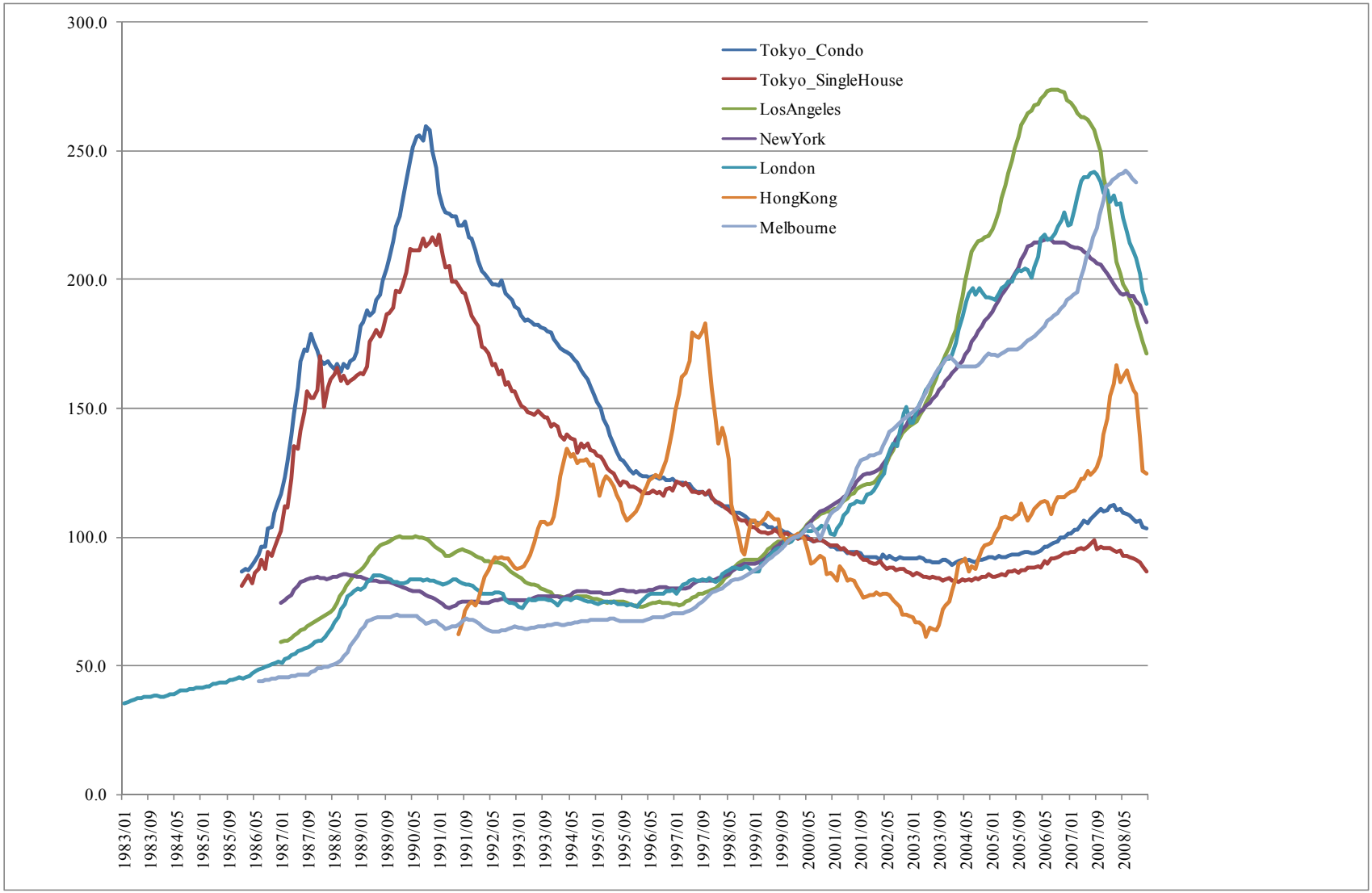
2009 Ottawa Group Meeting in Neuchâtel, Switzerland, 27-29 May 2009

House Prices and Rents in Tokyo

- A Comparison of Repeat-sales and Hedonic measures-

Chihiro Shimizu(Reitaku University)
Kiyohiko.G.Nishimura(Bank of Japan)
Tsutomu Watanabe(Hitotsubashi University)

2.2.Causality of House Price index between Major Cities.



Hedonic method and Repeat sales method

- The location, history and facilities of each house are *different* from each other in **varying degrees**.
- Houses have "***particularity with few equivalents***."
- **Quality-Adjustment Methodology** in House Price Index
-
- → Hedonic method and Repeat sales method

Problems for the repeat sales method

- (i) there is ***sample selection bias*** (Clapp and Giaccotto 1992);
- (ii) the assumption that there are ***no changes in property characteristics*** and their parameters during the transaction period is unrealistic (Case and Shiller,1987, 1989; Clapp and Giaccotto, 1992, 1998, 1999; Goodman and Thibodeau,1998; Case et al. 1991).

Problems for the hedonic method

- (i) there is an ***omitted variable bias*** (Case and Quigley 1991; Ekeland, Heckman and Nesheim 2004; Shimizu 2009);

- (ii) the assumption of ***no structural change*** is unrealistic (Case et al. 1991; Clapp et al. 1991; Clapp and Giaccotto 1992, 1998; Shimizu and Nishimura 2006, 2007, Shimizu, Takatsuji, Ono, and Nishimura 2007).

Contents of Our Research:

- 1. Introduction.
- 2. Five Measures of House Prices.
- 2.1. Traditional hedonic index.
- 2.2. Traditional repeat sales index.
- 2.3. Case-Shiller adjustment to repeat sales index.
- 2.4. Age-adjustment to repeat sales index.
- 2.5. Structural-change adjustment to hedonic index.
- 3. Data Properties.
- 4. Estimation Results.
- 5. Conclusion.

House Price Transaction Samples

P*i,t* : property *i*, transaction time *t*, *Repeat Sales Samples

	Time									
	1	2	3	4	5	6	7	8	9	10
1*	$p_{1,1}$			$p_{1,4}$					$p_{1,9}$	
2								$p_{2,8}$		
3*		$p_{3,2}$		$p_{3,4}$			$p_{3,7}$			$p_{3,10}$
4						$p_{4,6}$				
5		$p_{5,2}$								
6					$p_{6,5}$					
7*			$p_{7,3}$				$p_{7,7}$			
8				$p_{8,4}$						
.		. .	. .	. .	. .	. .	. .	. .	. .	. .
n*								$p_{n,8}$		$p_{n,10}$

Repeat Sales Method and Hedonic Method

- Traditional Hedonic Model (pooling data)

$$\ln P_{it} = \sum_{k=1}^{K} \beta_k X_{ikt} + \sum_{s=1}^{\tau} \delta_s D_s + \varepsilon_{it} \quad \Longrightarrow \quad \ln(\hat{P}_t / \hat{P}_{t-1}) = \hat{\delta}_t - \hat{\delta}_{t-1}$$

- $\hat{\delta}_t : TimeDummyParameter$ ➡ House Price Index

- Traditional Repeat Sales Model (Bailey, Muth and Nourse1963 A.S.A.J; RS_{BMN})

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

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

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

-

Adjustment to Repeat Sales Index

- **Case-Shiller adjustment:**
- Case and Shiller (1987, 1989) have proposed a model in which a GLS estimation is performed taking account of ***heteroscedasticity***.

- **Age-adjustment to repeat sales index:**
- The number of years for which are houses in the market is remarkably short(**Average age is under 30years!),** the ***depreciation problem*** is potentially significant in Japan.
- To take account of the ***age effect***, we estimate Age-adjustment to repeat sales index which indicates in section 2.4.

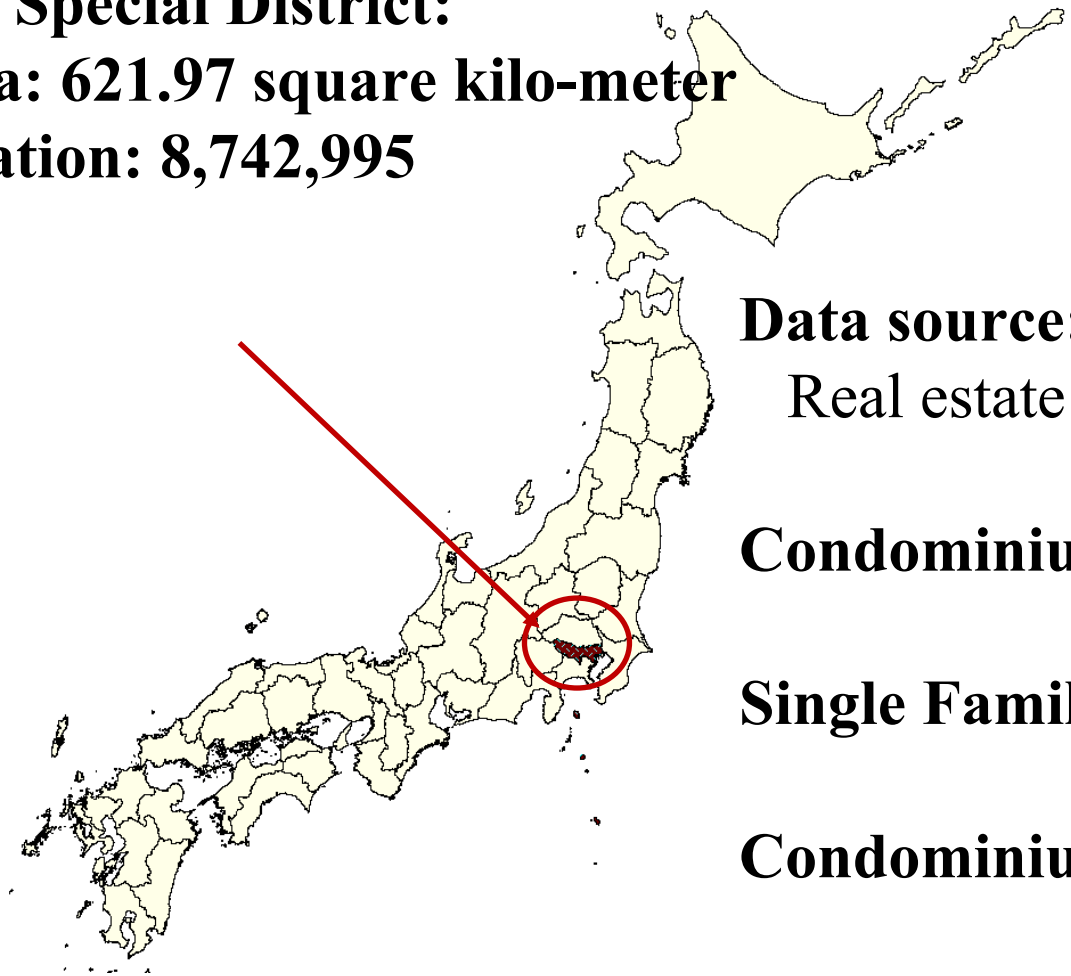
Adjustment to Hedonic Index

- **Structural-change adjustment to hedonic :**
- We estimated hedonic model ***considering structural change*** by **Overlapping Period Hedonic Model**; OPHM, proposed by Shimizu et.al(2007).

- OPHM may be more appropriate to estimate regression coefficients on the basis of a process of successive changes by taking a certain **length as the estimation "window",** by shifting this period in a way of **rolling regressions**, in essence similar to moving averages.

2. Data Properties.

Tokyo Special District:
Area: 621.97 square kilo-meter
Population: 8,742,995



Data source:
Real estate advertisement magazine
(1986-2008: 23 years)
Condominium Price:
157,627 samples
Single Family House Price:
315,791 samples
Condominium Rent:
1,139,043 samples

Table 2. Summary statistics of housing prices and rents.

Variables	Condominium(Asset Price)		Single Family(Asset Price)		Condominium(Rent Price)	
	Hedonic	Repeat Sales	Hedonic	Repeat Sales	Hedonic	Repeat Sales
Price of Condominium/Single Family (10,000 Yen) , Rent of Condominium(Yen/month)	3,862.26 (3,190.83)	4,463.43 (4284.10)	7,950.65 (8275.04)	7,635.24 (7055.96)	136,229.50 (116,436)	156,260.13 (122366.20)
FS : Floor space (m^2)	58.31 (21.47)	59.54 (24.09)	102.53 (43.47)	105.82 (45.60)	40.54 (26.63)	44.97 (26.84)
GA : Ground Area (m^2)	- -	- -	108.20 (71.19)	101.41 (63.17)	- -	- -
Age :Age of Building(months)	166.82 (101.17)	180.20 (101.35)	162.19 (102.66)	63.79 (99.39)	134.09 (89.27)	105.35 (80.86)
TS : Time to the nearest station: (minutes)	7.96 (4.43)	7.77 (4.28)	9.85 (4.54)	9.60 (4.37)	7.28 (4.03)	6.92 (3.92)
TT : Travel Time to Central Business District (minutes)	12.58 (7.09)	10.73 (6.88)	13.23 (6.34)	11.89 (6.18)	10.20 (6.48)	9.28 (6.28)
1986/01-2008/12	n=157,627	n=67,436	n=315,791	n=19,428	n=1,139,043	n=305,557

4 Estimation Results

Table 3: Results of hedonic regressions

Estimation Method OLS
Dependent Variable Logarithm of Price or Rent per m^2
Independent Variables

Variables	Condominium(Price)		Single Family(Price)		Condominium(Rent)	
	coefficient	t-value	coefficient	t-value	coefficient	t-value
Constant	4.470	358.778	4.615	378.620	8.951	826.498
FS : Floor space (m^2)	0.029	25.340	0.002	125.046	-0.191	-762.560
GA : Ground Area (m^2)			0.002	213.860	-	-
Age :Age of Building(months)	-0.186	-351.585	-0.011	-190.559	-0.037	-466.013
TS : Time to the nearest station: (minutes)	-0.069	-92.747	-0.013	-137.989	-0.052	-230.110
Bus:Bus Dummy	-0.137	-6.603	-0.198	-24.595	-0.010	-3.350
Bus×*TS*	0.007	0.815	0.002	4.300	0.018	13.690
TT : Travel Time to Central Business District	-0.068	-68.028	-0.009	-114.091	-0.077	-261.313
Top:Top of Building	0.022	5.390	-	-	-	-
BeforeConstruction Standard	-0.090	-80.770	-	-	-0.122	-256.050
Steel Dummy	0.010	10.650	-	-	0.082	200.050
Balcony Area	0.022	32.950	-	-	-	-
Road Width	-	-	0.207	154.500	-	-
Private Road	-	-	-0.003	-9.840	-	-
Land only Dummy	-	-	-0.109	-63.180	-	-
Old house	-	-	-0.086	-36.020	-	-
New Construction	-	-	-0.121	-69.330	-	-
1986/01-2008/12	n=157,627		n=315,791		n=1,139,043	
Adjusted R-square=	0.876		0.861		0.895	

Figure1a. Traditional hedonic *vs.* Traditional Repeat Sales (Condominium price)

