Hitotsubashi-RIETI International Workshop on Real Estate Markets and the Macro Economy

# Sticky Rent and Housing Prices

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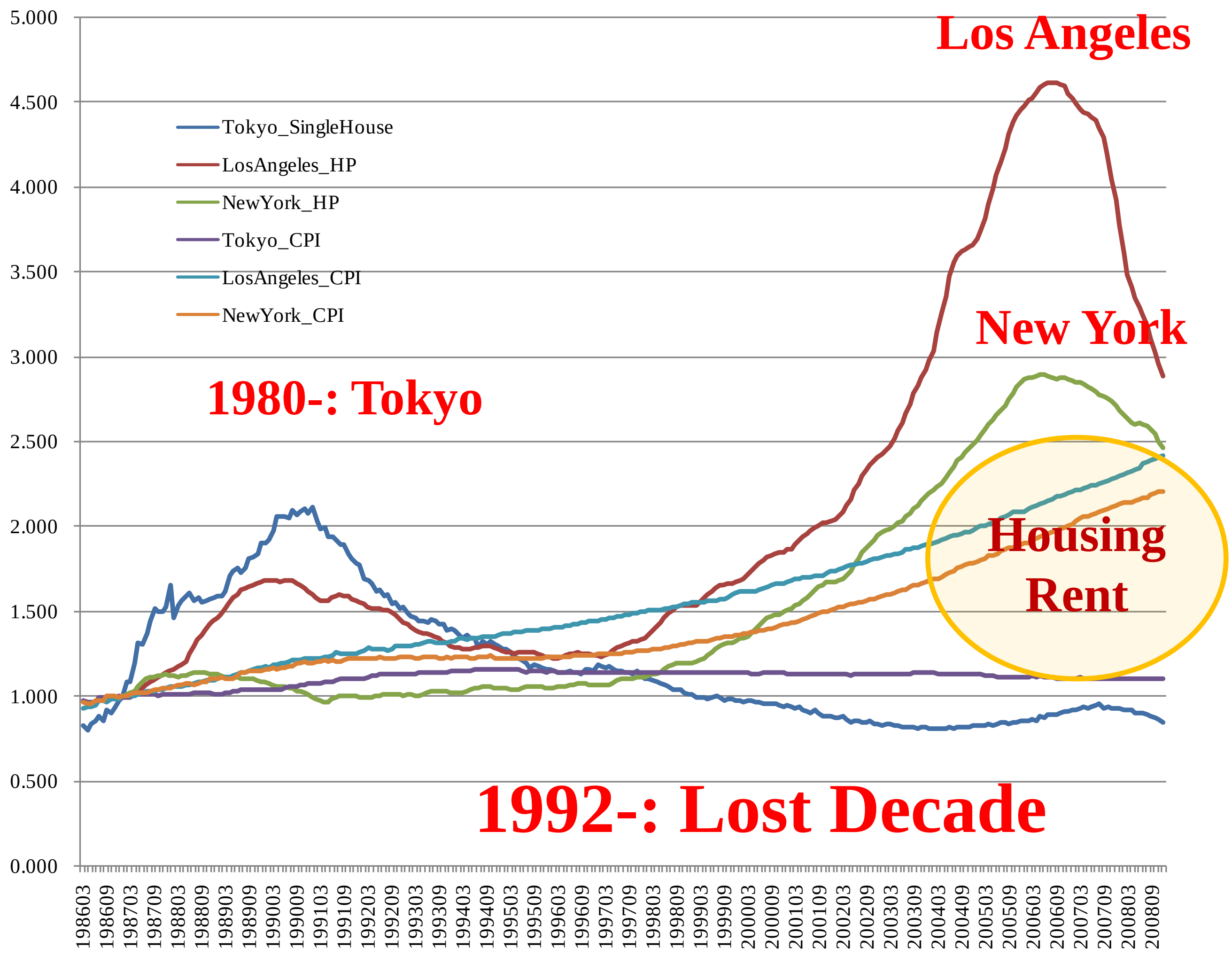
# Comparison House Price and CPI-house in Tokyo, LA, NY



# Outline or Questions

- **Why are housing rents in CPI and National Accounts sticky?**
  - Real estate prices and goods & services prices is linked through housing rents. But housing rents did not rise much, and consequently CPI inflation was stable even during the bubble period. This caused delay in monetary tightening
  - How much and why are housing rents sticky?
  - Proposals to make CPI more linked to asset price developments

- **How should we estimate Residential Property Price Indexes or RPPI?**
  - In the wake of the release of this Handbook, how should different countries construct residential property price indexes?
  - Hedonic, Repeat Sales, SPAR, Conjuint, Matching etc.

