Change in house price structure with time and housing price index

-Centered around the approach to the problem of structural change-

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What is housing price index?: macroeconomic Indicator

- **The Paris OECD-IMF Workshop on Real Estate Price Indexes2006:**
- **Erwin Diewert, Discussion Paper 07-01, Department of Economics,The University of British Columbia**

- Fenwick (2006; 6) suggested the following list of possible uses for house price indexes:
- •As a general macroeconomic indicator (of inflation);
- •As an input into the measurement of consumer price inflation;
- •As an element in the calculation of household (real) wealth and
- •As a direct input into an analysis of mortgage lender's exposure to risk of default.

Monetary Policy

- **Arthur (2006) also suggested some (related) uses for real estate price indexes:**

- **•Real estate price bubbles (and the subsequent collapses) have repeatedly been related to financial crises and thus it is important to measure these price bubbles accurately and in a way that is comparable across countries and**

- **•Real estate price indexes are required for the proper conduct of monetary policy.**

SNA (System of National Accounts)

- Fenwick also argued that various real estate price indexes are required for deflation purposes in the System of National Accounts:
- “The primary focus of a national accountant seeking an appropriate deflator for national accounts will be different. Real estate appears in the National Accounts in several ways;
- •the imputed rental value received by owner occupiers for buildings, as opposed to land, is part of household final consumption,
- •the capital formation in buildings, again as opposed to land, is part of gross fixed capital formation, depreciation, and the measurement of the stock of fixed capital,
- •and land values are an important part of the National stock of wealth.”
- David Fenwick (2006; 7-8)

1.Objectives of the study

- Houses have “particularity with few equivalents”

- There are two approaches in constructing a housing price index that takes into account issues resulting from particularity with few equivalents and changes in quality

- 1).Hedonic price method
- 2).Repeat-sales method

- it is necessary to estimate the price index taking into account
- -structural changes (Shimizu and Nishimura(2007))
- -sample selection bias (seasonal)

2.Structurally restricted hedonic housing price index: RHI

$$\ln P_{it} = \sum_{k=1}^{K} \beta_k X_{ikt} + \sum_{s=1}^{\tau} \delta_s D_s + \varepsilon_{it} \qquad (1)$$

$t = 1, 2, \ldots, T$.

$i = 1, 2, \ldots, n_t$ (designates ith data among the n_t data samples in period t).

P_{it} = price of house i in period t (designates ith data among the data in period t, instead of designating the same house i over each of the t periods).

β_k = parameter of residential property characteristic k.

X_{ikt} = value of property characteristic k of house i in period t.

δ_s = parameter of the time dummy variable in period s.

D_s: when $s = 1$, this takes a constant value of 1 (constant term). When $2 \leq s \leq T$, this is a time dummy variable, and it takes a value of 1 when s = t and a value of 0 otherwise.

ε_{it} = random disturbance term.

Structurally unrestricted hedonic housing price index: URHI

- RHI:

$$\ln(\hat{P}_t / \hat{P}_{t-1}) = \hat{\delta}_t - \hat{\delta}_{t-1}$$

- URHI:

$$\ln P_{it} = \sum_{k=1}^{K} \beta_{kt} X_{kit} + \delta_t + \varepsilon_{it}$$

$$\ln(\hat{P}_t / \hat{P}_{t-1}) = \sum_{k=1}^{K} (\hat{\beta}_{kt} - \hat{\beta}_{k,t-1}) X_k + (\hat{\delta}_t - \hat{\delta}_{t-1})$$

Repeat-sales housing price index

- It is also assumed that the residential property characteristics do not change with time.

$$\ln P_{ht} = \sum_{k=1}^{K} \beta_k X_{hk} + \sum_{s=1}^{T} \delta_s D_s + \varepsilon_{ht}$$

$$\ln P_{ht_1} = \sum_{k=1}^{K} \beta_k X_{hk} + \delta_1 + \delta_{t_1} + \varepsilon_{ht_1}$$

$$\ln P_{ht_2} = \sum_{k=1}^{K} \beta_k X_{hk} + \delta_1 + \delta_{t_2} + \varepsilon_{ht_2}$$

$$\ln(P_{ht_2} / P_{ht_1}) = \delta_{t_2} - \delta_{t_1} + \left(\varepsilon_{ht_2} - \varepsilon_{ht_1}\right)$$

$$\ln(P_{ht_2} / P_{ht_1}) = \sum_{s=1}^{T} \delta_s D_s + \mu_h$$

Problems in the repeat-sales method

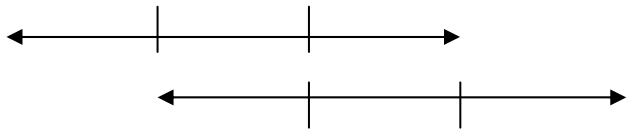
- (i) a sample selection bias issue, that is, houses that are repeatedly on sale have different characteristics from the houses traded in the market (so-called lemons) (Clapp and Giaccotto, 1992), and

- (ii) accommodating qualitative changes and structural changes because of the assumption that there are no changes in the property characteristics and their parameters during the transaction period in the repeat-sales method

Overlapping-period hedonic housing price index: OPHI

- **…… regression coefficients on the basis of a process of successive change by taking a certain period length τ as the estimation period.**
- **Assuming that we have pooled data over the periods 1, 2, …*T*. With respect to some of these periods, i.e., a period length τ, we assume the following basic model.**

$$\ln P_{it} = \sum_{k=1}^{K} \beta_k X_{ikt} + \sum_{s=1}^{\tau} \delta_s D_s + \varepsilon_{it}$$



$$q_{\tau+\tau-1} = q_{\tau+\tau-2} + (\delta_{\tau}^{(r)} - \delta_{\tau-1}^{(r)})$$

Parameter: $(\hat{\beta}_{kt} - \hat{\beta}_{k,t-1})$

3.Data

- Prices of secondhand condominiums
- Area: the 23 wards of Tokyo metropolitan area,
- Period: January 1986 and September 2006.
- Residential Information Weekly (or Shukan Jyutaku Joho in Japanese) published by RECRUIT, Co.

- Asking Price
- -the initial asking price
- -the price upon removal from the magazine
- Transaction Price
- -Land Registry
- -Mortgage

Table 1. List of analyzed data

Symbols	Variables	Contents	Unit
FS	Floor space/ square meters	Floor space.	m^2
AGE	Age of Building :Number of years since construction	Period between the date when the data is deleted from the magazine and the date of construction of the building.	month
TS	Time to nearest station	Time distance to the nearest station (Time by Walk or Bus).	minute
TT	Travel Time to central business district	Minimum of railway riding time in daytime to Terminal 7 stations in 2005*.	minute
BS	Balcony space/ square meters	Balcony space.	m^2
NU	Number of units	Total units of the condominium.	unit
RT	Market reservation time	Period between the date when the data appear in the magazine for the first time and the date of being deleted.	week
FD	First floor dummy	The property is on the ground floor 1, on other floors 0.	(0,1)
HF	Highest floor dummy	The property is on the top floor 1, on the other floors 0.	(0,1)
SD	South-facing dummy	Fenestrae facing south 1, other directions 0.	(0,1)
FD	Ferroconcrete dummy	Steel reinforced concrete frame structure 1, other structure 0.	(0,1)
LDj (j=0,…,J)	Location (Ward) dummy	*j th administrative district 1,* other district 0.	(0,1)
RDk (k=0,…,K)	Railway line dummy	*k th railway line 1,* other railway line 0.	(0,1)
TDl (l=0,…,L)	Time dummy (monthly)	*l th month 1,* other month 0.	(0,1)

*Terminal Staion : Tokyo,Shinagawa,Shibuya,Shinjuku,Ikebukuro,Ueno, and Ootemachi

Table 2. Summary of statistical values of secondhand condominium price data.

Variables	Average	Standard Deviation	Minimum	Maximum
RP: Resale Price of Condominimum (10,000 Yen)	3,904.66	2,348.54	850.00	19,500.00
FS: Floor space (㎡)	56.57	19.40	16.00	134.99
RP/*FS*	70.93	36.78	24.00	270.90
Age:Age of Building(months)	165.74	91.98	5.00	413.00
TS: Time to the nearest station: (minutes)	7.60	4.27	0.00	32.00
TT: Travel Time to Central Business District (minutes)	15.32	5.30	0.00	30.00
NU: The Number of Units	100.03	131.05	10.00	1149.00
RT: Market reservation time (week)	11.58	10.62	1.00	64.00

1986/01-2006/09 n=211,179

4.Estimation results

Estimation results of the RHM: 23 wards of Tokyo.

$$\log RP/FS = 4.631 + 0.0126 \cdot \log FS - 0.189 \cdot \log Age - 0.078 \cdot \log TS - 0.117 \cdot \log TT + 0.019 \cdot \log NU$$
$$(498.23) \quad (+10.81) \qquad (-337.38) \qquad (-99.69) \qquad (-36.21) \qquad (40.90)$$

$$-0.276 \cdot BD + 0.058 \cdot (BD \times \log WT) - 0.026 \cdot FF + 0.018 \cdot HF - 0.097 FD + 0.0093 \cdot SD$$
$$(-13.140) \quad (6.970) \qquad (-19.210) \qquad (8.000) \quad (-10.150) \quad (10.790)$$

$$+ \beta_{1j} \sum_j LD_j + \beta_{2k} \sum_k RD_k + \beta_{3l} \sum_l TD_l + \varepsilon$$

Adjusted R-Square: 0.837

Number of Observation: 211,178

Table 3. Estimation results of the RHM: 23 wards of Tokyo.