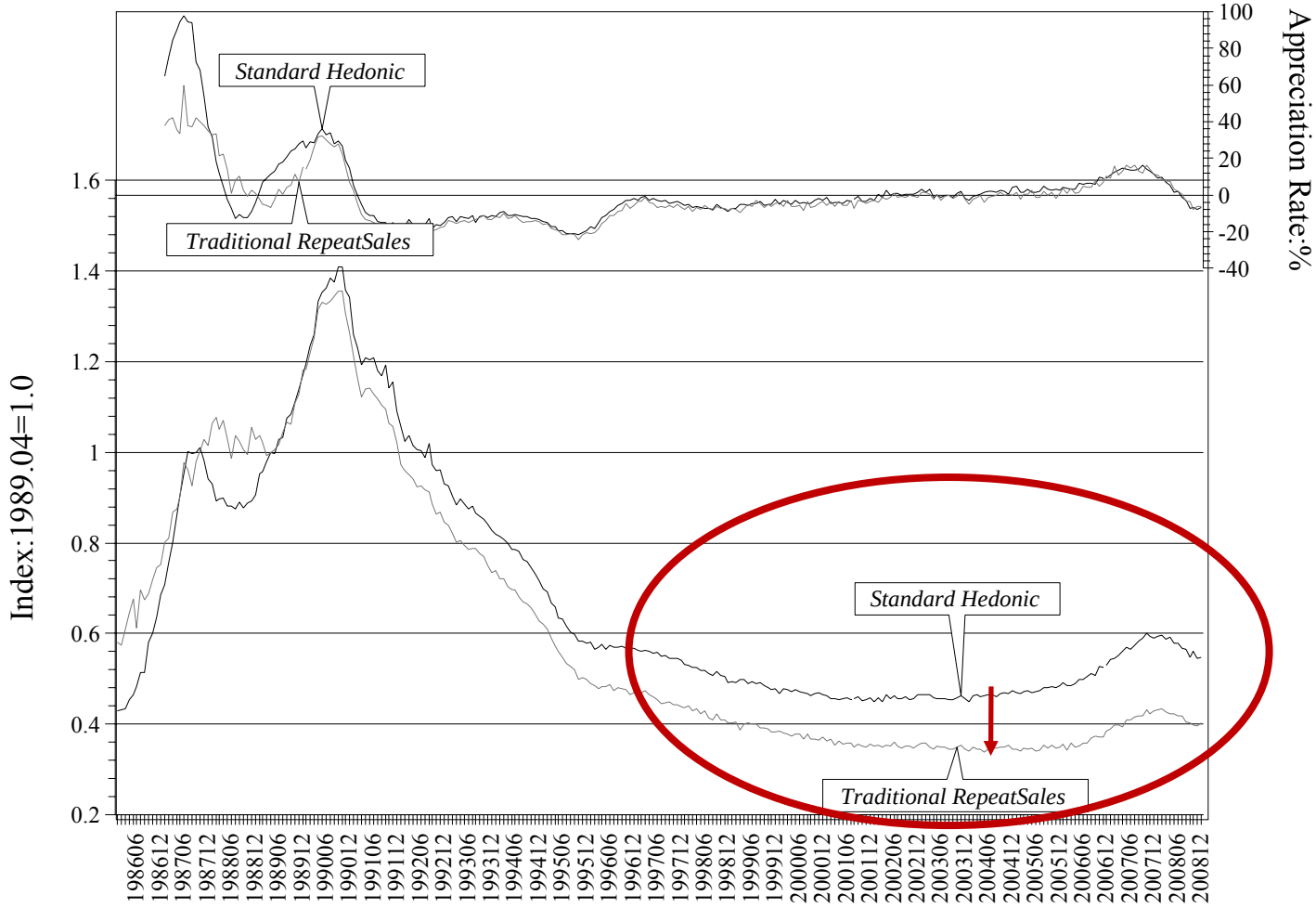


Figure1b. Traditional hedonic vs. Traditional Repeat Sales (Single family house price)

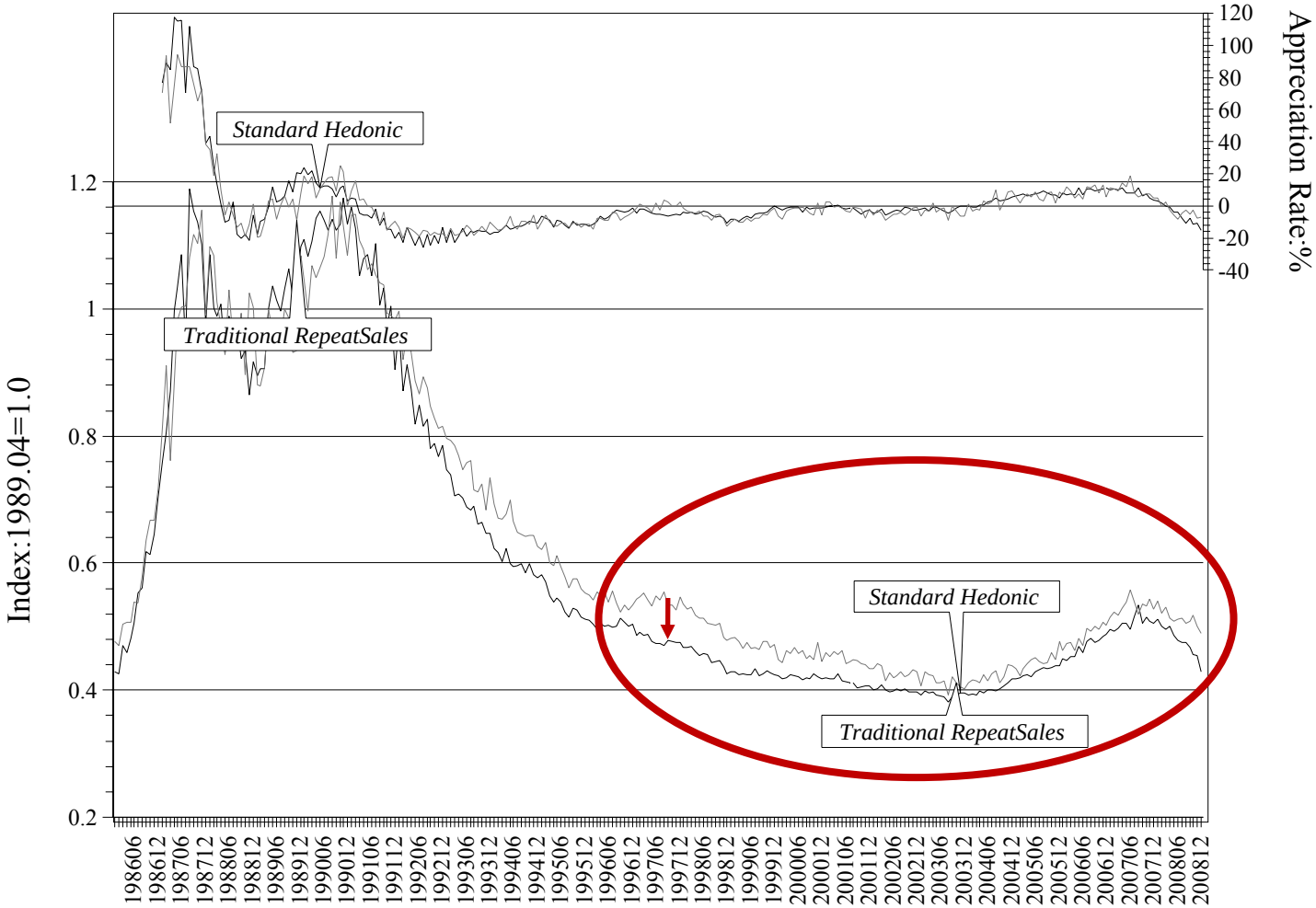


Figure1c. Traditional hedonic vs. Traditional Repeat Sales (Condominium rent)

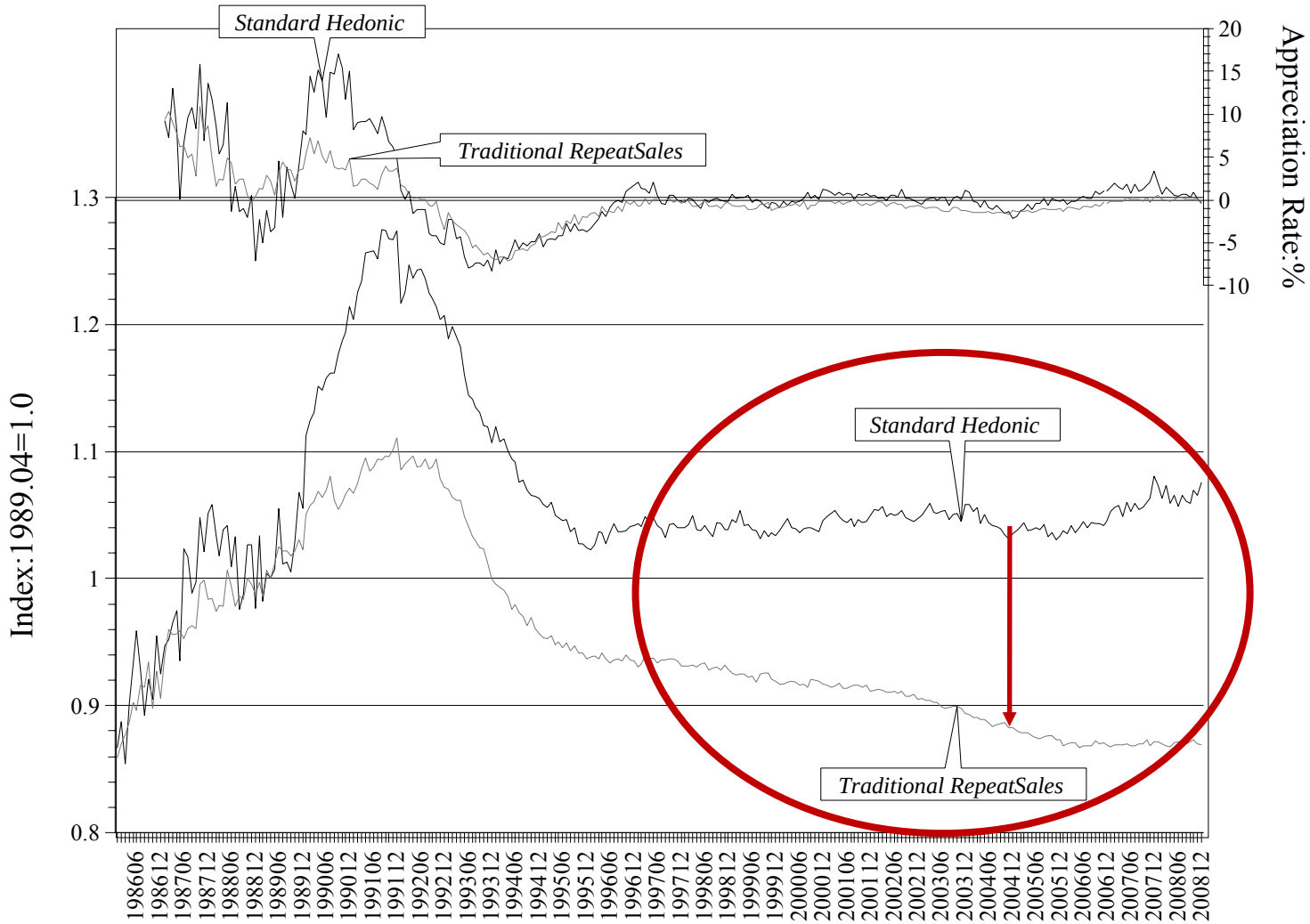


Table 4: Age adjustment to repeat sales measure

	standard error of reg.	adjusted R-square	S.B.I.C
(Condominium Price)			
Traditional_RS	0.1752	0.7494	**-20896.9**
Case&Shiller	0.1914	0.7587	**-13583.5**
Age-adjustment	0.0075	-	**-28817.2**
(Single Family House Price)			
Traditional_RS	0.2115	0.4756	**-2755.8**
Case&Shiller	0.2190	0.5093	**-1783.2**
Age-adjustment	0.0244	-	**-3574.8**
(Condominium Rent)			
Traditional_RS	0.0627	0.1385	**-190929.0**
Case&Shiller	0.0684	0.1454	**-176623.0**
Age-adjustment	-	-	-

	θ	λ
Condominium Price		
coef.	-0.0272	0.8944
s.e.	0.0015	0.0113
P-value	[.000]	[.000]
Single Family		
coef.	-0.0093	1.1041
s.e.	0.0031	0.0269
P-value	[.003]	[.000]

We cannot get the maximum value for the condominium rent data.

Figure2a.Case&Shiller adjustment *vs.* Age adjustment Repeat Sales (Condominium price)

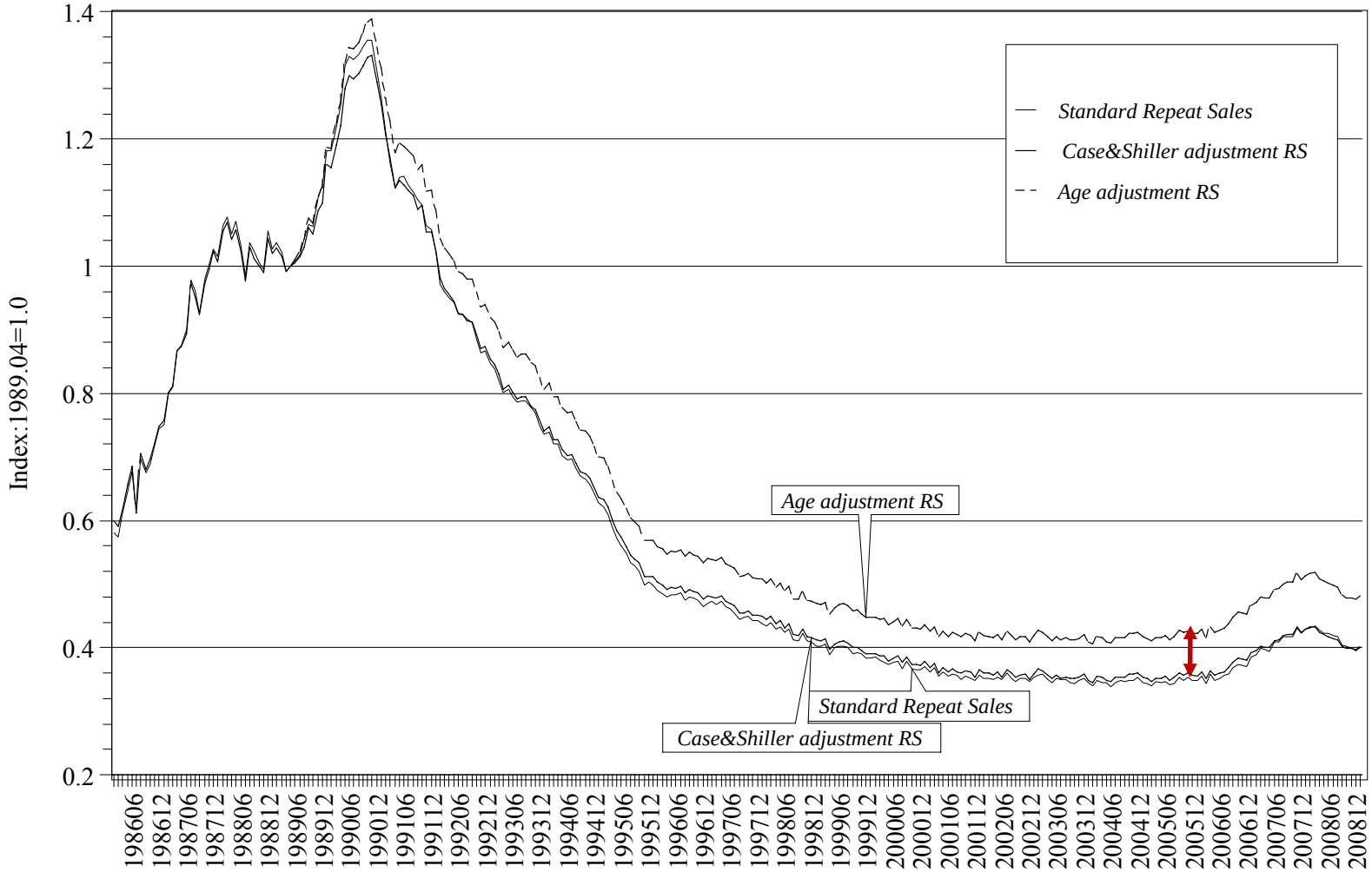


Figure2b.Case&Shiller adjustment *vs.* Age adjustment Repeat Sales (Single family house price)