# Background papers.

- **Rigidity of Housing Rent.**
- Shimizu, C., K. G. Nishimura and T. Watanabe (2010), "Residential Rents and Price Rigidity: Micro Structure and Macro Consequences," Journal of Japanese and International Economy, Vol.24, 282-299.
- **→ Shimizu, C, E.W.Diewert and S.Imai (2015). "Residential Rents and CPI," Conference Paper at Ottawa Group Meeting, May 2015.**

- **Comparison of Residential Property Price Indexes.**
- Shimizu, C., K. G. Nishimura and T. Watanabe (2010), "House Prices in Tokyo - A Comparison of Repeat-sales and Hedonic Measures-," Journal of Economics and Statistics, Vol. 230 (6), 792-813.
- **→Shimizu, C, and K.Karato (2014). "Estimation of Residential Property Price Indexes in Tokyo-," Conference Paper for Hitotsubashi-RIETI International Workshop on Real Estate Markets and the Macro Economy.**

# 1. Macroeconomic Policy and Housing Market.

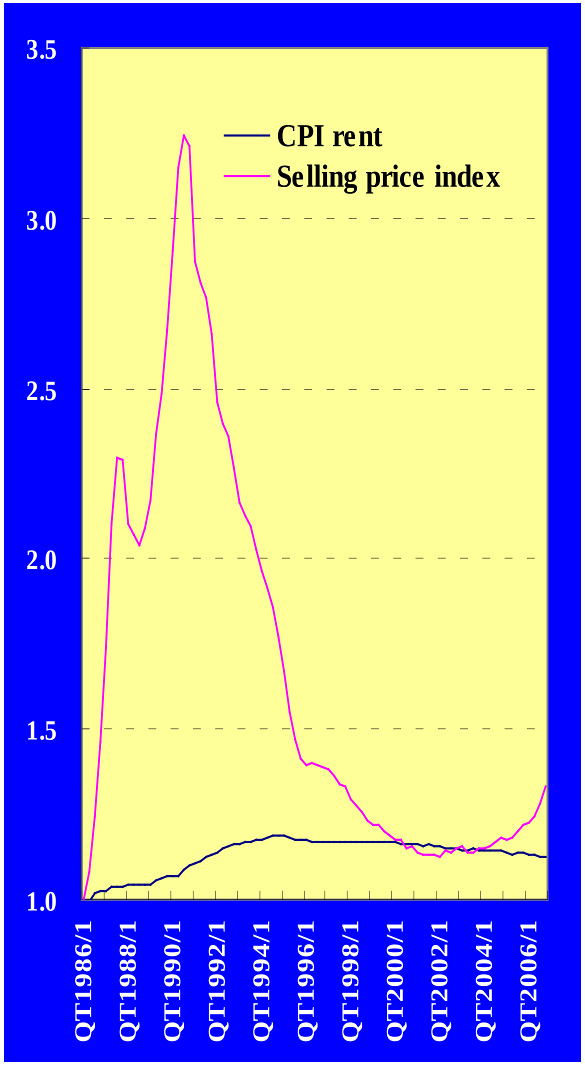
**Expenditures for housing services: 26.4%**

| | |
|---|---|
| **Housing rents:** | **4.9%** |
| **Imputed rents from owner occupied housing:** | **19.4%** |
| **Housing maintenance and others:** | **2.3%** |

**"Consumer Price Index (CPI) in Tokyo, 2010"**

- The most important link between *asset prices* and *goods & services prices* is the one through **housing rents** (Goodhart 2001)