Method of Estimation
OLS
Dependent Variable
RP : Resale Price of Condominiums (in log)
Independent Variables

Property Characteristics (in log)	Coefficient	t-value
Constant	4.631	498.230
FS : Floor space	0.013	10.810
Age : Age of building	-0.190	-337.380
TS : Time to the nearest station	-0.078	-99.690
TT : Travel Time to CBD	-0.040	-36.210
NU : Number of units	0.019	40.900
RT : Market reservation time	0.014	32.530
Property Characteristics (dummy variables)	**Coefficient**	**t-value**
BD : Bus Dummy	-0.276	-13.140
TS × *BD*	0.059	6.970
FF : First Floor Dummy	-0.026	-19.210
HF :Highest floor dummy	0.018	8.000
FD :*Ferroconcrete dummy*	-0.010	-10.150
SD :*South-facing dummy*	0.009	10.790
Location (Ward) Dummy *LDj (j=0,…,J)*	**Coefficient**	**t-value**
Chiyoda	0.625	110.740
Chuo	0.347	82.770
minato	0.552	154.730
Shinjuku	0.407	115.620
Bunkyo	0.356	95.060
Taito	0.047	10.080
Koto	-0.030	-8.970
Shinagawa	0.315	86.020
Meguro	0.443	109.280
Ota	0.233	62.930
Setagaya	0.407	115.890
Shibuya	0.583	155.950
Nakano	0.284	65.620
Suginami	0.248	60.990
Toshima	0.243	61.220
Kita	0.092	17.620
Arakawa	-0.064	-14.580
Itabashi	0.007	1.960
Nerima	0.146	37.100
Adachi	-0.171	-43.080
Katsushika	-0.144	-38.390
Edogawa	-0.080	-21.890

Railway/Subway Line Dummy *LDk (k=0,…,K)*	Coefficient	t-value
Yamanote	0.033	4.236
Ginza	0.158	11.460
Marunouchi	0.056	5.556
Hibiya	0.085	9.039
Tozai	0.040	4.727
Chiyoda	0.067	7.858
Yurakucho	0.053	3.609
Hanzomon	-0.029	-2.621
ToeiAsakusa	-0.265	-2.420
ToeiShinjuku	-0.338	-10.244
Keihinkyukou	-0.214	-15.225
Keihintohoku	-0.265	-6.692
Ikegami	-0.089	-6.782
Tokyutoyoko	0.036	1.712
Setagaya	-0.091	-5.465
Odakyu	-0.025	-1.649
Inogashira	0.076	5.800
keio	0.032	2.361
Chuo	-0.045	-1.621
Seibushinjuku	-0.053	-4.024
Seibuikebukuro	0.040	2.455
Toubutojou	-0.126	-10.416
Saikyo	0.065	5.680
Takasaki	-0.063	-5.655
Toubuisezaki	-0.073	-2.694
Jouban	-0.111	-7.410
Soubu	-0.122	-5.927
Time Dummy *TDl (l=0,…,L)*	**Coefficient**	**t-value**
yes(see Figure)		

Adjusted R square= 0.837
Number of Observations= 211,179

Table 4 .Estimation of URHI

Time	Constant	*FS*: Floor space	*Age*: Age of building	*TS*: Time to the nearest station	*TT*: Travel Time to CBD	*NU*: Number of units	*RT*: Market reservation time	*BD*: Bus Dummy	*WT* × *BD*	Number of Observations	Adjusted R square
198601	4.402	0.007	-0.143	-0.100	-0.048	-0.011	-0.010	1.333	-0.495	416	0.761
198602	4.508	0.066	-0.144	-0.089	-0.099	-0.010	-0.021	-0.323	0.068	528	0.776
198603	4.464	-0.032	-0.110	-0.070	-0.046	-0.007	-0.022	-0.994	0.480	489	0.823
198604	4.413	0.051	-0.161	-0.106	-0.029	0.006	-0.012	1.160	-0.489	455	0.824
198605	4.669	0.012	-0.155	-0.096	-0.095	-0.002	-0.034	0.722	-0.268	605	0.727
198606	4.343	0.057	-0.133	-0.132	-0.025	0.014	-0.020	-0.912	0.268	446	0.751
198607	3.930	0.083	-0.120	-0.116	-0.054	0.002	-0.046	-0.470	0.168	430	0.785
198608	4.401	0.034	-0.128	-0.113	-0.009	0.021	-0.058	0.078	-0.095	564	0.791
198609	4.526	0.069	-0.146	-0.146	-0.018	0.008	-0.020	-0.308	0.084	394	0.838
198610	4.250	0.043	-0.114	-0.092	-0.025	0.014	-0.024	0.177	-0.122	560	0.826
198611	4.310	-0.001	-0.109	-0.121	0.053	0.010	-0.031	0.036	-0.080	340	0.866
198612	4.822	0.077	-0.154	-0.133	-0.142	-0.006	-0.032	-1.199	0.425	342	0.896
199001	5.831	-0.114	-0.154	-0.084	-0.067	0.022	0.005	-0.198	0.025	857	0.763
199501	4.820	0.090	-0.208	-0.070	-0.048	0.011	0.044	-0.203	0.064	1,109	0.641
200001	4.402	0.071	-0.209	-0.036	-0.035	0.021	0.005	-0.373	0.125	778	0.697
200501	4.548	0.035	-0.208	-0.057	-0.015	0.018	0.009	-0.752	0.294	702	0.757
200601	4.303	0.084	-0.191	-0.093	-0.011	0.023	-0.002	-0.576	0.188	650	0.809
200602	4.484	0.115	-0.201	-0.106	-0.040	-0.002	-0.010	-0.382	0.125	768	0.766
200603	4.584	0.056	-0.201	-0.087	-0.024	0.025	-0.007	-0.670	0.207	1,015	0.785
200604	4.441	0.067	-0.182	-0.091	-0.024	0.012	-0.011	-0.242	0.051	826	0.775
200605	4.583	0.060	-0.186	-0.080	-0.036	0.015	-0.014	-0.224	0.049	966	0.774
200606	4.807	0.033	-0.208	-0.072	-0.022	0.000	-0.018	-0.248	0.039	776	0.775
200607	4.530	0.063	-0.187	-0.092	0.001	0.007	-0.006	-0.039	-0.043	819	0.770
200608	4.742	0.024	-0.198	-0.079	-0.015	0.011	-0.011	0.324	-0.135	901	0.784
200609	4.566	0.020	-0.198	-0.072	0.012	0.018	-0.005	0.089	-0.070	900	0.766

Figure1.Estimation accuracy of the URHM: between 1986/01 and 2006/09.

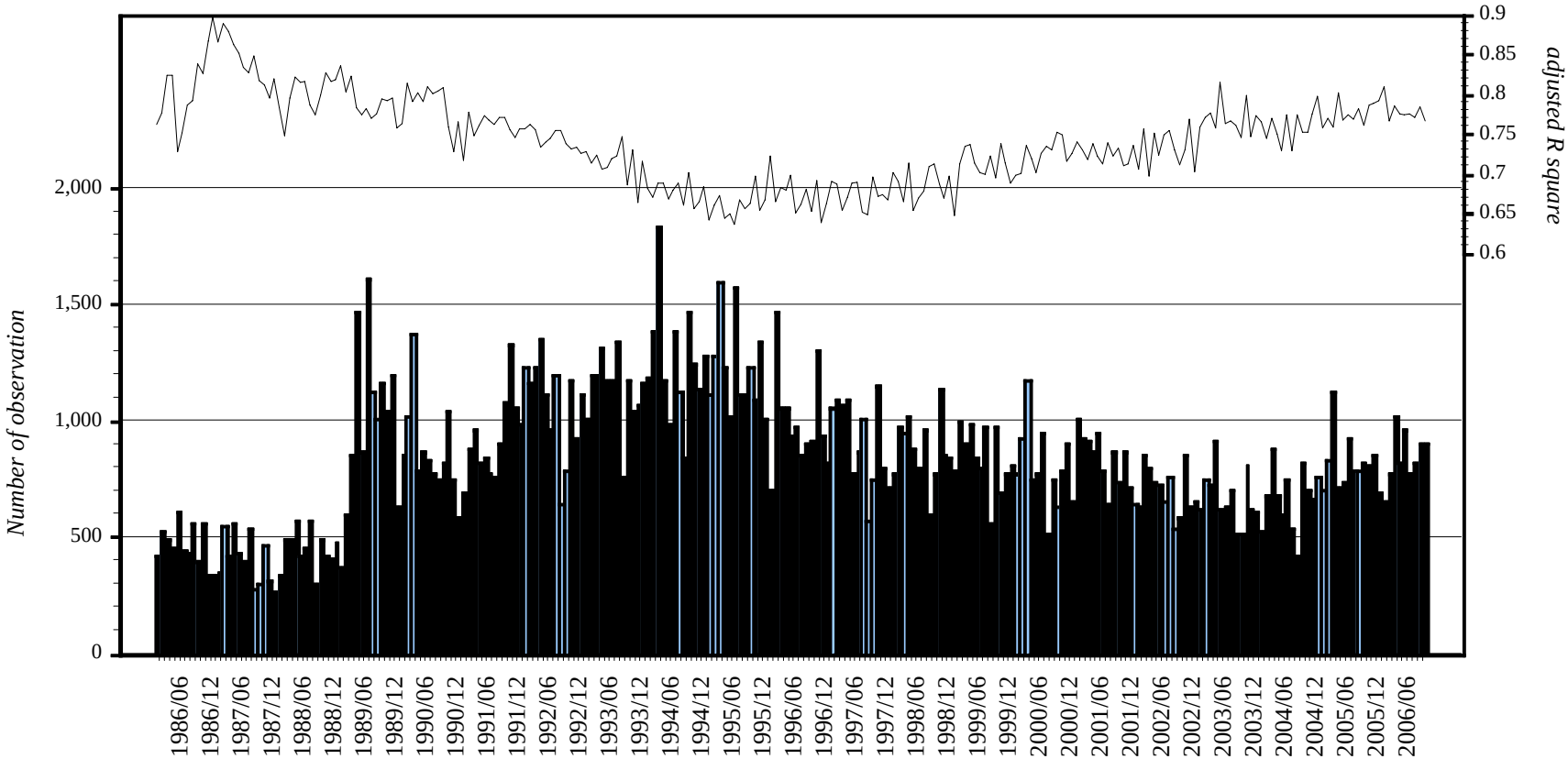


Table 5. Statistical values of major regression coefficients (URHM).