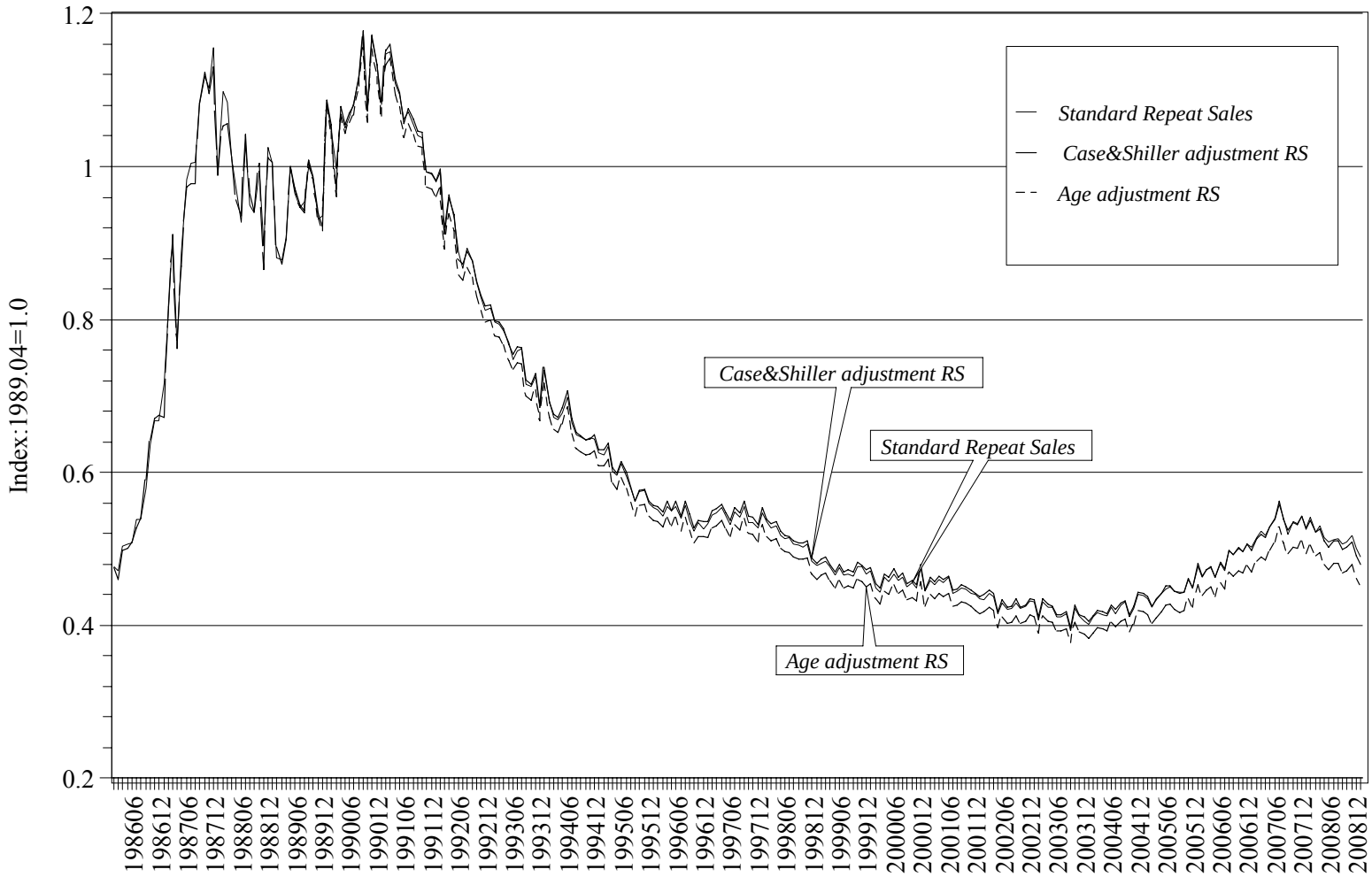


Figure2c.Case&Shiller adjustment (Condominium rent)

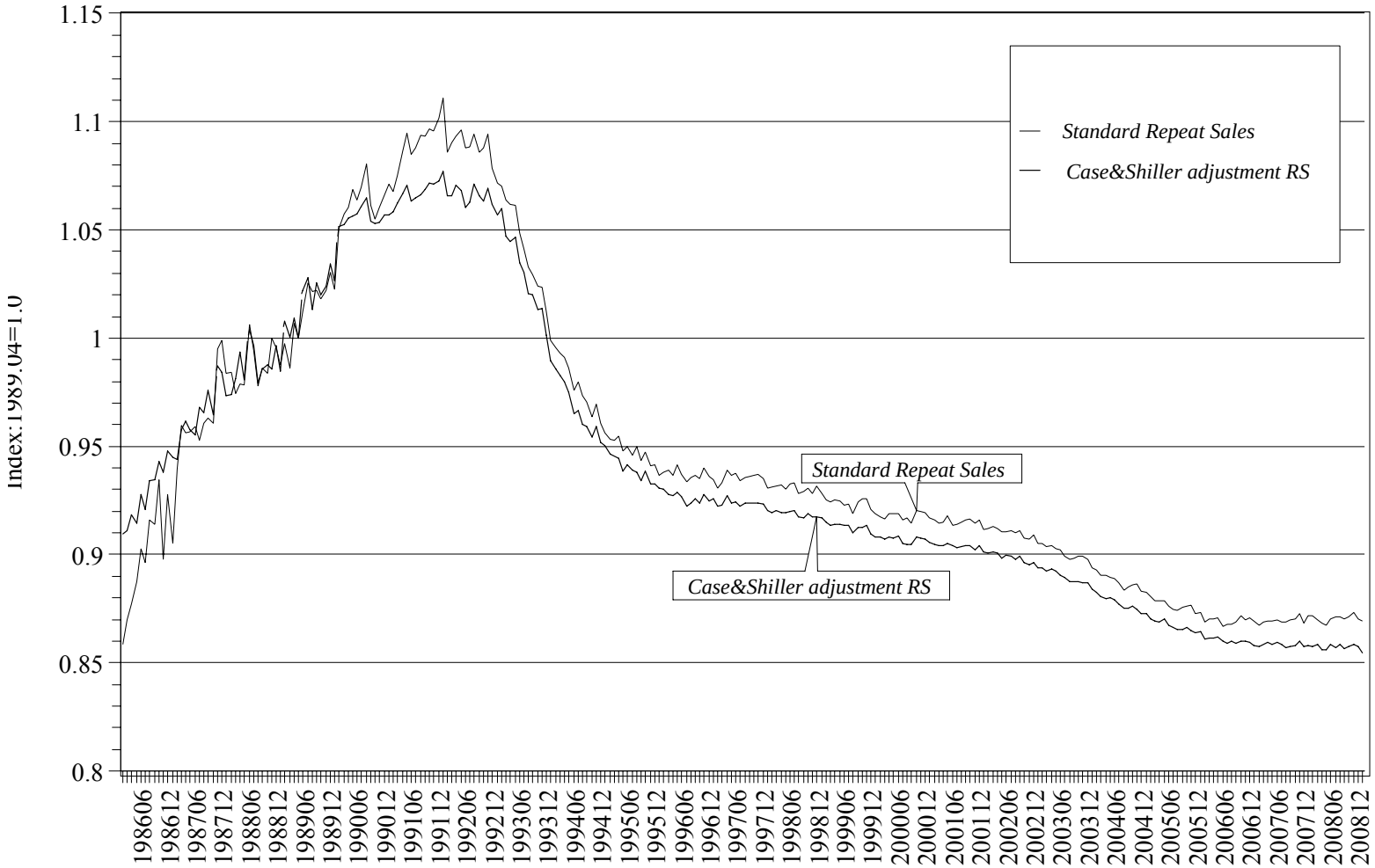


Table 5: Hedonic estimates of key parameters

	Constant	*FS* : Floor space	*Age* :Age of Building	*TS* : Time to the nearest station:	*TT* : Travel Time to Central Business District
Condonimium Price					
Standard Hedonic model	**4.470**	**0.029**	**-0.186**	**-0.069**	**-0.068**
12-months rolling regression					
Average	**4.852**	**0.047**	**-0.182**	**-0.072**	**-0.072**
Standard Deviation	0.629	0.078	0.029	0.010	0.031
Minimum	**4.193**	**-0.124**	**-0.237**	**-0.098**	**-0.130**
Maximum	**6.171**	**0.133**	**-0.108**	**-0.050**	**-0.022**
Single Family Price					
Standard Hedonic model	**4.615**	**0.002**	**-0.011**	**-0.013**	**-0.009**
12-months rolling regression					
Average	**4.912**	**0.002**	**-0.012**	**-0.013**	**-0.009**
Standard Deviation	0.261	0.001	0.001	0.002	0.002
Minimum	**4.596**	**0.0006004**	**-0.015**	**-0.019**	**-0.012**
Maximum	**5.425**	**0.0032335**	**-0.009**	**-0.009**	**-0.004**
Condonimium Rent					
Standard Hedonic model	**8.951**	**-0.191**	**-0.037**	**-0.052**	**-0.077**
12-months rolling regression					
Average	**9.132**	**-0.178**	**-0.042**	**-0.059**	**-0.081**
Standard Deviation	0.117	0.037	0.015	0.016	0.014
Minimum	**8.884**	**-0.224**	**-0.071**	**-0.090**	**-0.111**
Maximum	**9.312**	**-0.092**	**-0.018**	**-0.028**	**-0.054**

number of models= 265

Figure3a. Traditional hedonic *vs.* 12-months rolling regression (OPHM): Condominium price

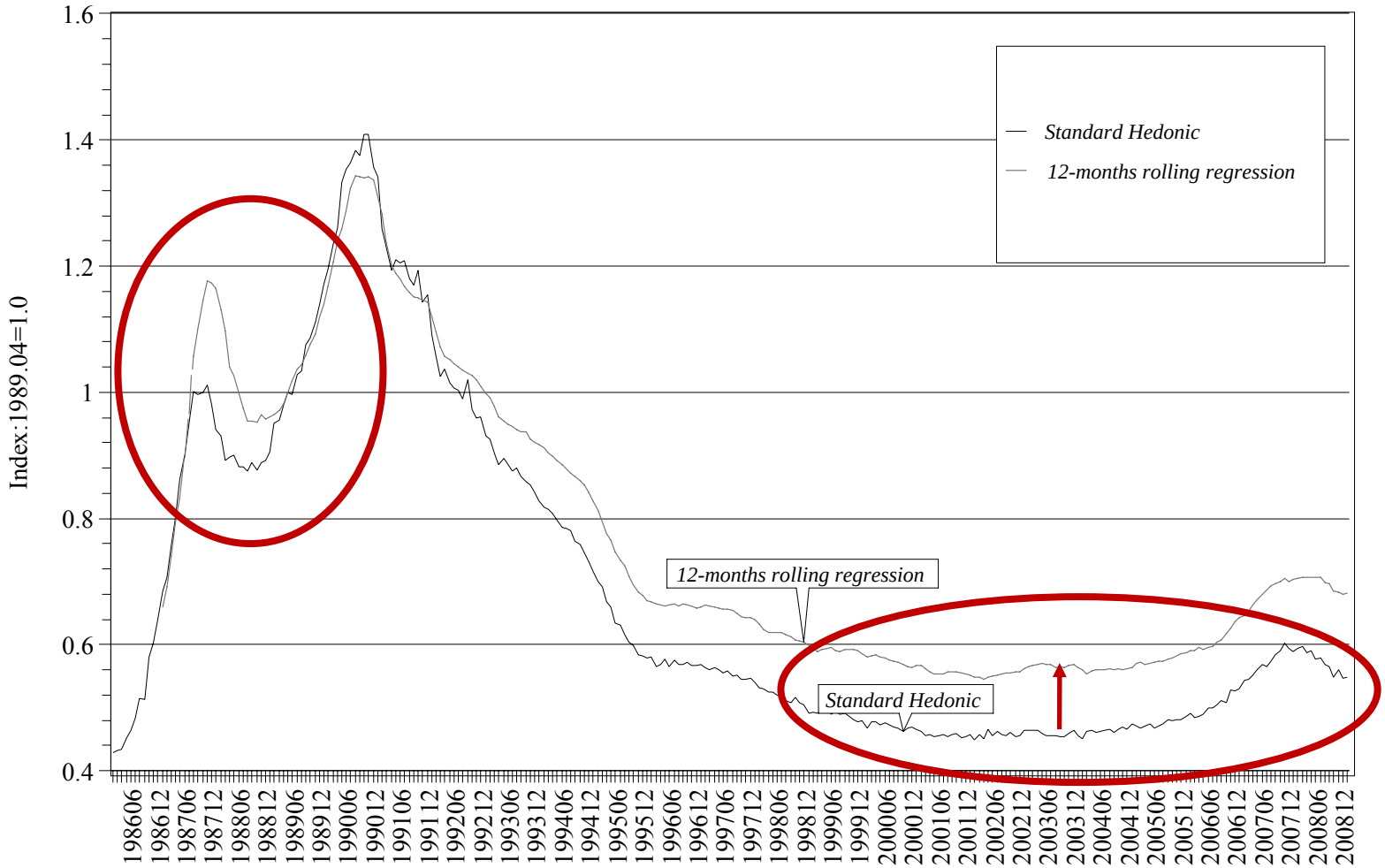


Figure3b. Traditional hedonic *vs.* 12-months rolling regression (OPHM): Single family house price