- Housing rents account for more than **one fourth** of personal spending



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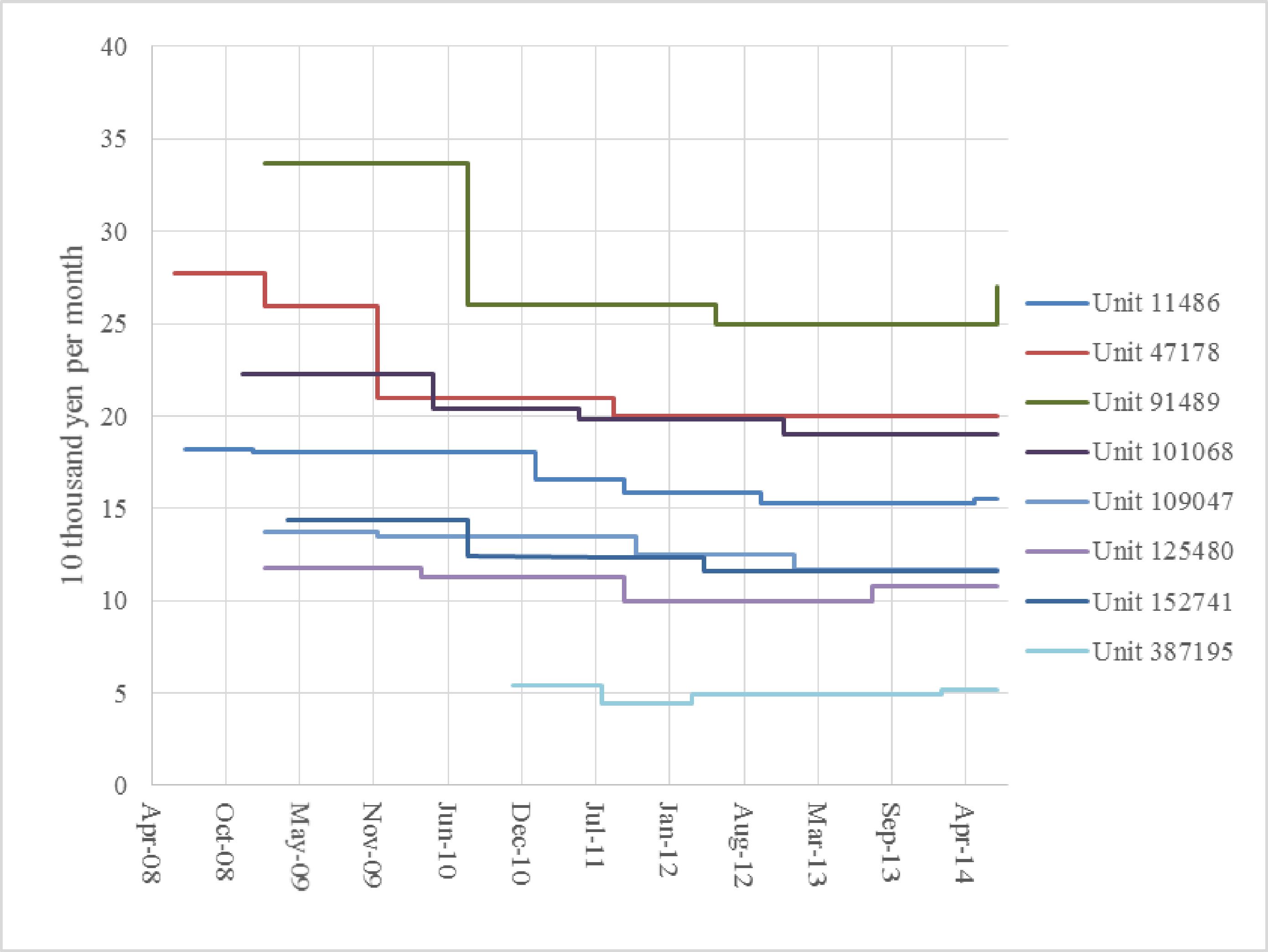
# Panel data of rental prices



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# Summary Statistics of Housing Rent

| | | | | | | |
|---|---|---|---|---|---|---|
| **Sample period** | **January 2010 - July 2014** | | | | | |
| **Frequency** | **Monthly** | | | | | |
| **Geographical scope** | **Tokyo 23 wards** | | | | | |
| **Data type** | **Actual rent** | | | | | |
| **Coverage** | **New contract and renewed contract** | | | | | |
| **Provider** | **Recruit** | | | | | |
| **No. of rooms** | **53,746** | | | | | |
| **Sample size** | **Whole sample** | | **New contract** | | **Renewed contract** | |
| | **1,492,542** | | **40,398** | | **35,139** | |
| | **mean** | **s.d.** | **mean** | **s.d.** | **mean** | **s.d.** |
| **Rent** | **104,783.6** | **57,252.5** | **102,620.2** | **52,697.4** | **105,586.8** | **59,275.9** |
| **$m^2$** | **33.1** | **17.7** | **32.7** | **17.3** | **33.6** | **18.2** |
| **$m^2$ unit rent** | **3,312.6** | **924.9** | **3,295.1** | **867.3** | **3,289.4** | **942.8** |
| **Actual age** | **13.0** | **9.9** | **12.2** | **10.0** | **13.7** | **9.8** |
| **Time to near station (m)** | **5.1** | **3.8** | **5.0** | **3.7** | **5.2** | **3.9** |
| **Time to urban center (m)** | **12.3** | **6.4** | **12.1** | **6.3** | **12.5** | **6.5** |