Principal Independent Variables	***RHI*** **:1986.01 - 2006.09**	***NRHI*** :Summary statistics of estimated parameter			
		Average	Standard deviation	Skewness	Kurtosis
FS :Floor space/square meters	0.013	0.033	0.081	-0.758	-0.627
Age :Age of building	-0.190	-0.185	0.033	0.474	0.110
WT :Distance to nearest station	-0.078	-0.082	0.019	-0.640	0.799
TT :Travel Time to central business district	-0.040	-0.041	0.032	-0.320	0.136
Adjusted-R Square	0.837	0.741	0.054	0.190	-0.379
Number of Samples	211,179	844.720	282.977	0.369	0.123

1986.01 - 2006.09:Monthly ,Number of Mode=250

Fig2. Time profile of regression coefficient of the URHM, constant term *cnst*: 1986/01–2006/09.

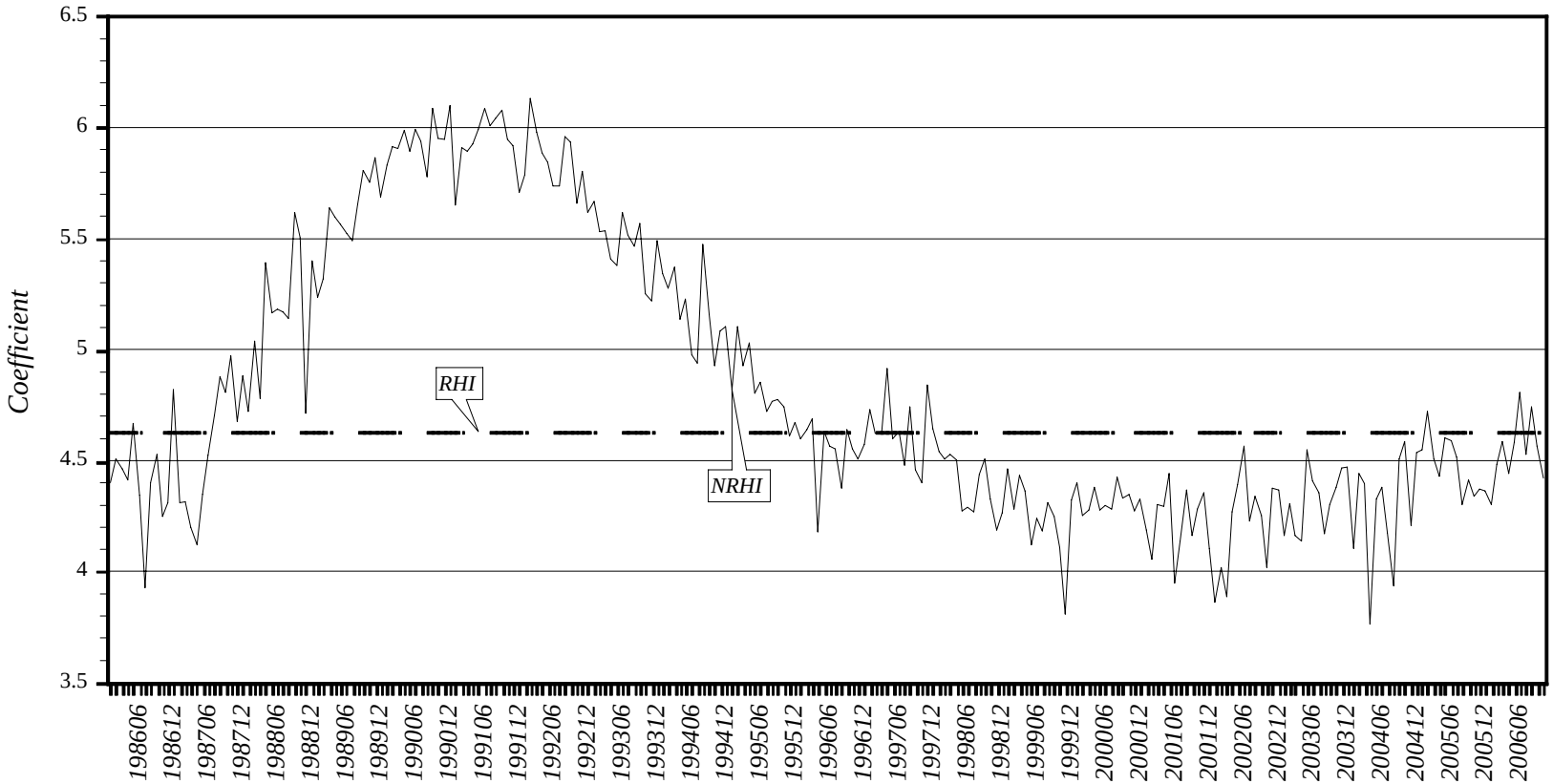


Fig3. Time profile of regression coefficient of the URHM, floor space *FS*: 1986/01–2006/09.

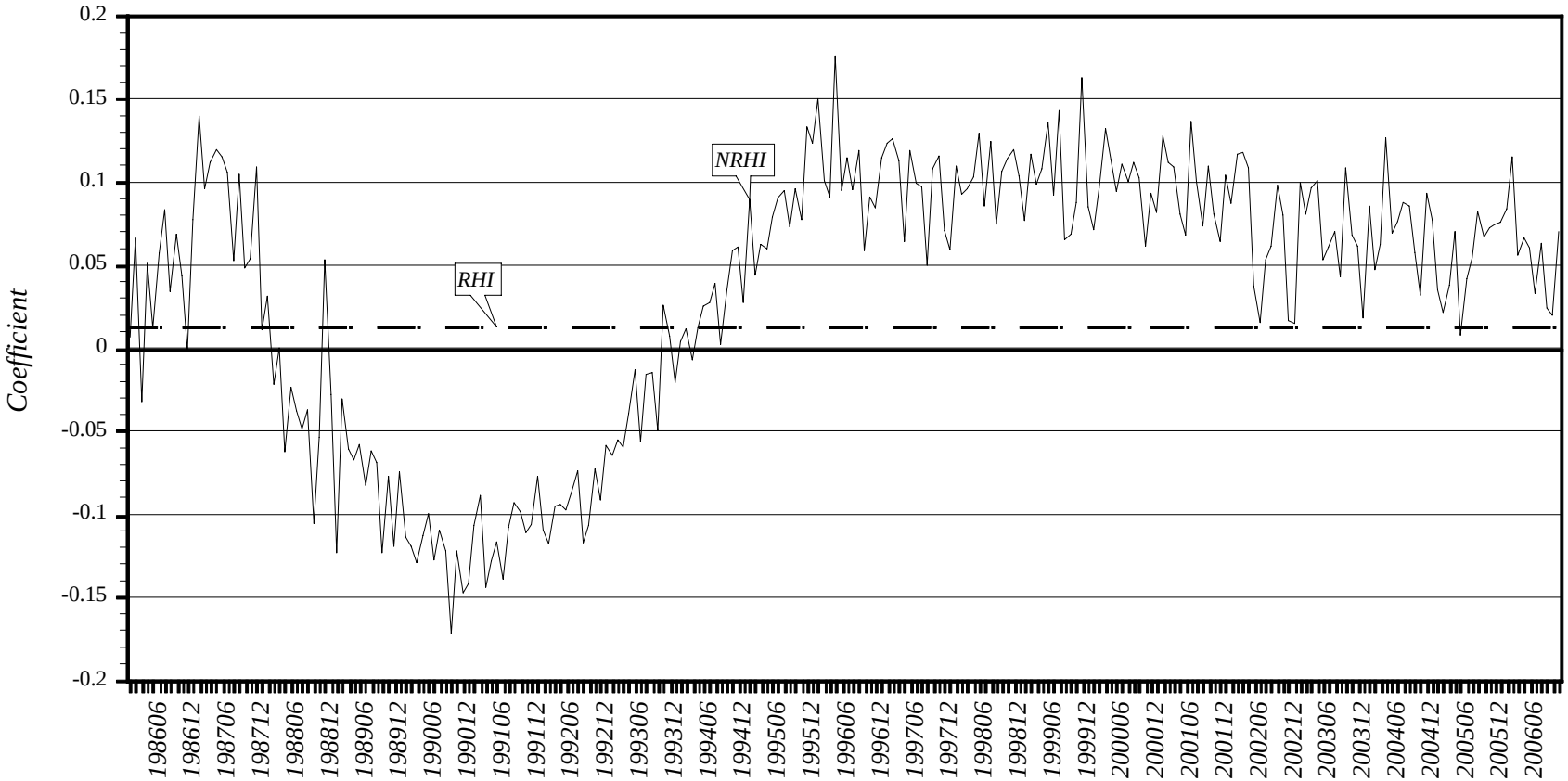


Fig4. Time profile of regression coefficient of the URHM, age of building *Age*: 1986/01–2006/09.