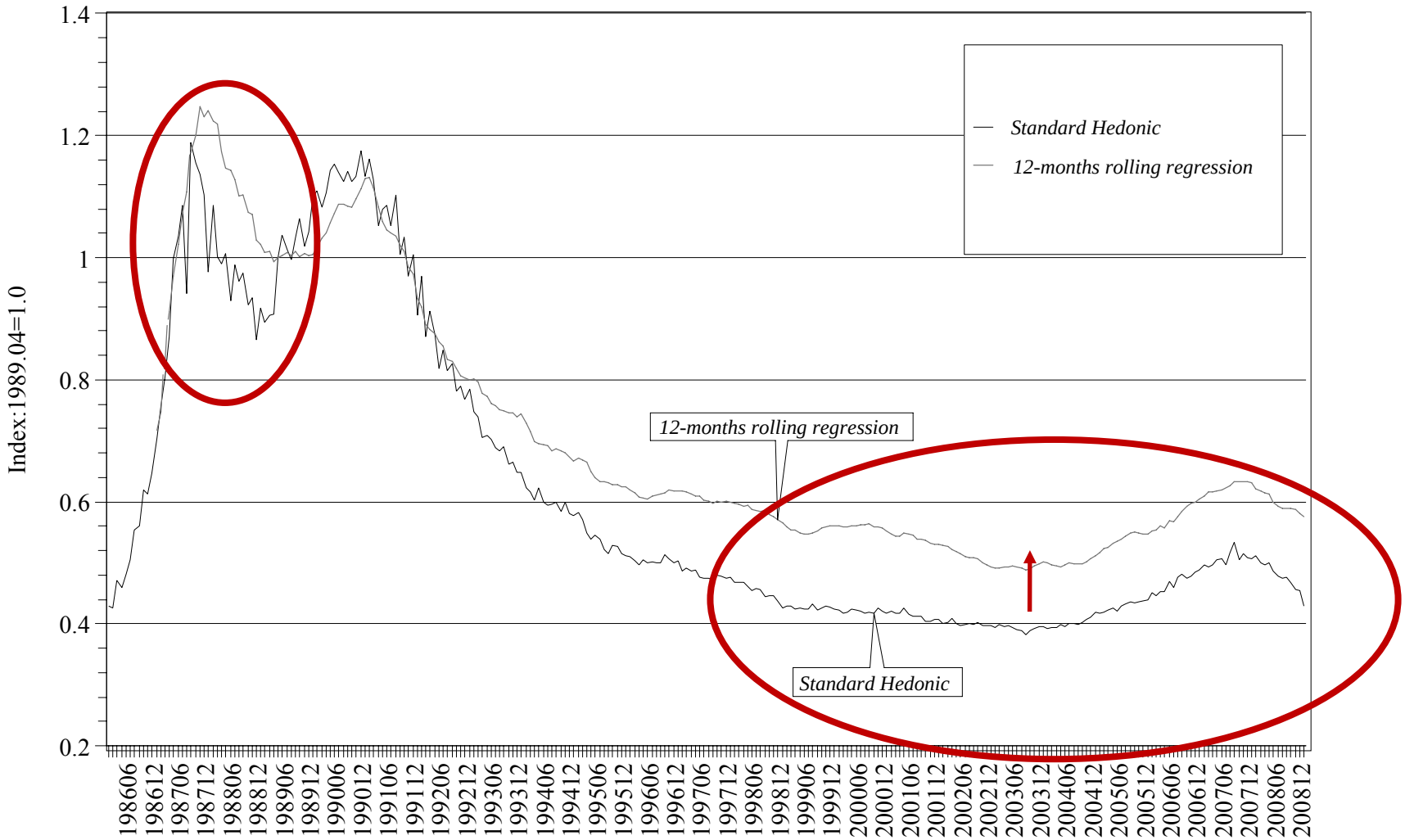
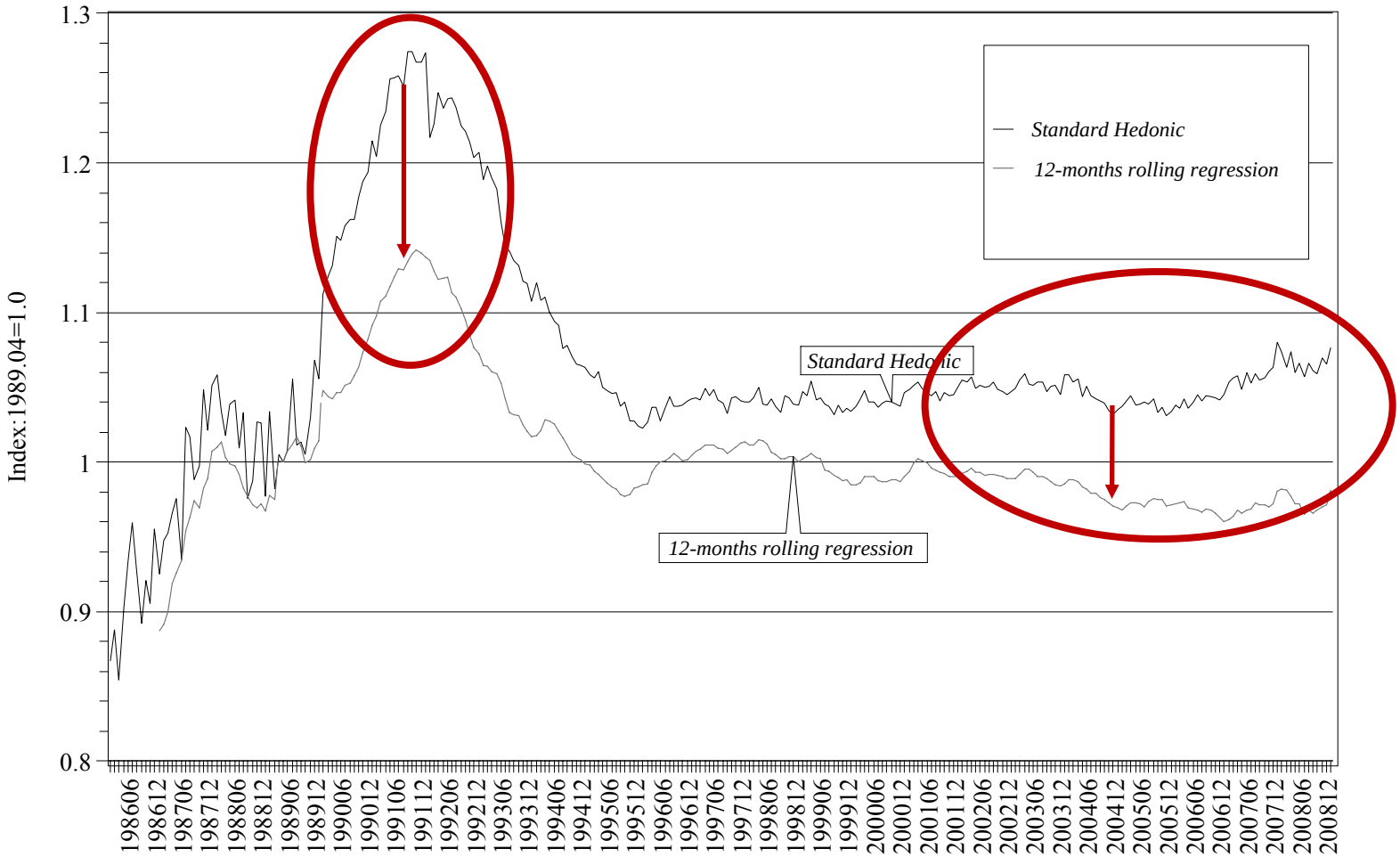
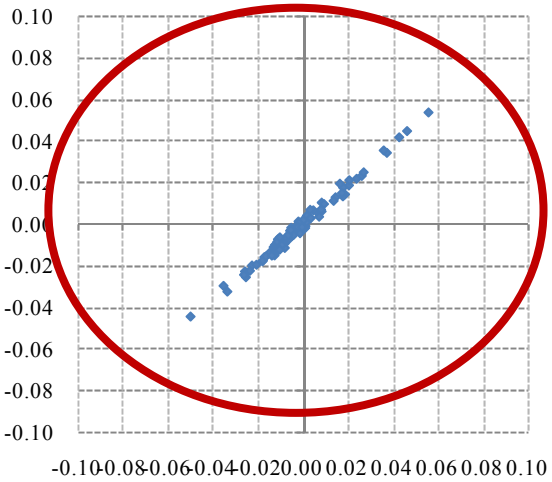


Figure3c. Traditional hedonic *vs.* 12-months rolling regression (OPHM): Condominium rent

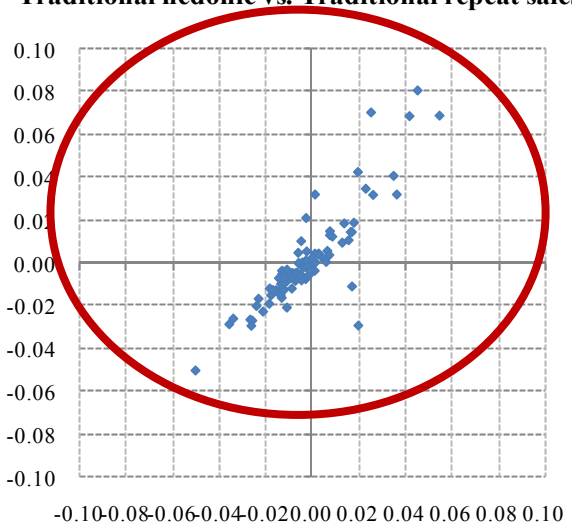


4.4 How much can the difference be reconciled?

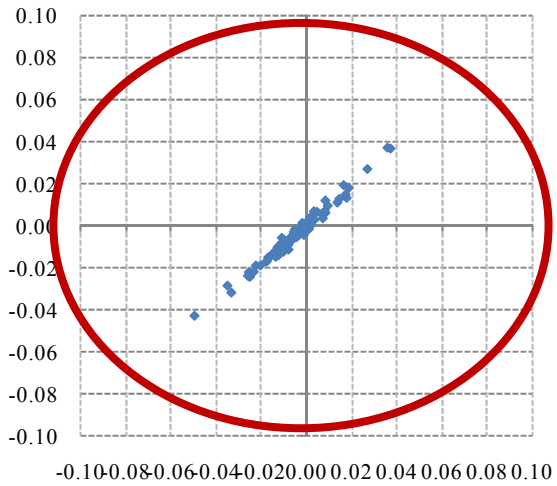
Case-Shiller vs. Traditional repeat sales



Traditional hedonic vs. Traditional repeat sales



Age-adjusted repeat sales vs. Traditional repeat sales



Rolling hedonic vs. Traditional repeat sales

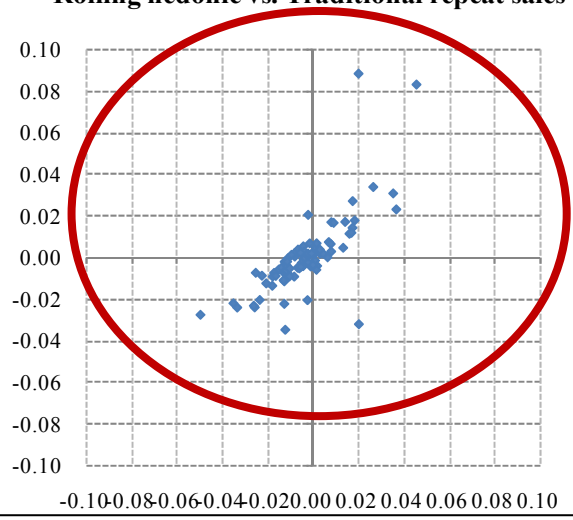


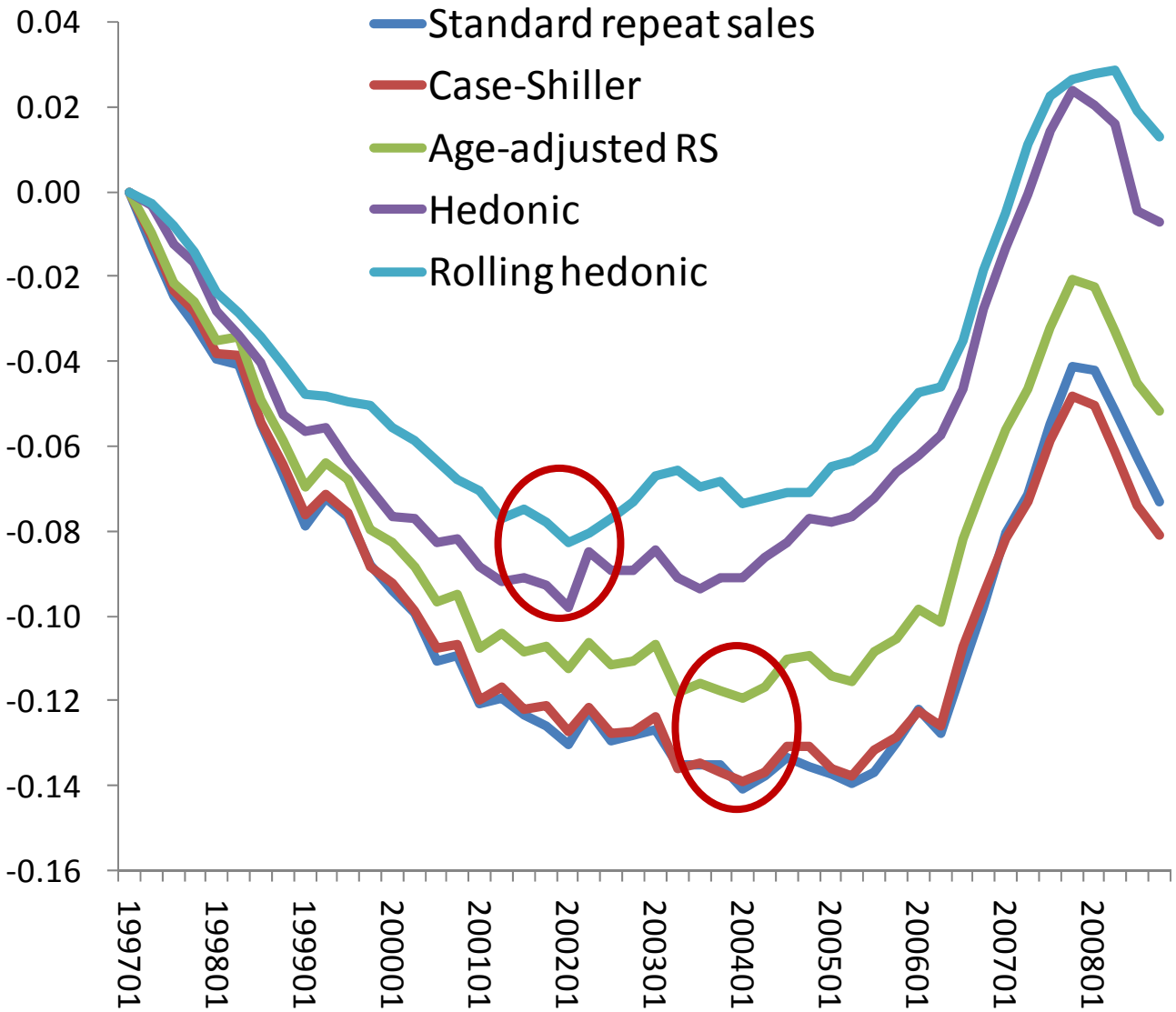
Table 6: Pairwise Granger-causality tests

Condominium	Standard repeat sales	Case-Shiller repeat sales	Age-adjusted Repeat sales	Standard hedonic	Rolling hedonic
Standard repeat sales		0.0120	0.0019	0.0037	0.0000
Case-Shiller RS	0.2018		n.a.	0.0411	0.0000
Age-adjusted RS	0.0568	n.a.		0.1067	0.0000
Standard hedonic	0.0005	0.0001	0.0000		0.0000
Rolling hedonic	0.0067	0.0095	0.0025	0.2209	

Single family house	Standard repeat sales	Case-Shiller repeat sales	Age-adjusted Repeat sales	Standard hedonic	Rolling hedonic
Standard repeat sales		0.2726	0.4345	0.2119	0.0040
Case-Shiller RS	0.2397		n.a.	0.1714	0.0098
Age-adjusted RS	0.3275	n.a.		0.1622	0.0078
Standard hedonic	0.0028	0.0025	0.0023		0.0018
Rolling hedonic	0.0705	0.0642	0.0709	0.1642	

Note: The number in each cell represents the p-value associated with the null hypothesis that the variable on the column does not Granger-cause the variable on the row. Cells shaded by blue color indicate that the p-value is smaller than 0.01, and thus the null hypothesis is rejected.

Figure 5: When did the condominium price hit bottom?



5.Conclusions:

- **Which one performs better, the repeat-sales measure or the hedonic measure?**
- We find that there remains a ***substantial discrepancy*** between **the repeat sales measure and the hedonic measure**, even though we have made various adjustments to both indexes.
- Especially, we find a substantial discrepancy in terms of turning points**: the repeat sales measure tends to exhibit a delayed turn compared with the hedonic measure**.
  - For example, the hedonic measure of condominium prices hit bottom at **the beginning of 2002**, while the corresponding repeat-sales measure exhibits reversal only in **the spring of 2004**.
  - The lead-lag relationships between the two indices may come from ***the omitted variable problem*** in **the hedonic measure** and/or the problem of ***non-random sampling*** in **the repeat sales measure**.

