			Repeat Sales -Age_adj		
	Peak	Bottom after 2008	Gap	Peak	Bottom	Gap
ALL	Apr-08	May-12	5.301	Apr-08	Nov-11	4.986
1R	Jun-08	Aug-12	5.896	Nov-07	Apr-12	4.651
1K	Apr-08	May-12	5.763	Sep-08	Nov-11	4.944
1DK	Dec-07	Mar-12	3.992	May-08	Apr-13	4.618
1LDK	Dec-07	Oct-11	7.231	Nov-07	Sep-11	4.640
2K	Feb-08	Jul-11	2.703	Aug-08	Feb-13	4.677
2DK	Dec-08	Feb-13	3.320	Sep-08	May-12	4.840
2LDK	Jan-08	Jan-12	6.492	Apr-08	Apr-11	4.552
3DK	May-08	Jan-12	4.598	Oct-08	May-13	4.524
3LDK	Jun-08	Sep-12	4.911	Jul-08	Sep-12	4.748

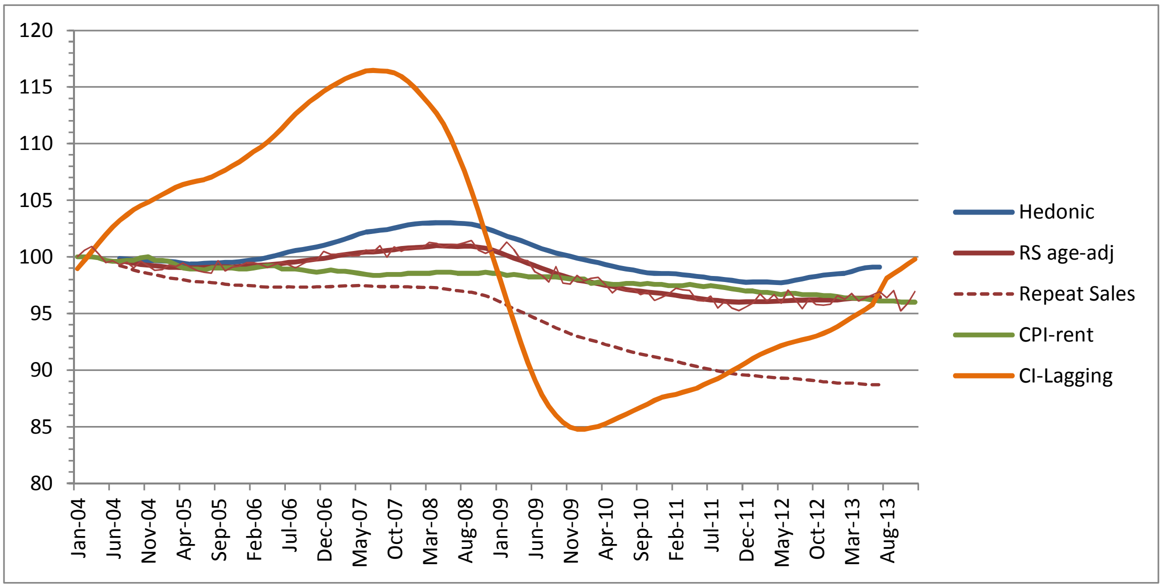

Figure 11. Hedonic rent index and $RS_{age\text{-}adj}$ index for ALL

6. Conclusion

In this study rent indices—indicators of the effect of economic climate on the rental apartment market—were calculated using two techniques typically employed to compute housing price indices—the hedonic method and repeat sales method. In addition to verifying the influence of economic climate changes on rental apartment, the features of the variation for both indices were confirmed.

The present results demonstrated that in the rental apartment market, which is influenced relatively little by economic climate fluctuation, a basic repeat sales rent index in which the effect of aging degradation cannot be controlled, is subject to a strong downward bias due to the unaccounted effects of such property aging. It was also confirmed that the index did not reveal any inflection points in economic climate variation. However, it was shown that when the effect of aging degradation can be controlled—though based only on a simple verification using a hedonic variable—the repeat sales rent index tends to bottom out earlier than a hedonic rent index after a downturn in economic climate.

With a basic repeat sales method, it is not possible to distinguish between the effects of simple passing of time and of time since construction (aging degradation). As a result, price indices derived by this method suffer from a downward bias due to the impact of such property aging. Although attempts have been made to calculate indices so that the effects of the passing of time and aging degradation are separated by revising models based on the ordinary repeat sales method (e.g., Chau et al., 2005), no consensus has yet been reached on any proposed method for estimating the repeat sales price index that controls for the effect of aging degradation. Accordingly, while the present study only made estimates based on simple methods, multiple proposed methods taking into account aging degradation will be applied in future studies, and the results will be used to make suitable comparisons.

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