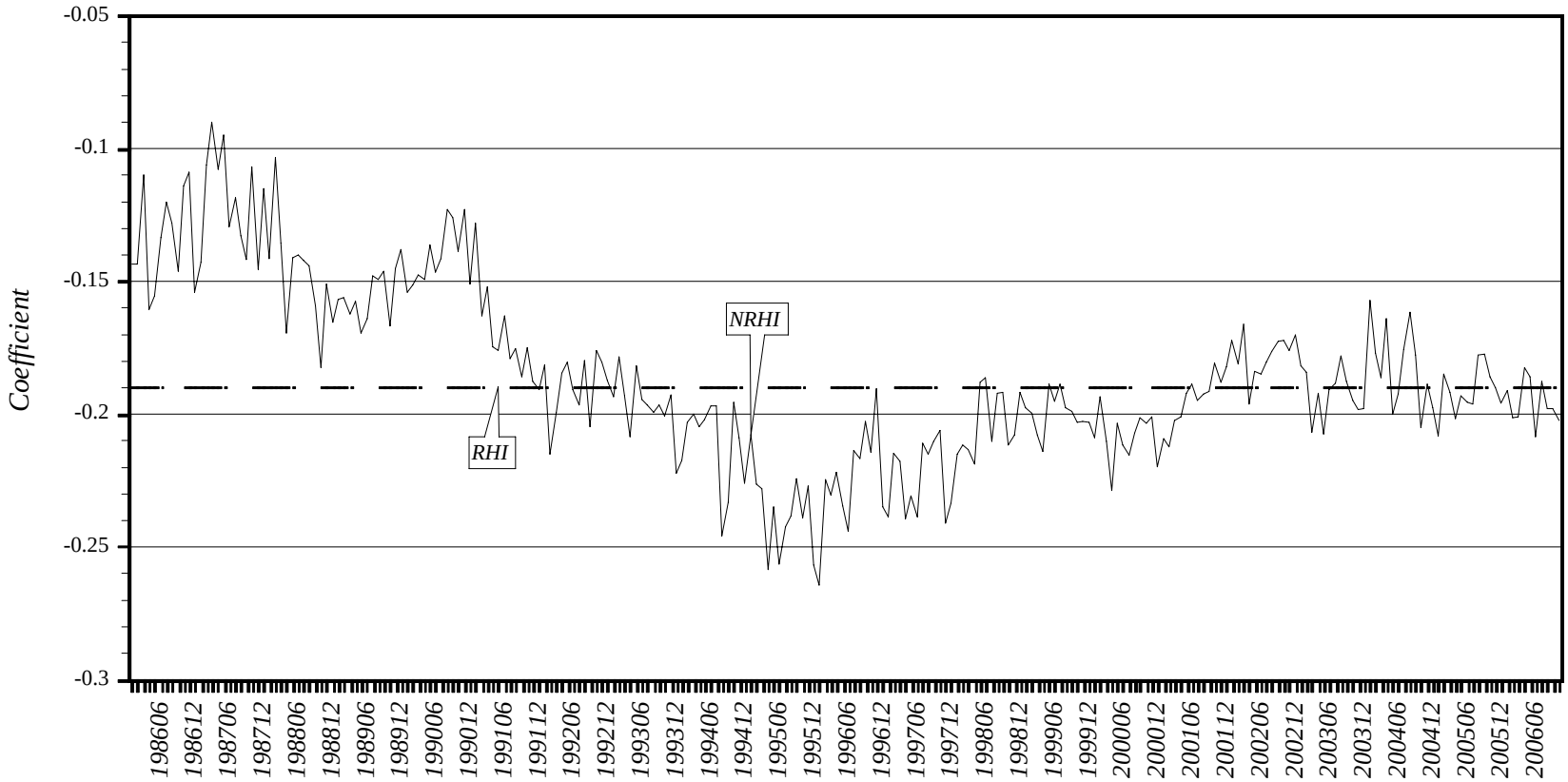


Fig5. Time profile of regression coefficient of the URHM, time to nearest station *TS*: 1986/01–2006/09.

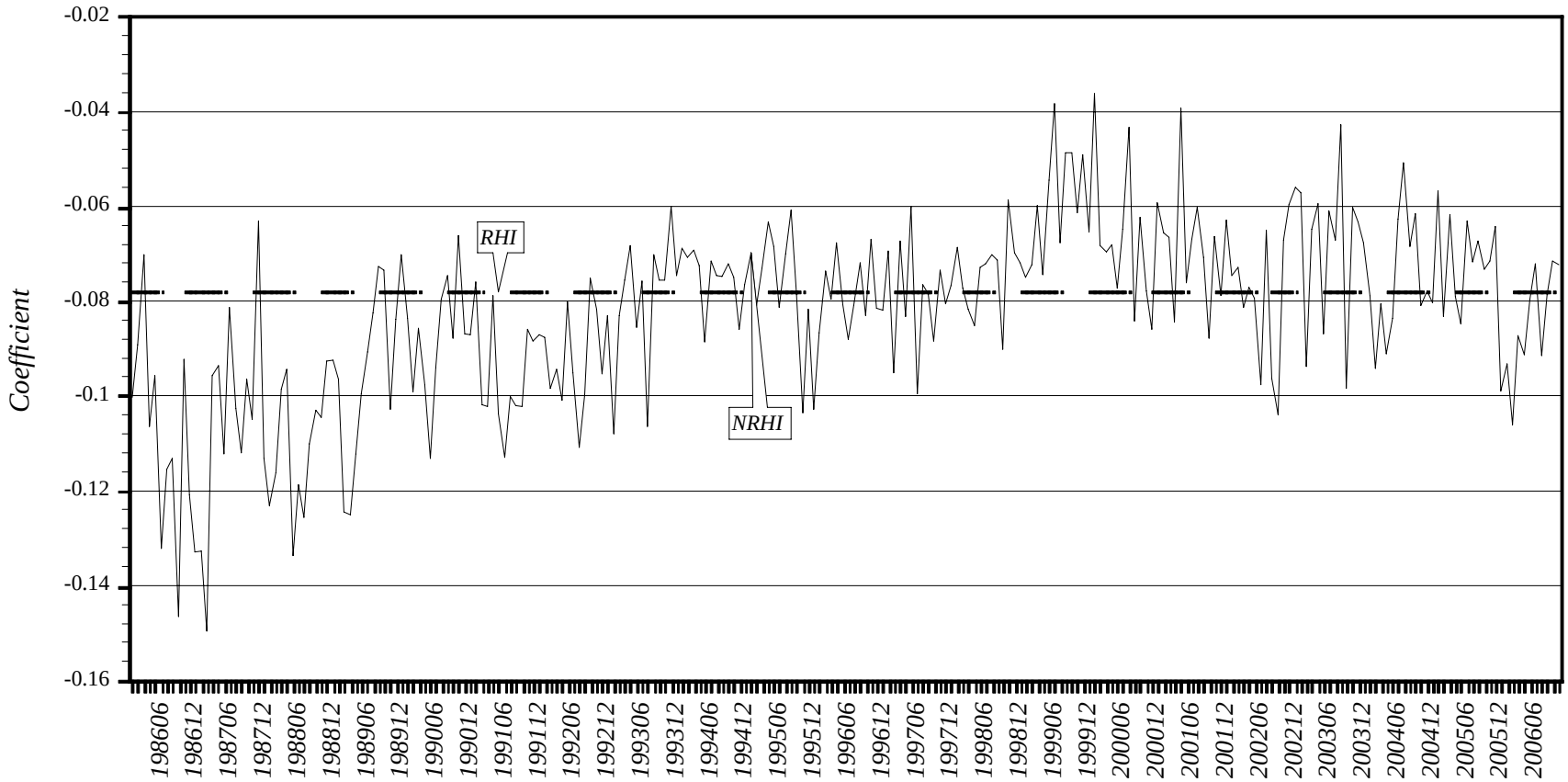


Fig6. Time profile of regression coefficient of the URHM, travel time to CBD *TT*: 1986/01–2006/09.