2009 Ottawa Group Meeting in Neuchâtel, Switzerland, 27-29 May 2009

House Price and House Rent in Tokyo

- Additional version-

Chihiro Shimizu(Reitaku University)
Kiyohiko.G.Nishimura(Bank of Japan)
Tsutomu Watanabe(Hitotsubashi University)

1.Data-
RECRUIT Data Base-週刊住宅情報-
“Housing Information Weekly”

り，2沿線以上利用可，閑静な住宅地

※画像をクリックすると拡大されます。

物件概要

価格	7680万円 ▸支払いシミュレーション
専有面積	96.05m²
バルコニー面積	10m²
間取り	3LDK
完成時期	1998年10月
交通	東急田園都市線『二子玉川』徒歩11分 東急大井町線『上野毛』徒歩6分 ▸乗り換え案内
所在地	東京都世田谷区上野毛2 ▸周辺環境を見る
物件特徴	2wayキッチン テラス 玄関ポーチ 南向き
関連リンク	【会社サイト】 ▸会社ホームページ

管理費等	2万1200円/月	修繕積立金	9600円/月
管理	日勤	構造/総戸数	RC / 29戸
階/階建	2階/6階建	リフォーム	
向き	南西	敷地権利	所有権
駐車場	無		
特記事項	施工清水建設株式会社　担当/堀越　用途地域/一種中高層		

Recruit Co. Ltd

Major real estate agent companies

Landlords

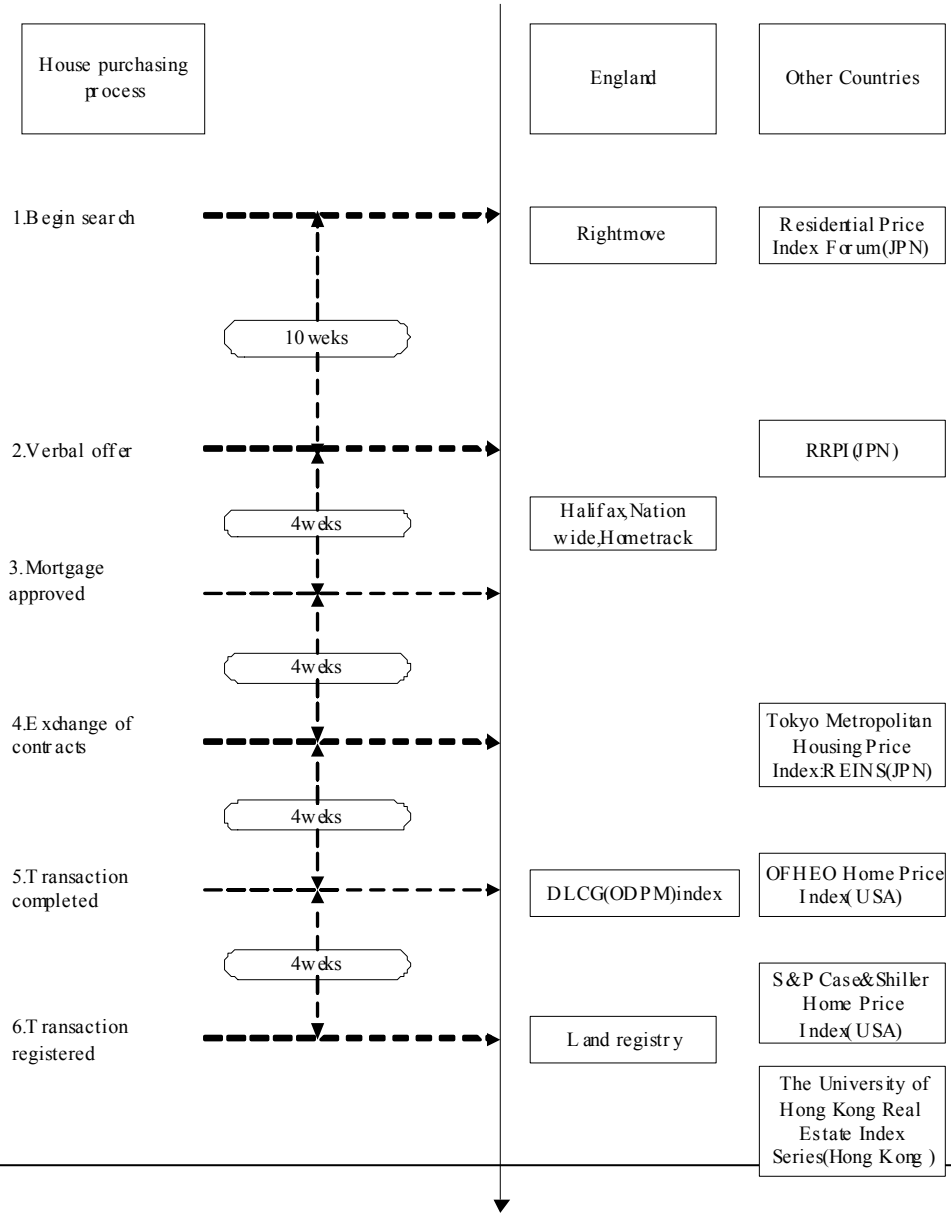
reported

First Week

Successful Sale

Last listed

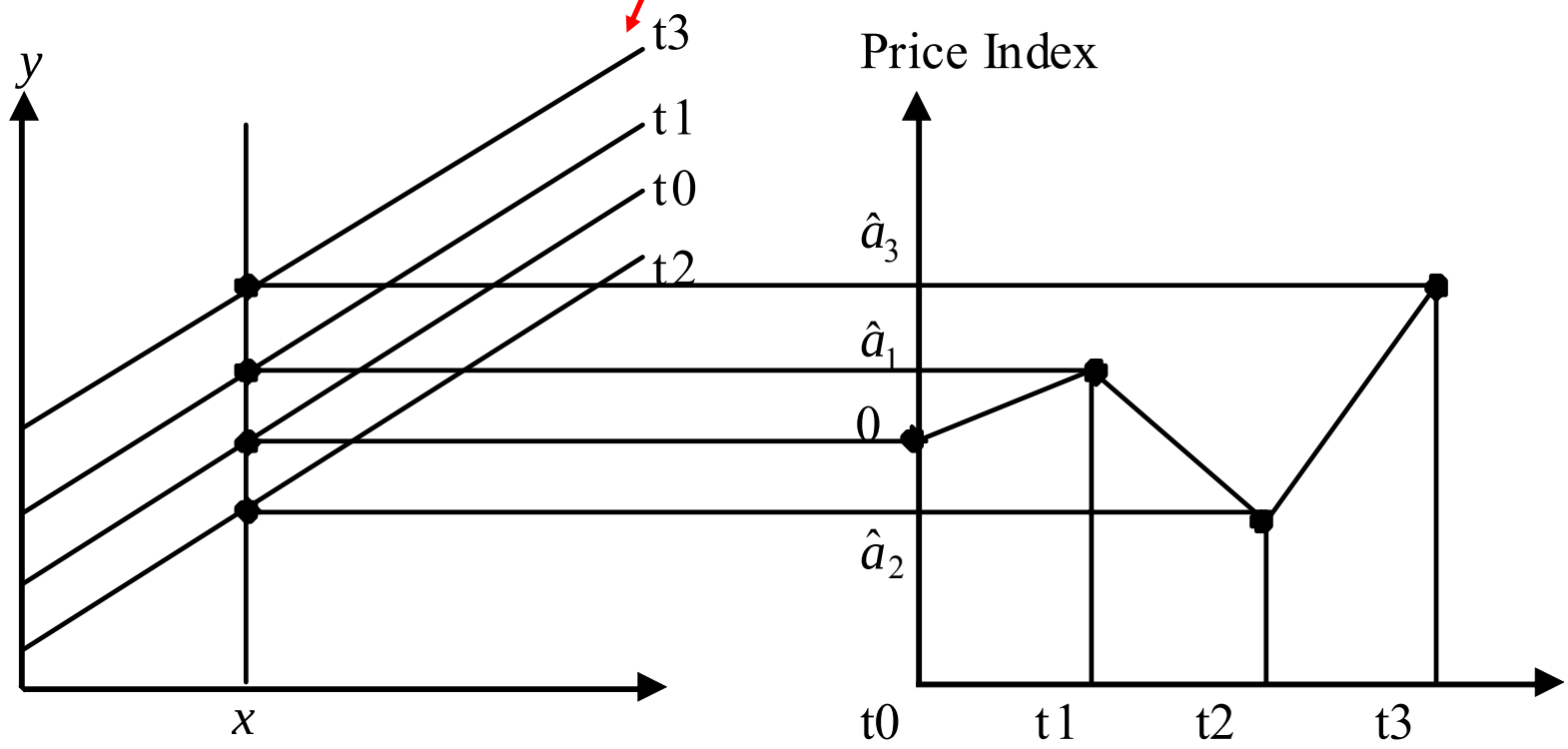
Time Line of Housing Data



Source : BOE(2003)

2.Hedonic Models;
Structurally restricted hedonic housing price index: RHI

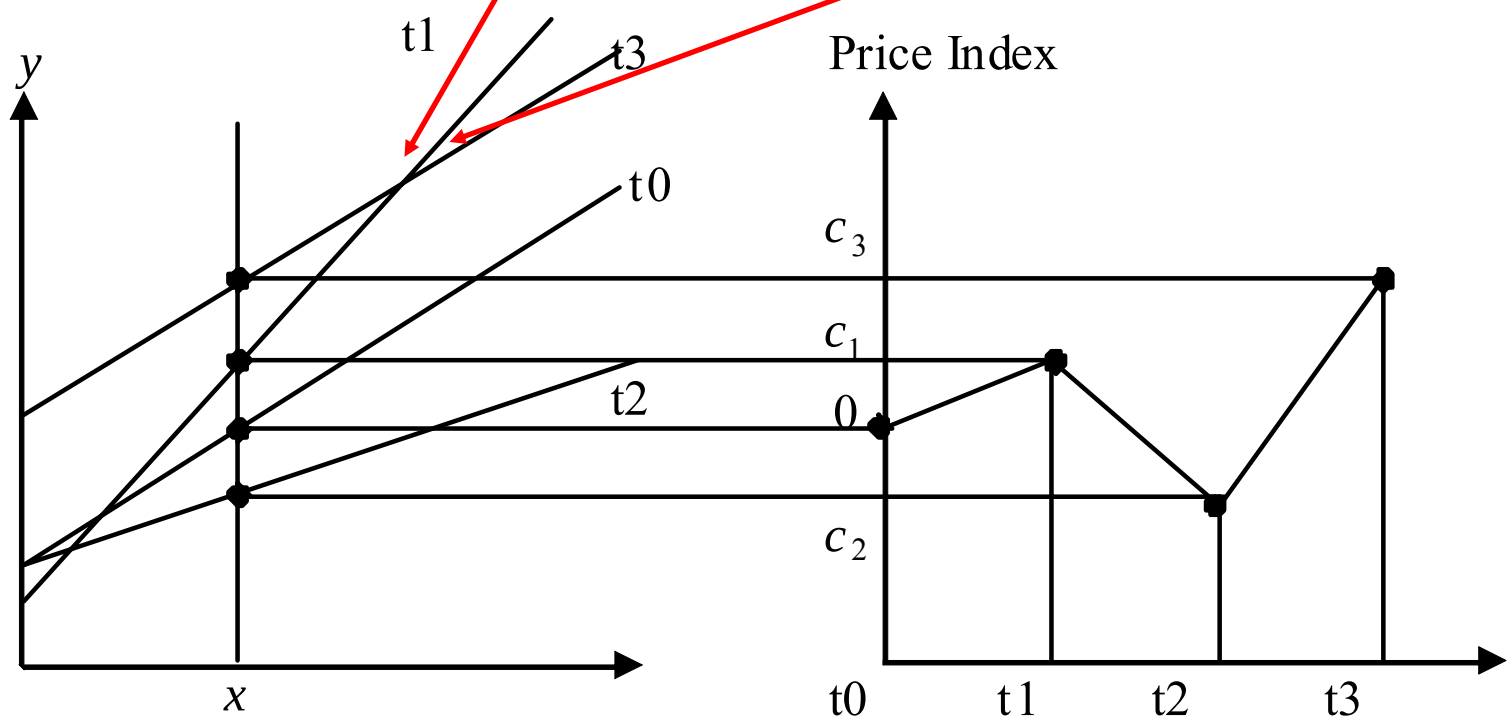
$$\ln P_{it} = \sum_{k=1}^{K} \beta_k X_{ikt} + \sum_{s=1}^{\tau} \delta_s D_s + \varepsilon_{it}$$



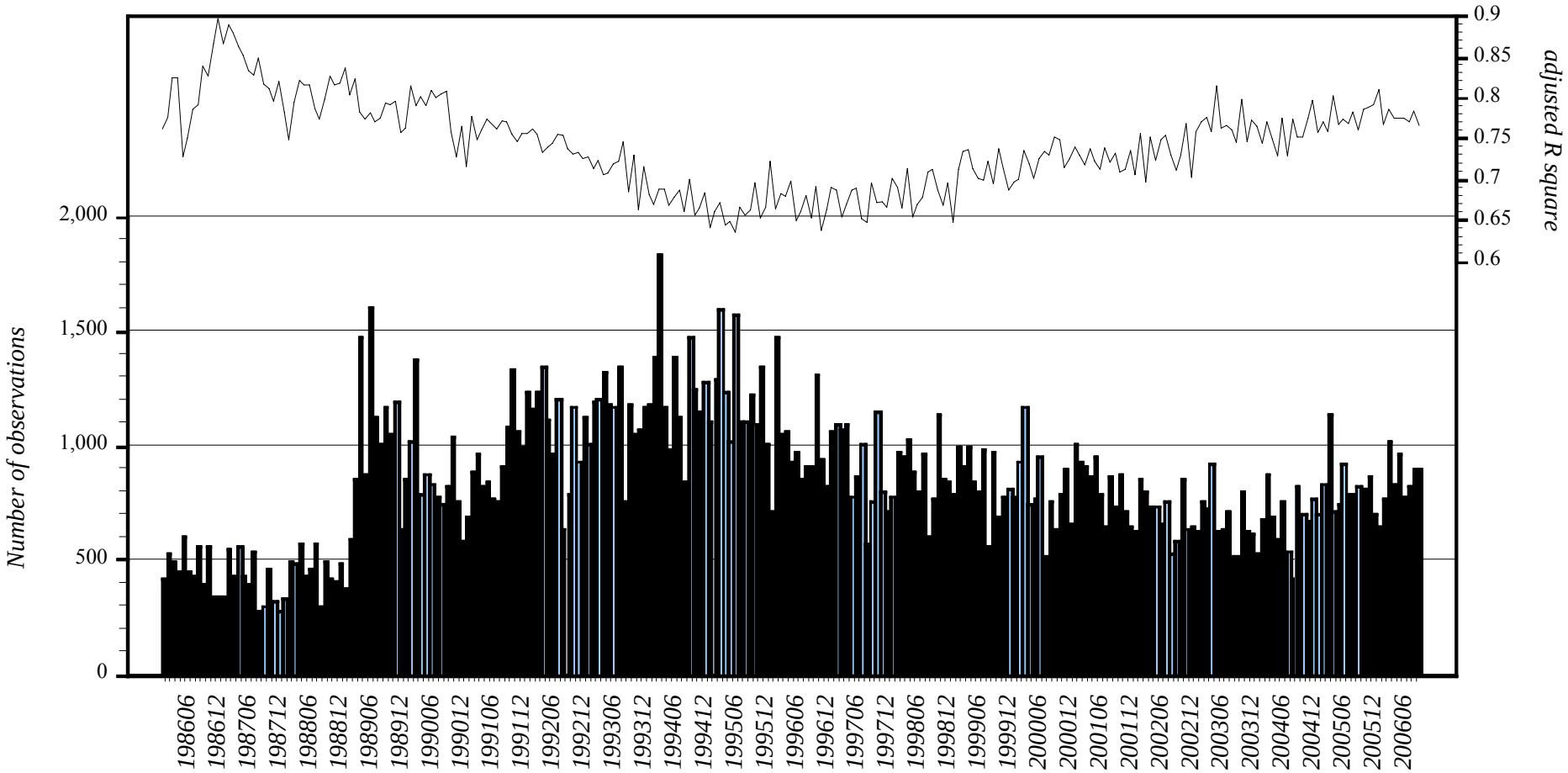
Structurally unrestricted hedonic housing price index

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

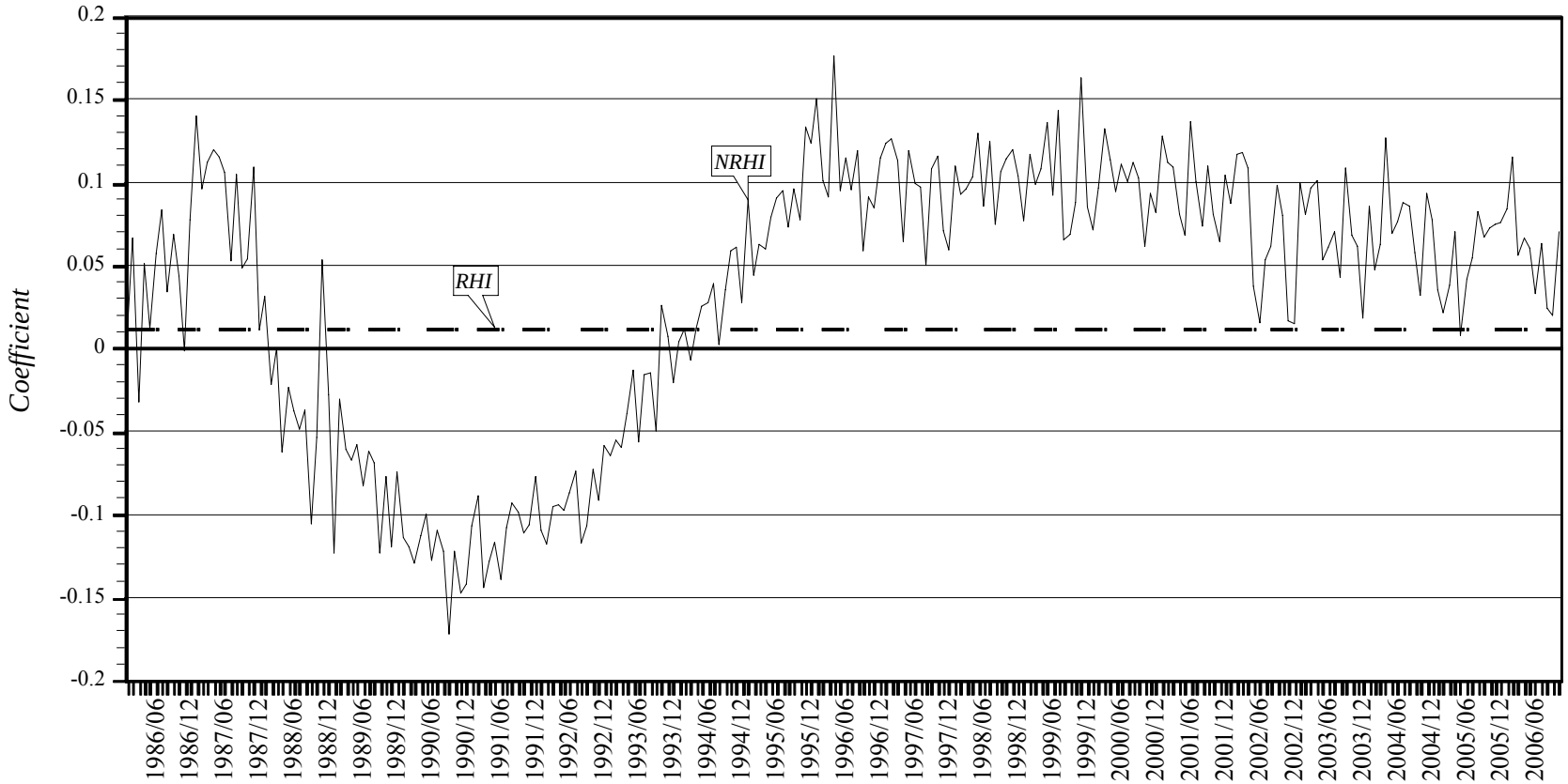
$$\ln(\hat{P}_t / \hat{P}_{t-1}) = \sum_{k=1}^{K} (\hat{\beta}_{kt} - \hat{\beta}_{k,t-1}) X_k + (\hat{\delta}_t - \hat{\delta}_{t-1})$$



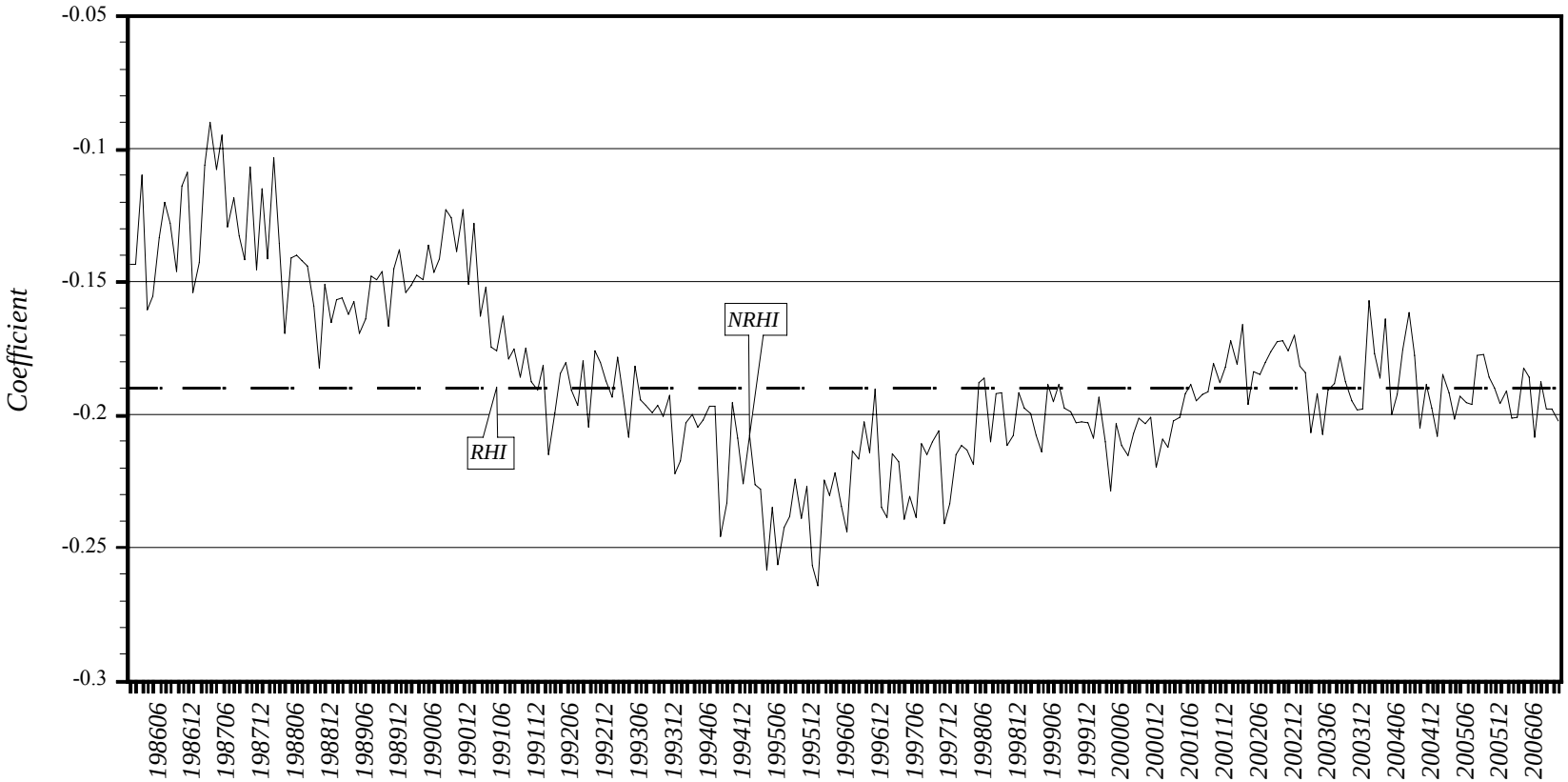
Estimation accuracy of the URHM



Time profile of regression coefficient of the URHM, Floor Space



Time profile of regression coefficient of the URHM, age of building

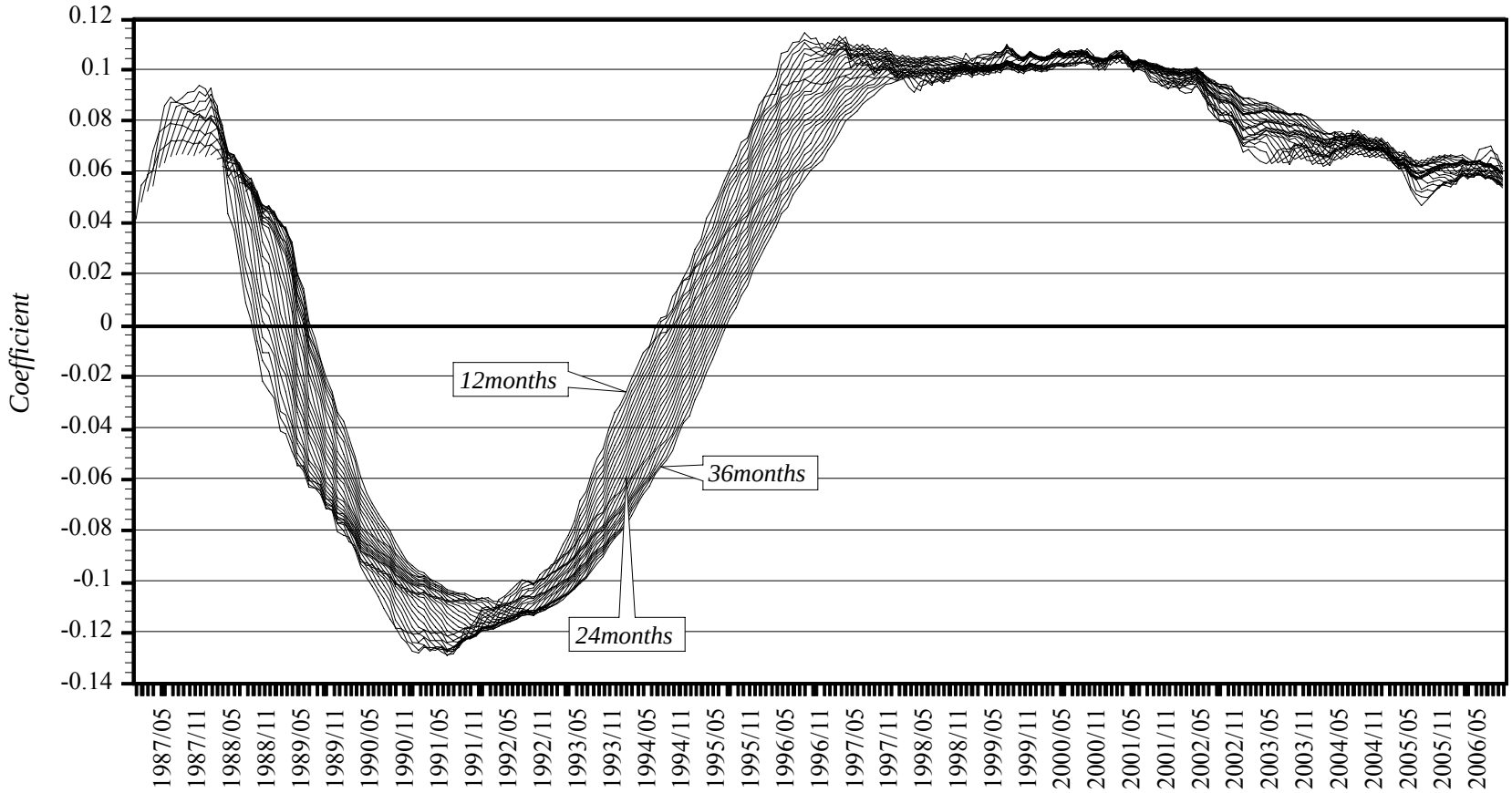


Overlapping Period Hedonic Method :Rolling Regression

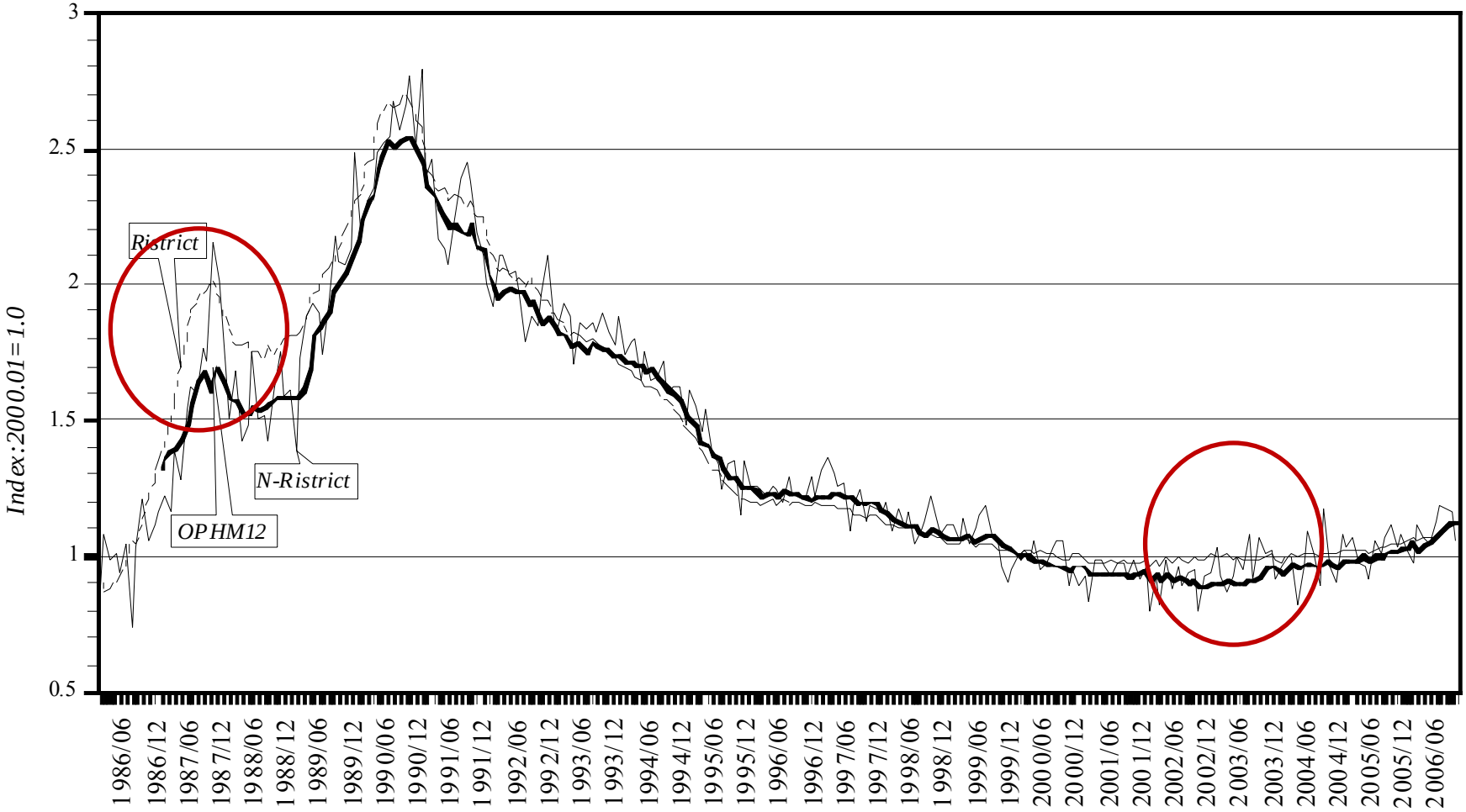
$$\ln P_{it} = \sum_{k=1}^{K} \beta_k X_{ikt} + \sum_{s=1}^{\tau} \delta_s D_s + \varepsilon_{it}$$

OPHM is obtained by applying the above restricted hedonic model to periods $[1, \tau]$, $[2, \tau + 1]$, …, $[r, r + \tau - 1]$, …,$[T - \tau + 1, T]$ successively.