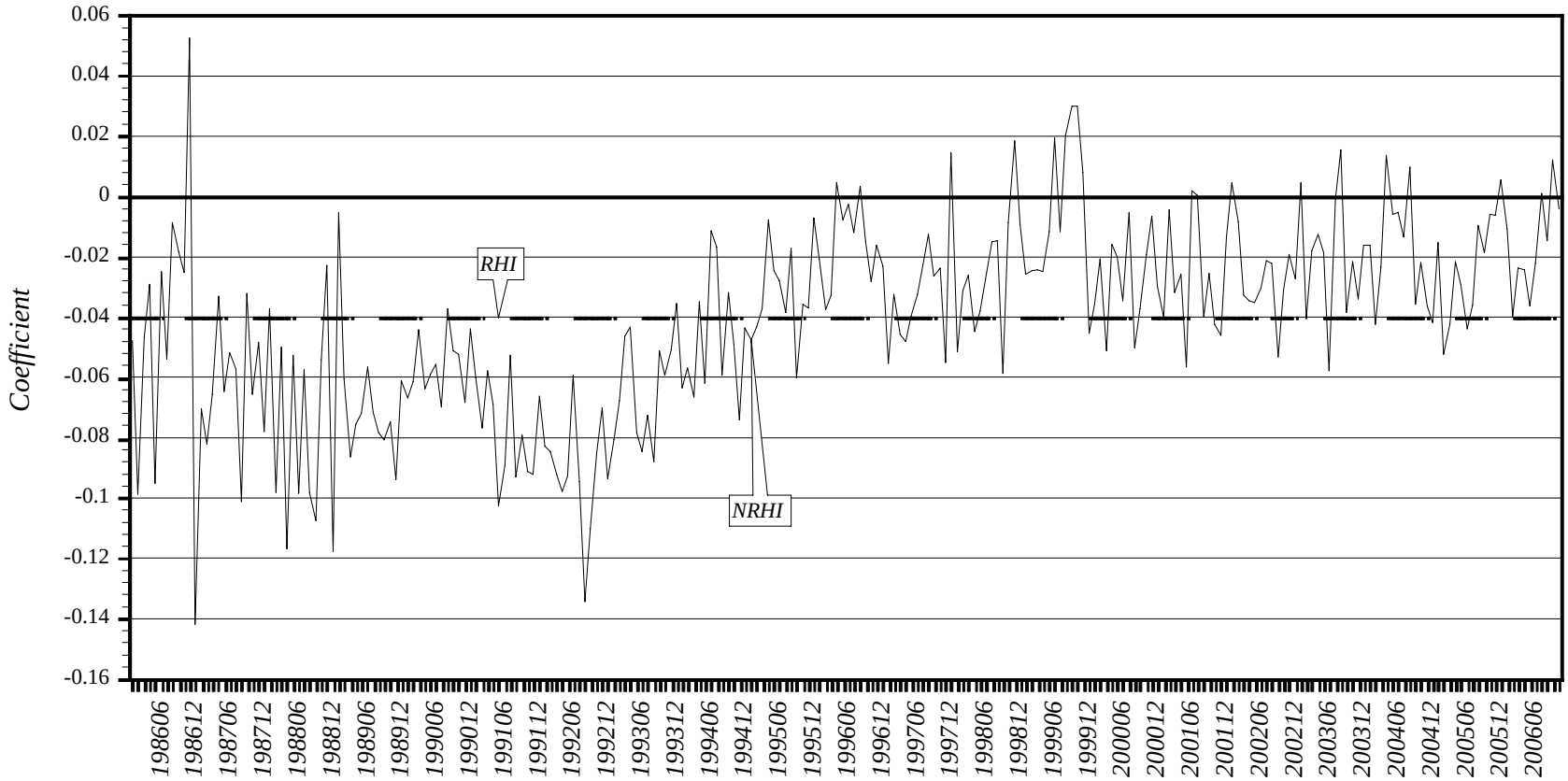


Table6. Estimation results of the OPHM ($\tau = 12$): 1986/01–2006/09.

Time	Constant	*FS*: Floor space	*Age*: Age of building	*TS*: Time to the nearest station	*TT*: Travel Time to CBD	*NU*: Number of units	*RT*: Market reservation time	*BD*: Bus Dummy	*WT* × *BD*	Number of Observations	Adjusted R square
198612	4.232	0.041	-0.129	-0.108	-0.046	0.002	-0.028	-0.156	0.035	5,497	0.785
198701	4.176	0.055	-0.129	-0.112	-0.047	0.003	-0.028	-0.106	0.010	5,425	0.796
198702	4.133	0.058	-0.126	-0.117	-0.043	0.007	-0.025	-0.075	-0.009	5,446	0.812
198703	4.067	0.068	-0.126	-0.120	-0.045	0.008	-0.022	-0.023	-0.034	5,383	0.824
198704	4.038	0.075	-0.123	-0.122	-0.050	0.011	-0.021	-0.088	-0.006	5,492	0.835
198705	3.994	0.085	-0.120	-0.124	-0.048	0.014	-0.019	-0.133	-0.005	5,316	0.849
198706	4.015	0.089	-0.122	-0.119	-0.050	0.013	-0.021	-0.095	-0.019	5,268	0.854
198707	4.053	0.087	-0.121	-0.118	-0.050	0.013	-0.021	-0.053	-0.037	5,372	0.856
198708	4.104	0.089	-0.120	-0.115	-0.057	0.012	-0.018	-0.049	-0.041	5,083	0.859
198709	4.139	0.091	-0.120	-0.111	-0.059	0.012	-0.020	-0.084	-0.031	4,986	0.857
198710	4.183	0.091	-0.119	-0.111	-0.059	0.012	-0.020	-0.162	0.002	4,888	0.852
198711	4.293	0.093	-0.123	-0.108	-0.066	0.010	-0.016	-0.231	0.024	4,863	0.846
198712	4.315	0.092	-0.121	-0.109	-0.066	0.012	-0.009	-0.257	0.033	4,792	0.839
199001	5.522	-0.083	-0.154	-0.092	-0.074	0.020	0.007	-0.275	0.049	12,360	0.788
199501	5.191	0.030	-0.209	-0.074	-0.047	0.019	0.030	-0.360	0.105	14,903	0.681
200001	4.244	0.105	-0.201	-0.059	-0.008	0.021	0.008	-0.307	0.084	10,033	0.710
200501	4.327	0.069	-0.185	-0.076	-0.020	0.023	0.000	-0.172	0.027	8,131	0.755
200601	4.454	0.057	-0.189	-0.075	-0.026	0.018	-0.006	-0.404	0.117	9,684	0.776
200602	4.443	0.062	-0.191	-0.076	-0.025	0.017	-0.006	-0.461	0.141	9,622	0.777
200603	4.450	0.063	-0.191	-0.079	-0.024	0.017	-0.006	-0.544	0.172	9,506	0.780
200604	4.439	0.064	-0.190	-0.080	-0.023	0.017	-0.007	-0.486	0.149	9,617	0.778
200605	4.438	0.069	-0.189	-0.080	-0.024	0.016	-0.007	-0.486	0.148	9,844	0.777
200606	4.446	0.069	-0.189	-0.082	-0.022	0.014	-0.008	-0.444	0.130	9,699	0.778
200607	4.449	0.070	-0.189	-0.083	-0.018	0.014	-0.008	-0.409	0.118	9,726	0.777
200608	4.485	0.064	-0.190	-0.084	-0.018	0.014	-0.007	-0.347	0.098	9,837	0.778
200609	4.494	0.060	-0.192	-0.083	-0.015	0.015	-0.008	-0.249	0.061	9,920	0.778

Fig7. Estimation accuracy of the OPHM: between 1986/01 and 2006/09.

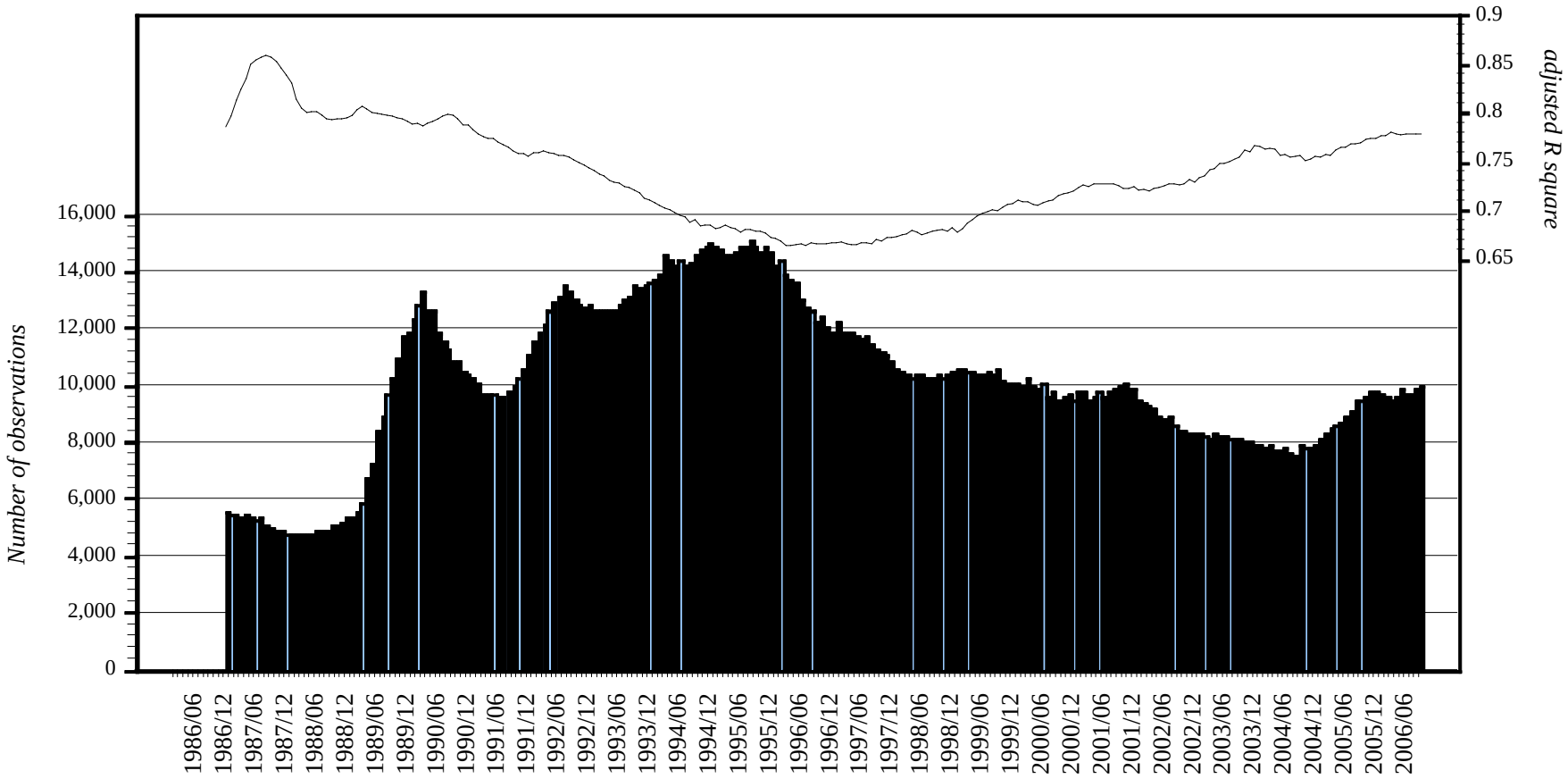


Fig. 8. Time profile of regression coefficient of the OPHM, constant term *cnst*: 1986/01–2006/09.

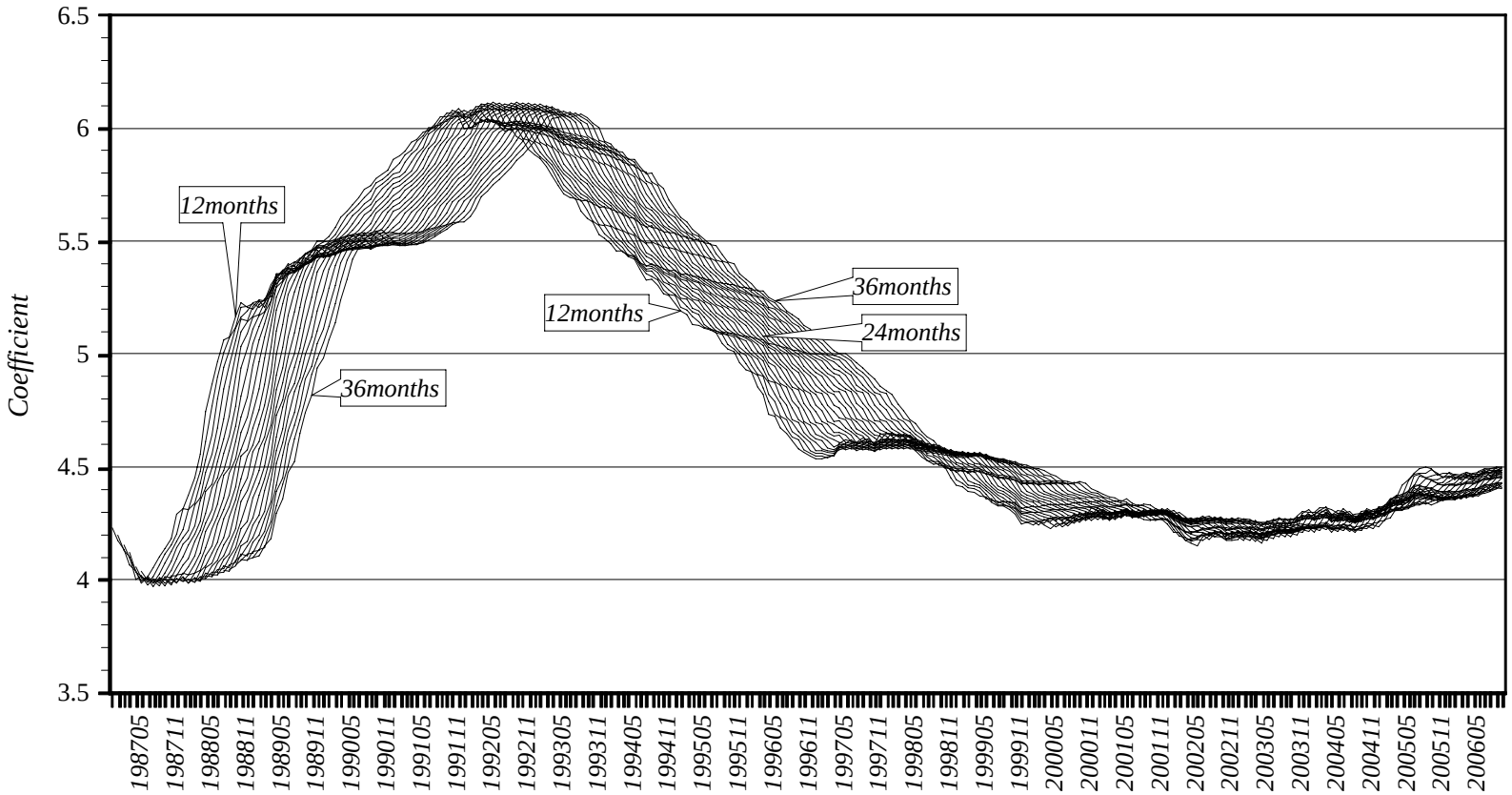


Fig9. Time profile of regression coefficient of the OPHM, floor space *FS*: 1986/01–2006/09.

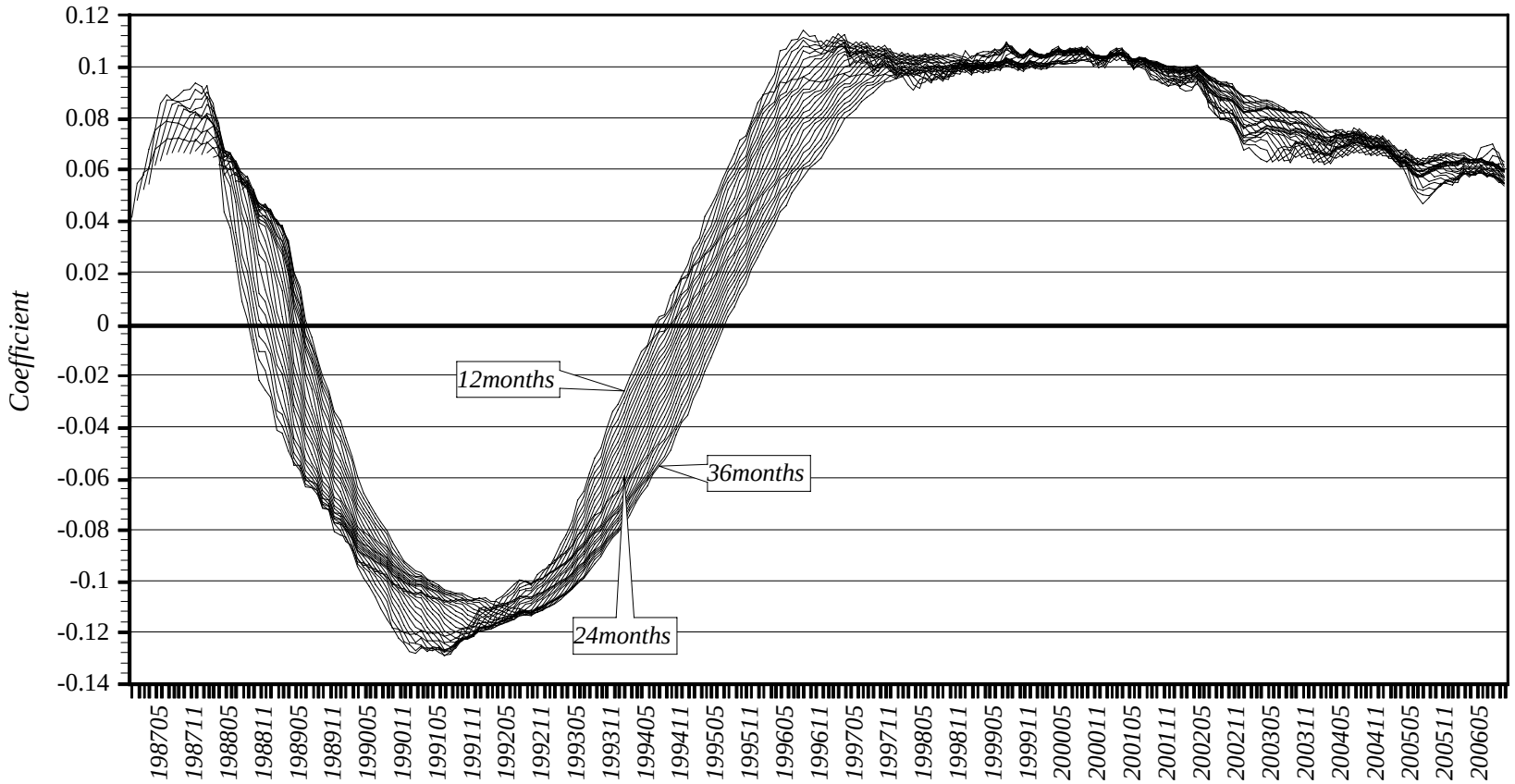


Fig10. Time profile of regression coefficient of the OPHM, age of building *Age*: 1986/01–2006/09.