Changing in time of OPHM coefficient : Floor Space



RHI,URHI and OPHM12 in Condominium Price



3.Ommited variables bias; in Shimizu(2009).

$$\log DP/GA = a_0 + \sum_h a_{1h} X_h + \sum_i a_{2i} Z_i + \sum_j a_{3j} \cdot LD_j + \sum_k a_{4k} \cdot RD_k$$

$$+ \sum_l a_{5l} \cdot TD_l + \sum_m a_{6m} \log V_m + \sum_{h,m} a_{7h,m} X_h \cdot V_m + a_8 u + a_9 v + \varepsilon$$

V_n :Neighborhood Effect Variables

- V_1 : *FR* / Floor Area Ratio/FAR per 500m mesh
- V_2 : *LR* / Lot Area Ratio/LAR per 500m mesh
- V_3 : *ZD* / Zoning Dummy
- V_4 : *LU* / Land Use Condition per 500m mesh
- V_5 : *HC* / Household Characteristics per 500m mesh
- V_6 : *NOi* / Noise per property

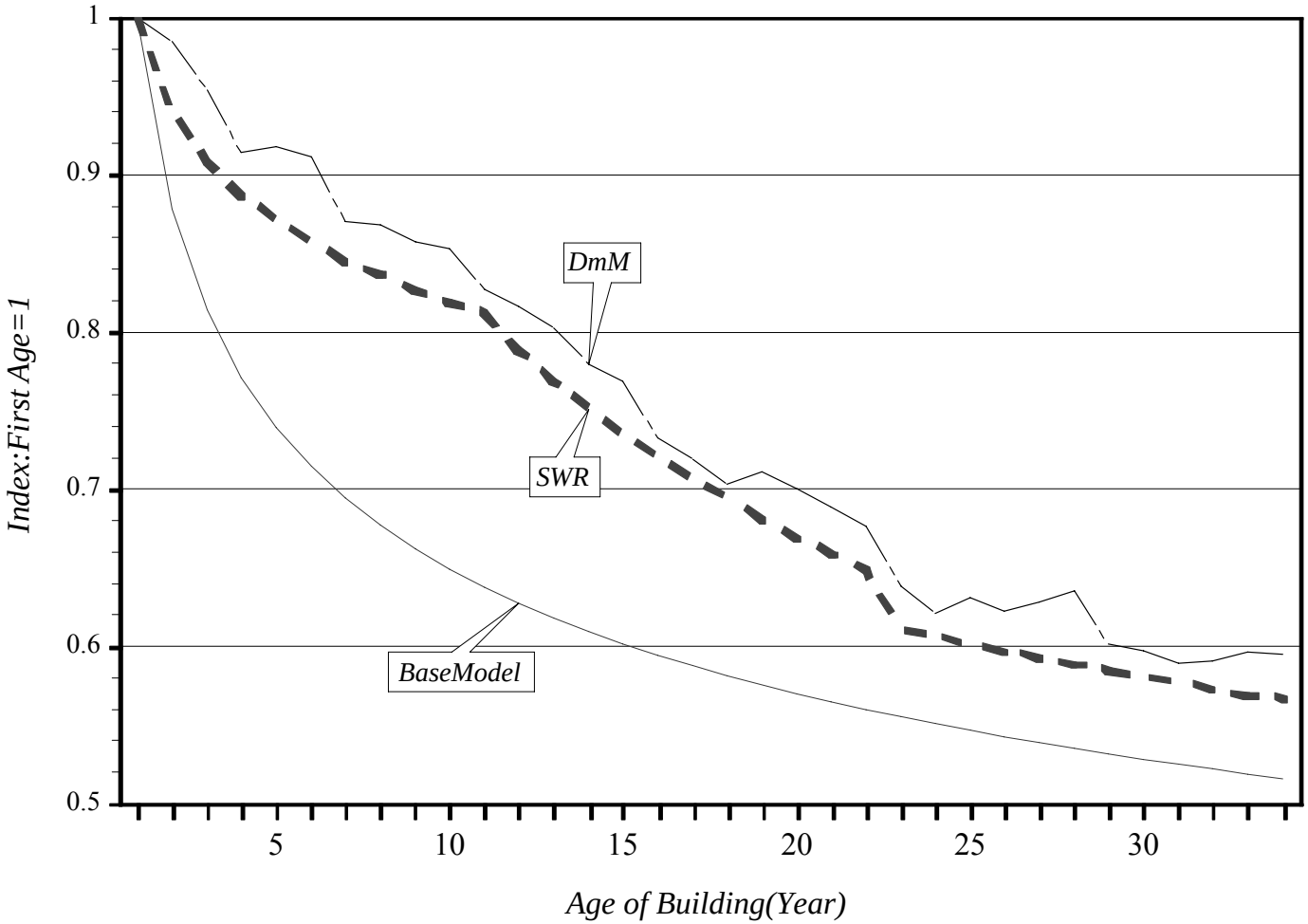
u,v :Longitude,latitude

In UK , Nationwide uses ACORN Classification

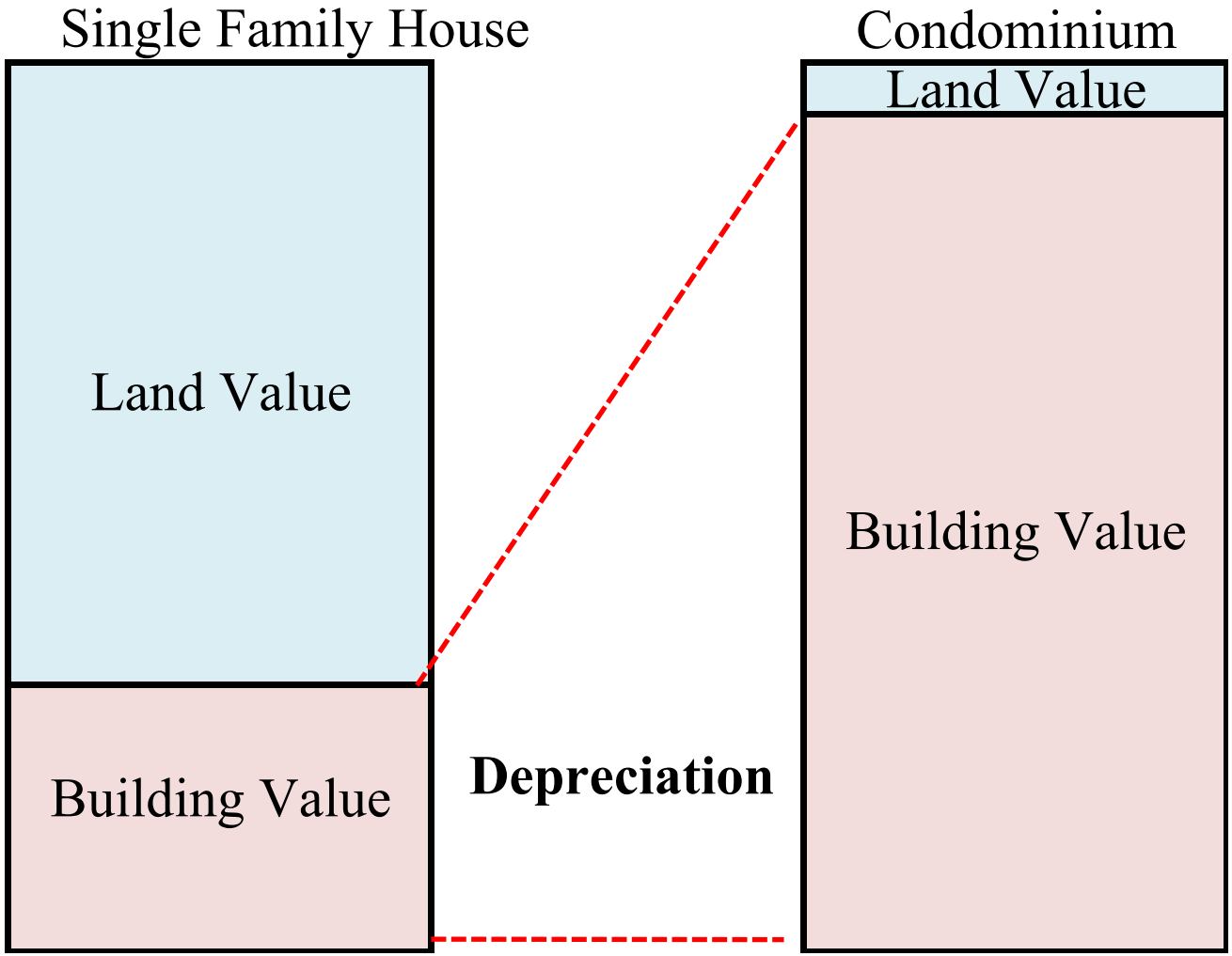
Considering Neighborhood Effects in Hedonic Model

- ***Hedonic estimates of Single family house price:***
- ***Road Width*:**
- Simple Model (0.017) / Expanded Model (0.010);
- ***Time to nearest stations*:**
- Simple Model (-0.009) / Expanded Model (-0.007);
- ***Bus dummy*:**
- Simple Model (-0.141) / Expanded Model (-0.134);
- ***Time to terminal station*:**
- Simple Model (-0.011) / Expanded Model (-0.007); and
- ***Age of building*:**
- Simple Model (-0.011) / Expanded Model (-0.009).

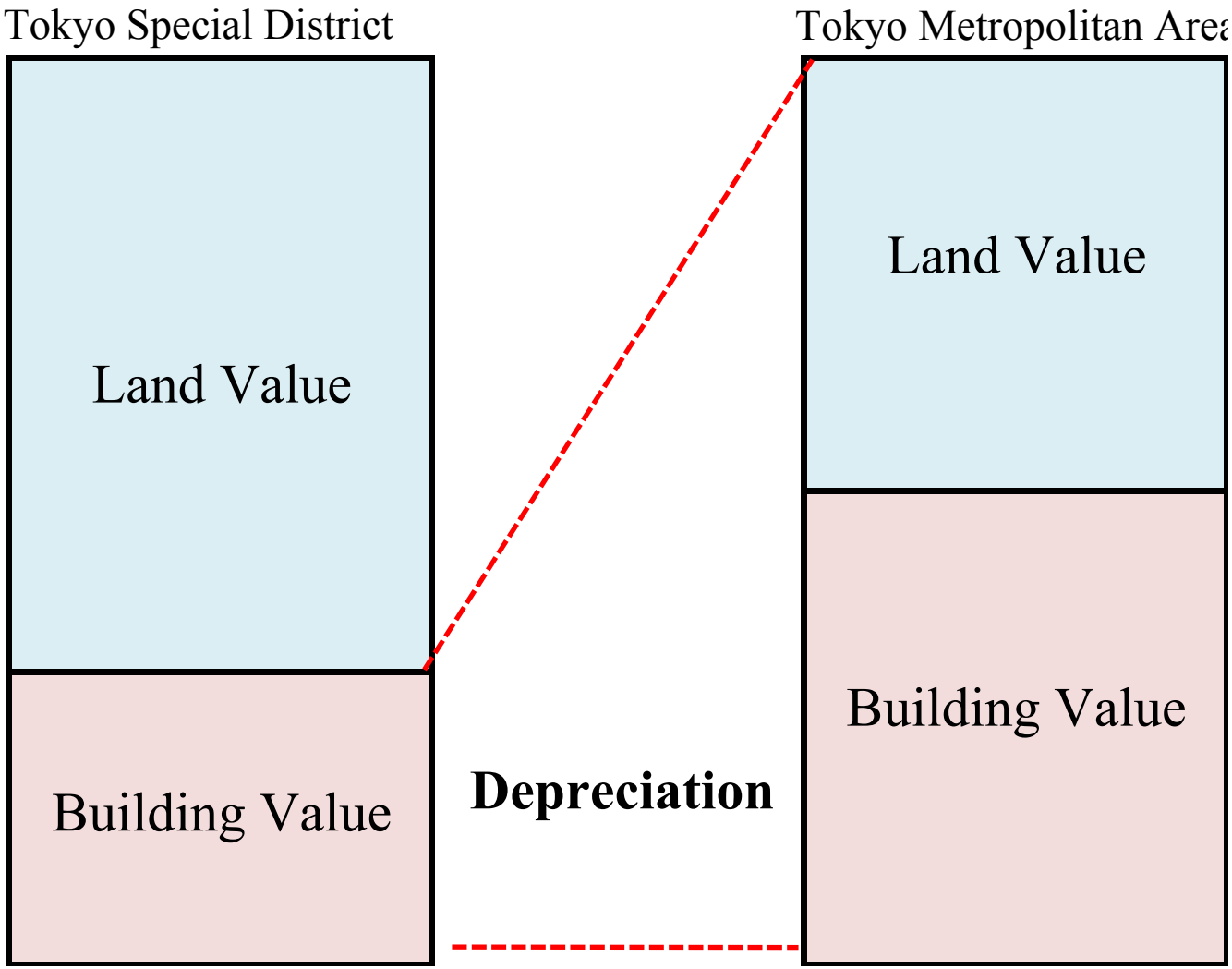
4. Age Effect in Japan; in Shimizu, Nishimura and Karato(2007).



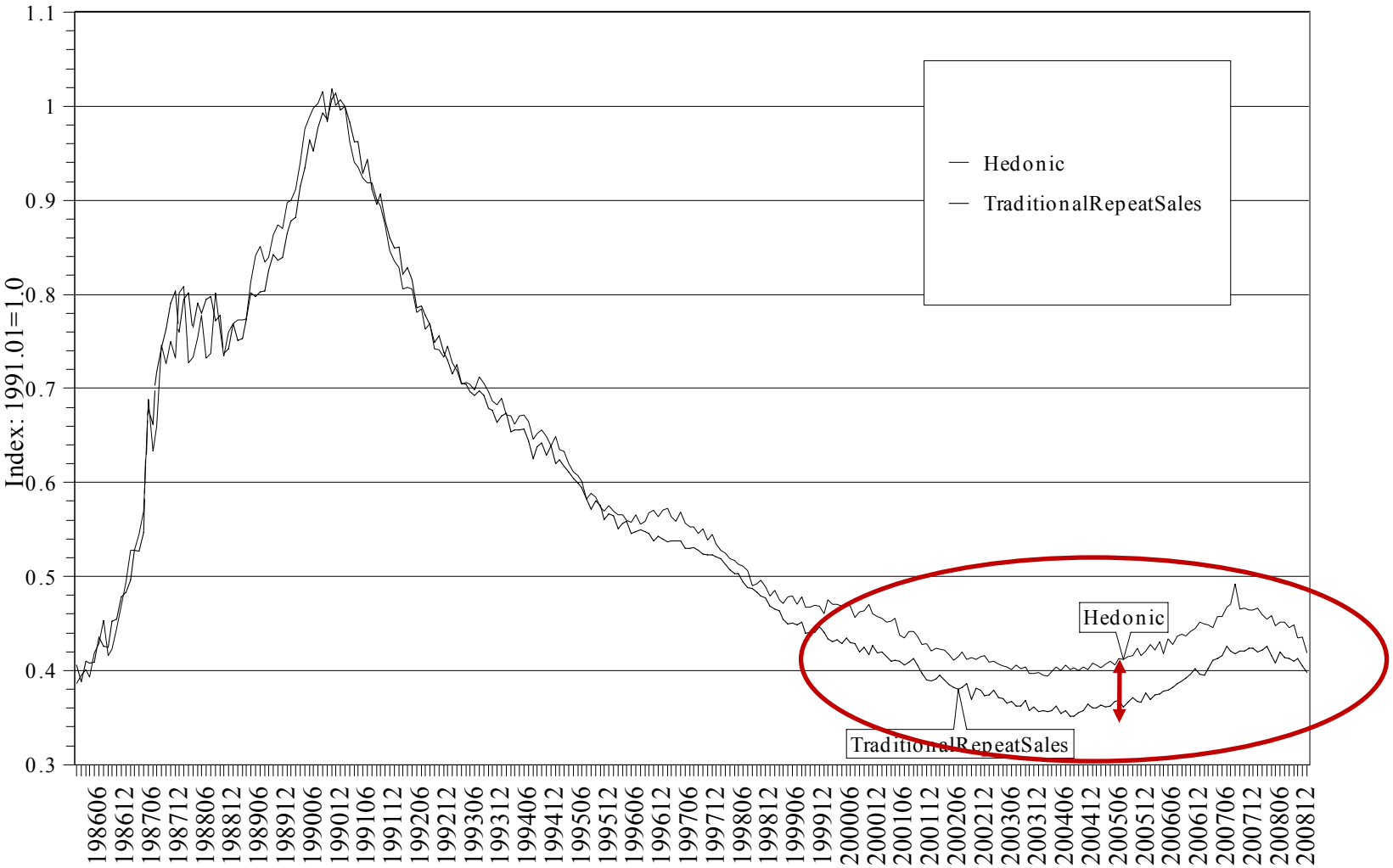
5.Why is Age effect of Condominium bigger than that of single family house price?