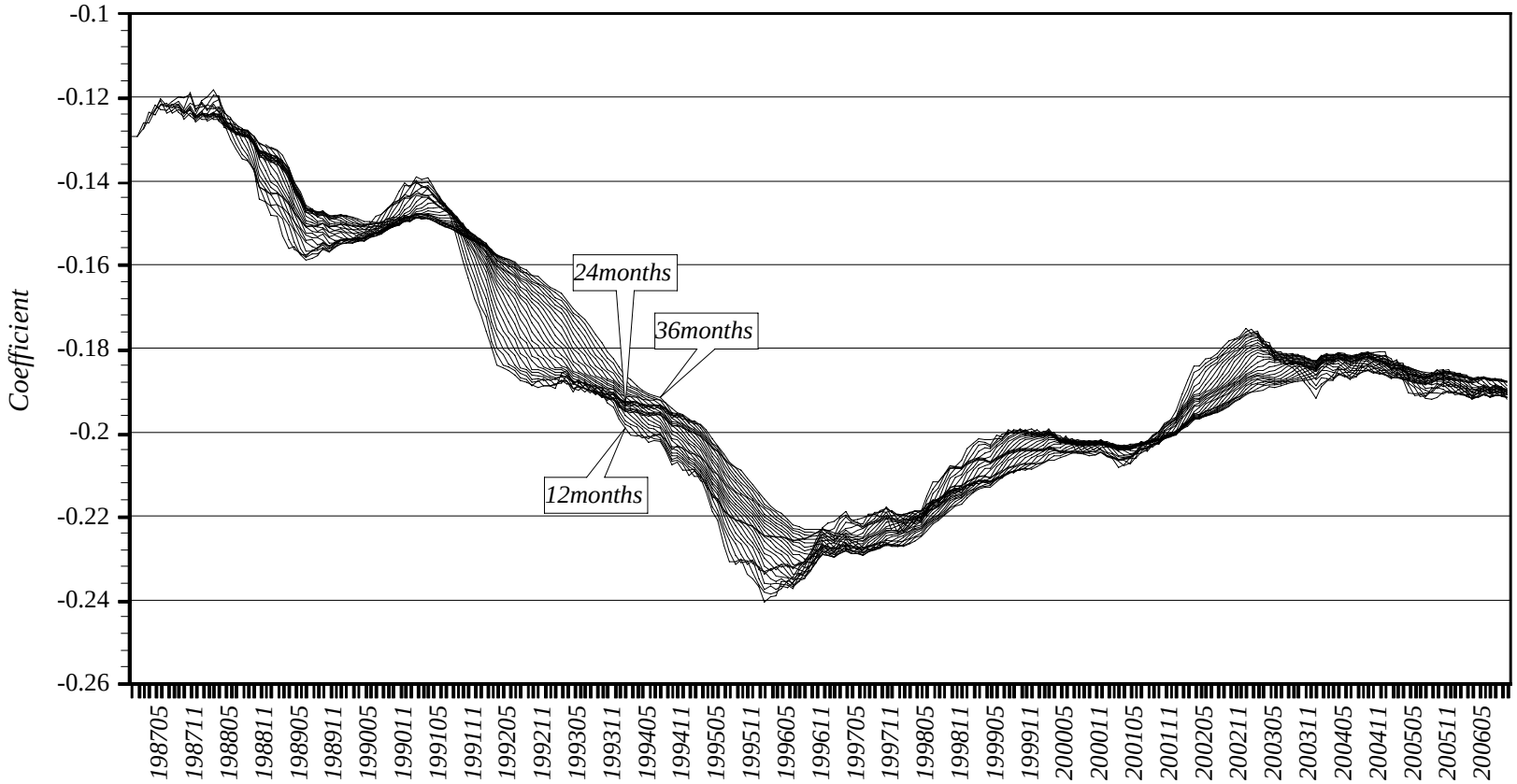


Fig11. Time profile of regression coefficient of the OPHM, time to nearest station *TS*: 1986/01–2006/09.

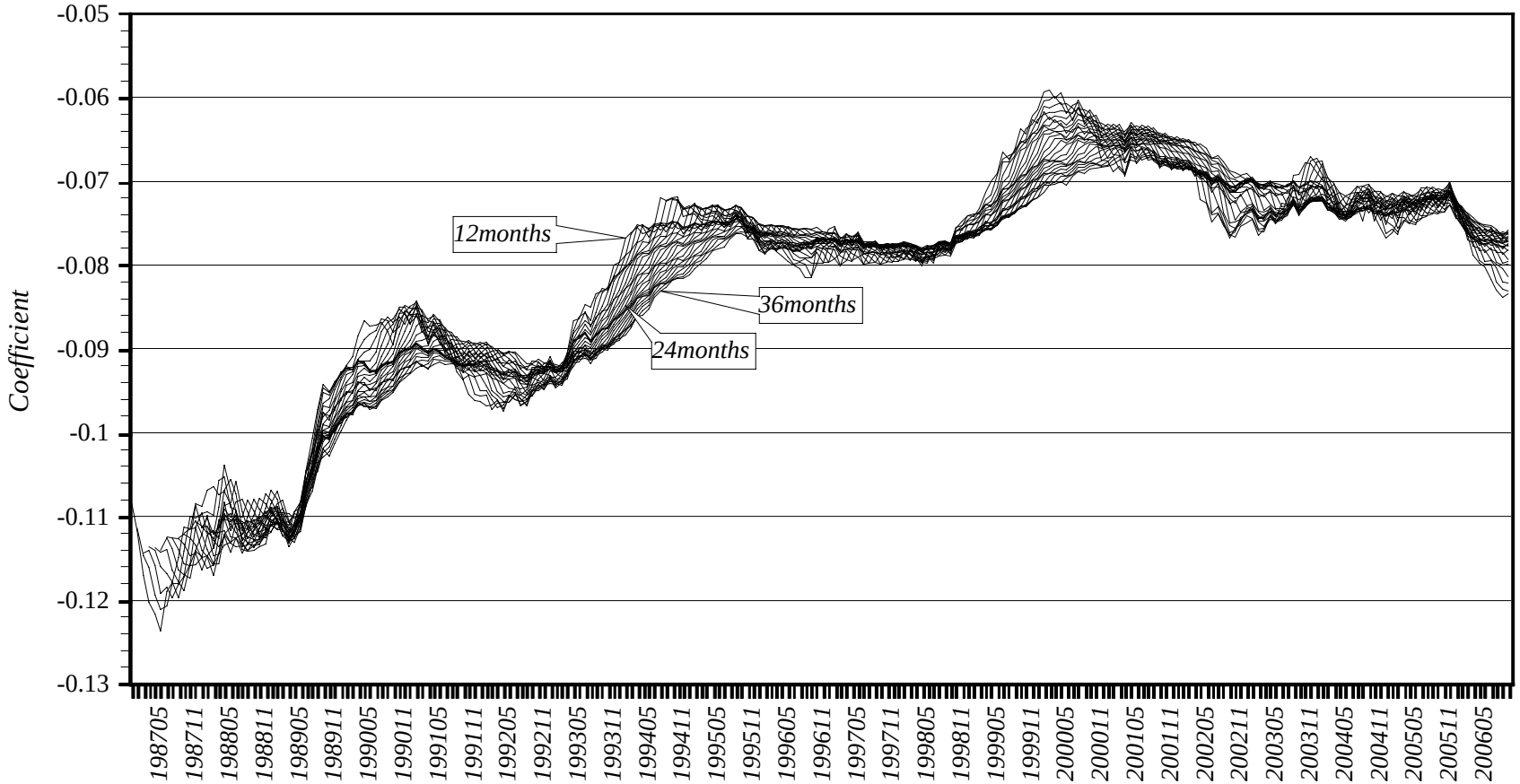


Fig12. Time profile of regression coefficient of the OPHM, travel time to CBD *TT*: 1986/01–2006/09.

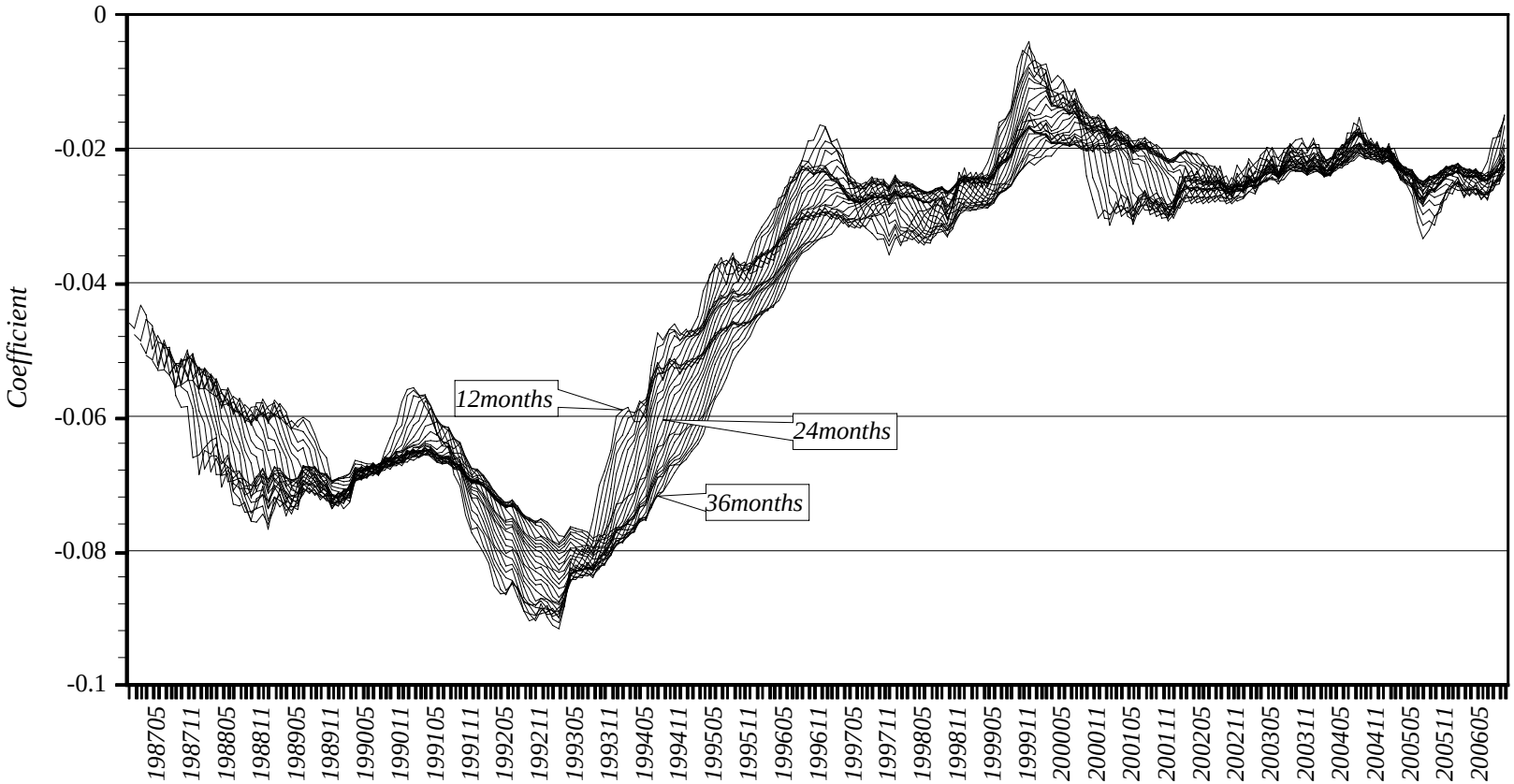


Fig13. Time profile of OPHI: 1986/01–2006/09.

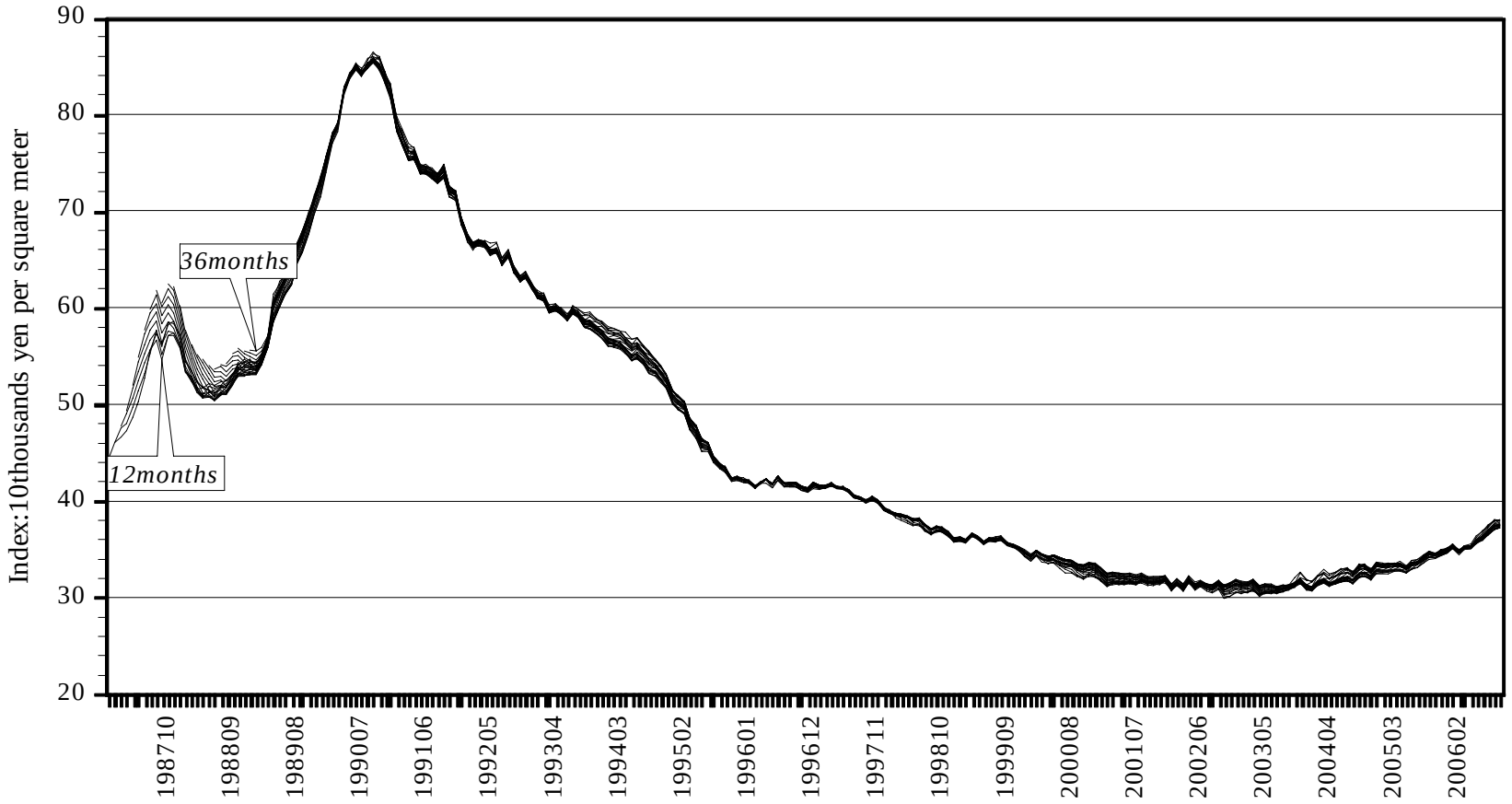
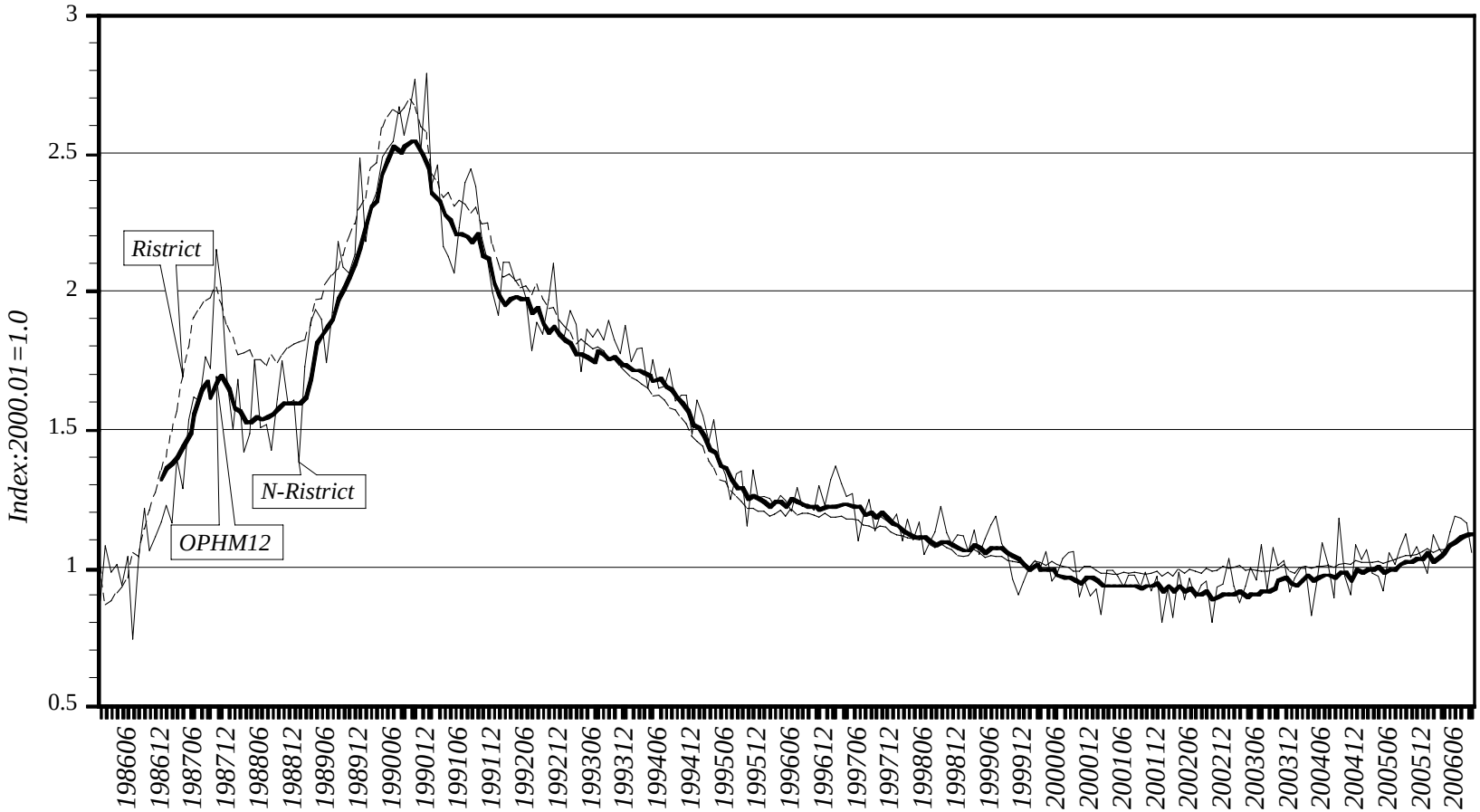


Fig14. Comparison of indices between RHI,URHI and OPHI(τ =12): 1986/01–2006/10.



Conclusions:

- URHI :the regression coefficients widely fluctuate in each period or every couple of periods
- →this fluctuation is observed within short periods, a specific trend is observed in the long term /seasonal sample selection bias
- →we proposed OPHM.

- OPHM:we set τ from 12 months to 36 months for the estimation.
- →Temporal changes in the regression coefficients revealed by OPHM
- →When τ between 12 months and 36 months were compared, the existence of a time lag in the regression coefficients was observed.

- The results of the above series of analyses indicated the superiority of the estimation by OPHI (τ = 12 months) in the secondhand condominium market in Japan, when structural changes in the market are to be accommodated.