5.Why is Age effect of Condominium bigger than that of single family house price?

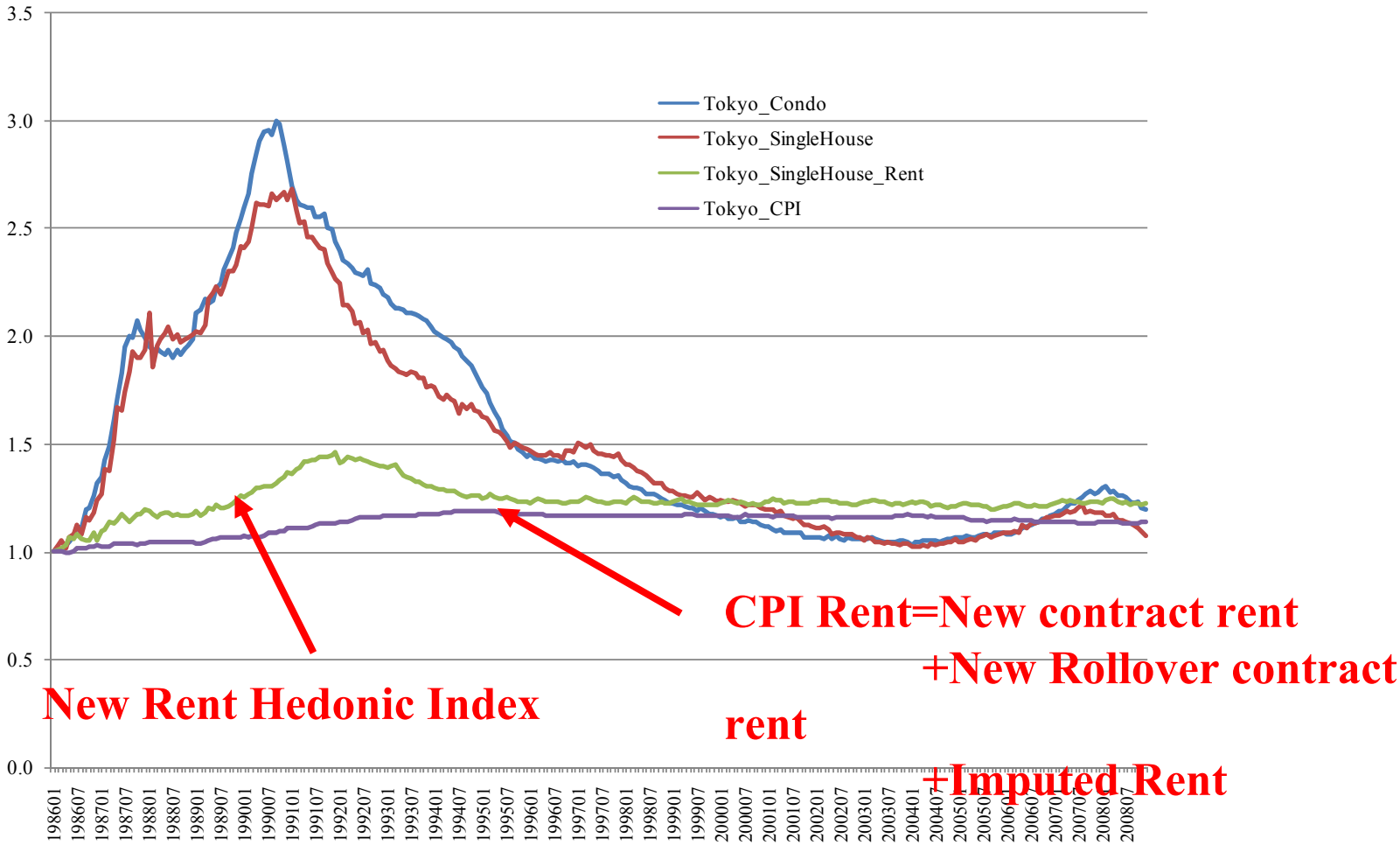


Single Family House Price Index : Tokyo Metro

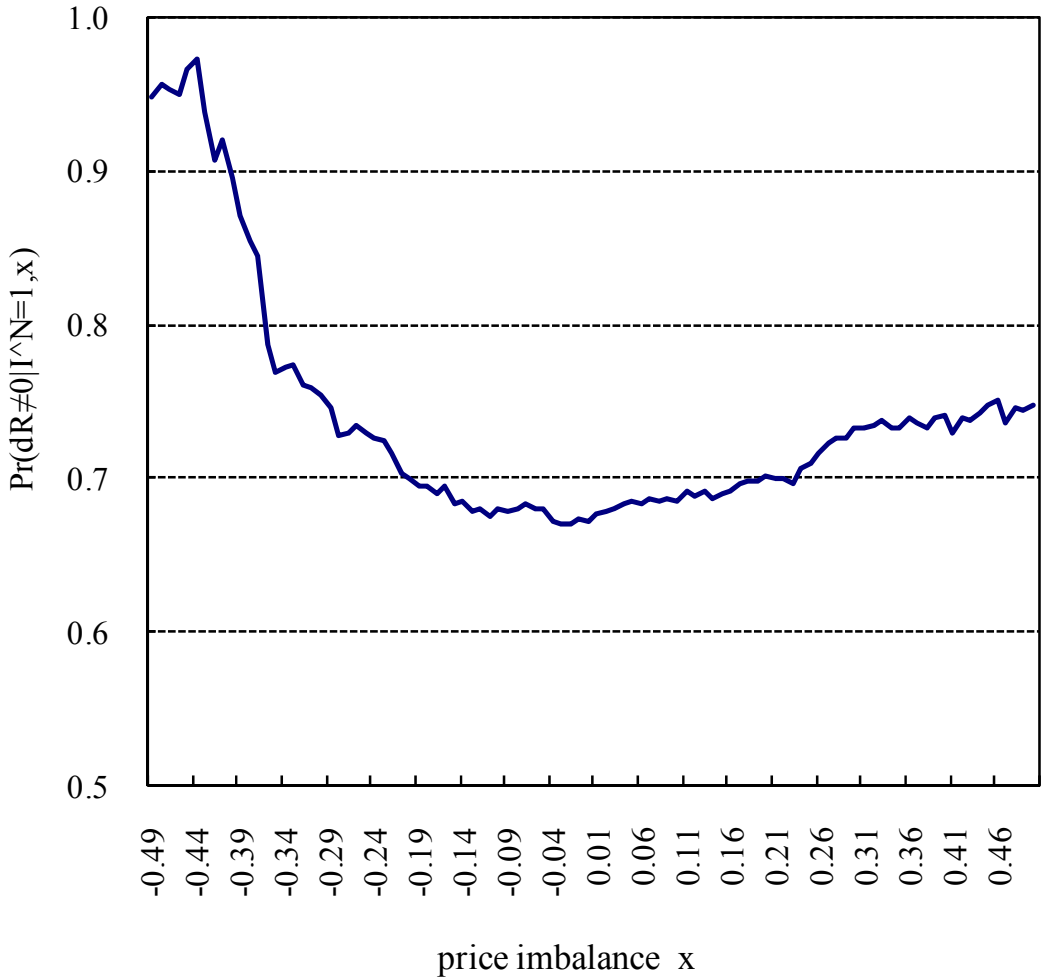


6.House Price and House Rent:

Comparison House Price and CPI-house in Tokyo

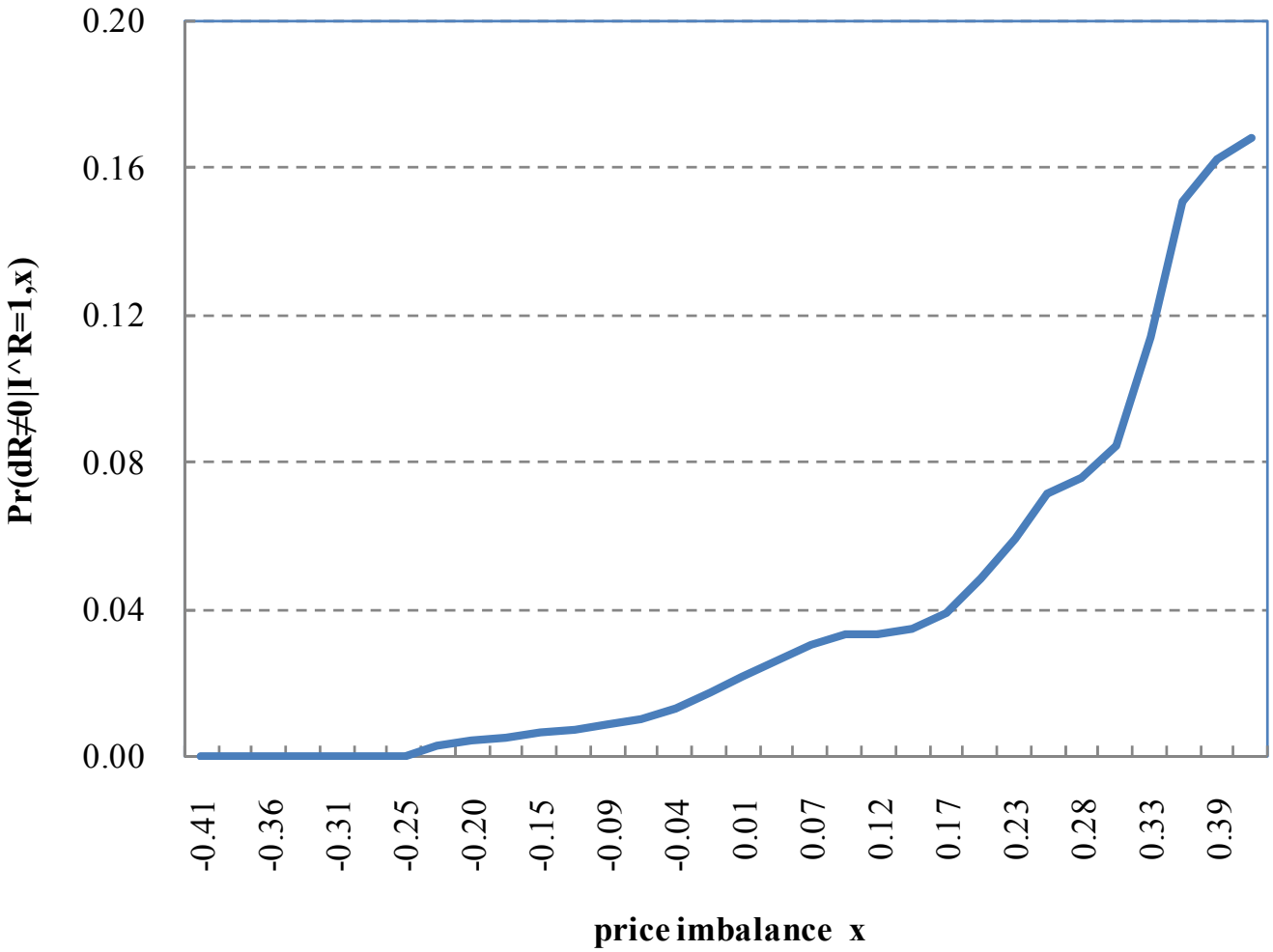


Adjustment Hazard Function for Turnover Units

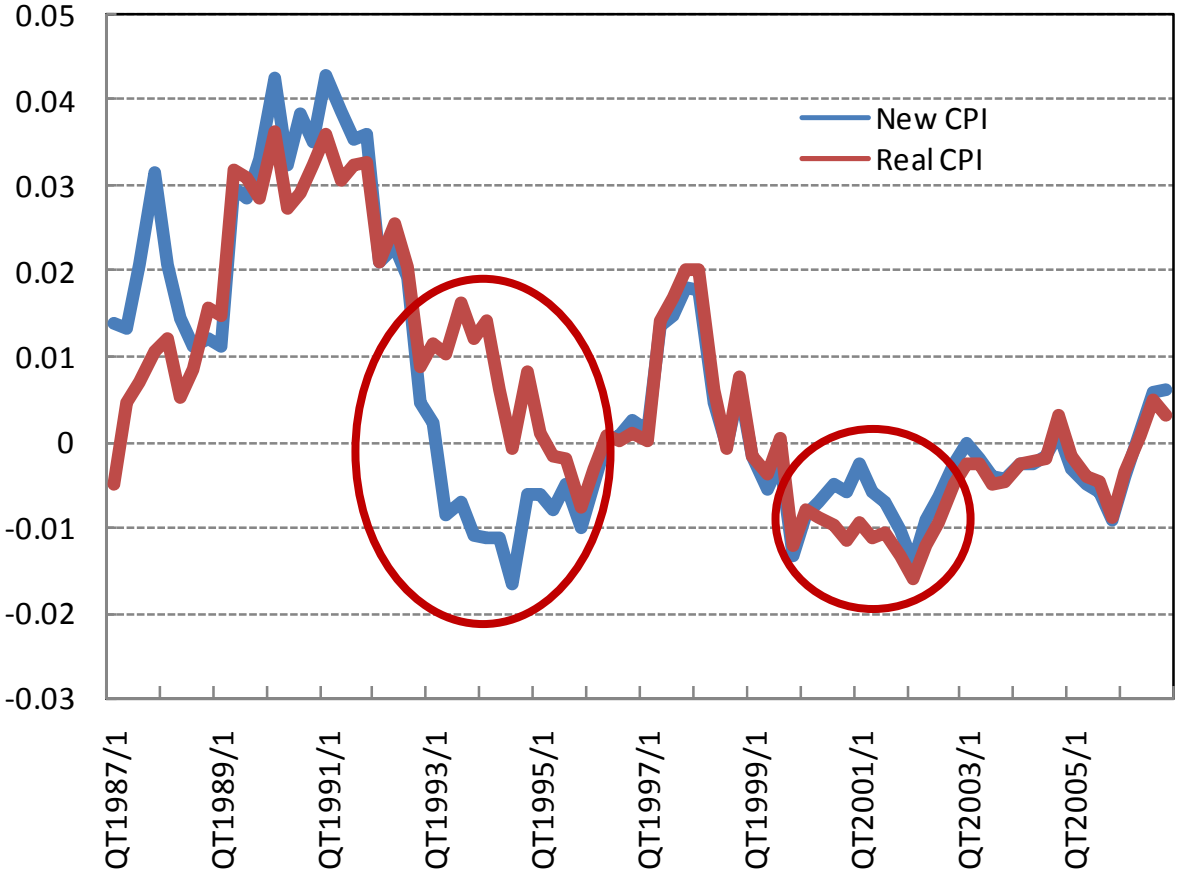


Shimizu, C.,K.G.Nishimura and T.Watanabe (2009), "Residential Rents and Price Rigidity: Micro Structure and Macro Consequences", in this conference.

Adjustment Hazard Function for Rollover Units



Re-estimates of CPI Inflation



Diewert, W. Erwin and Alice O. Nakamura (2008), "Accounting for Housing in a CPI," Price and Productivity Measurement, Volume 1: Housing, Chapter 2, pp.13-48.