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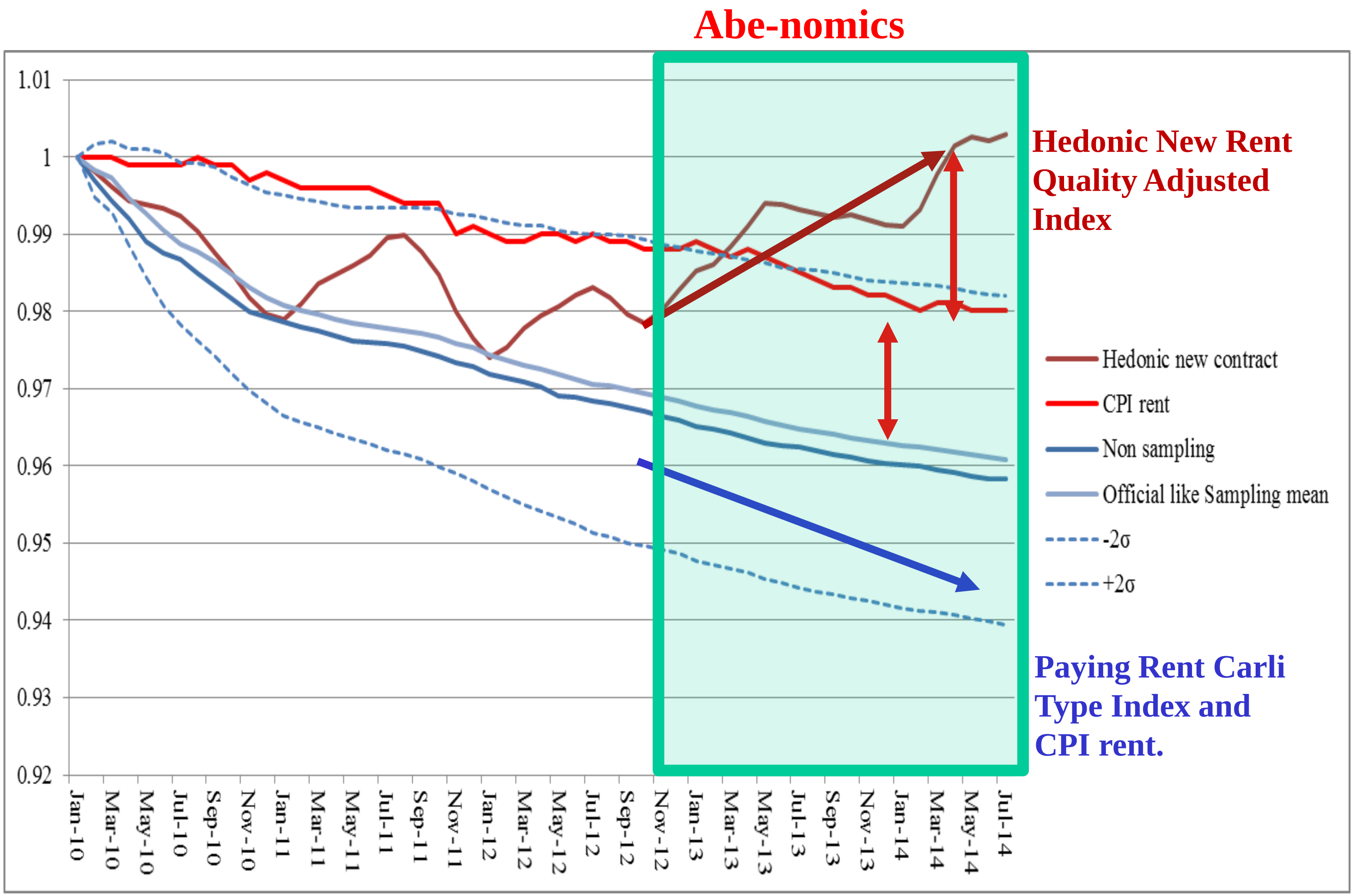
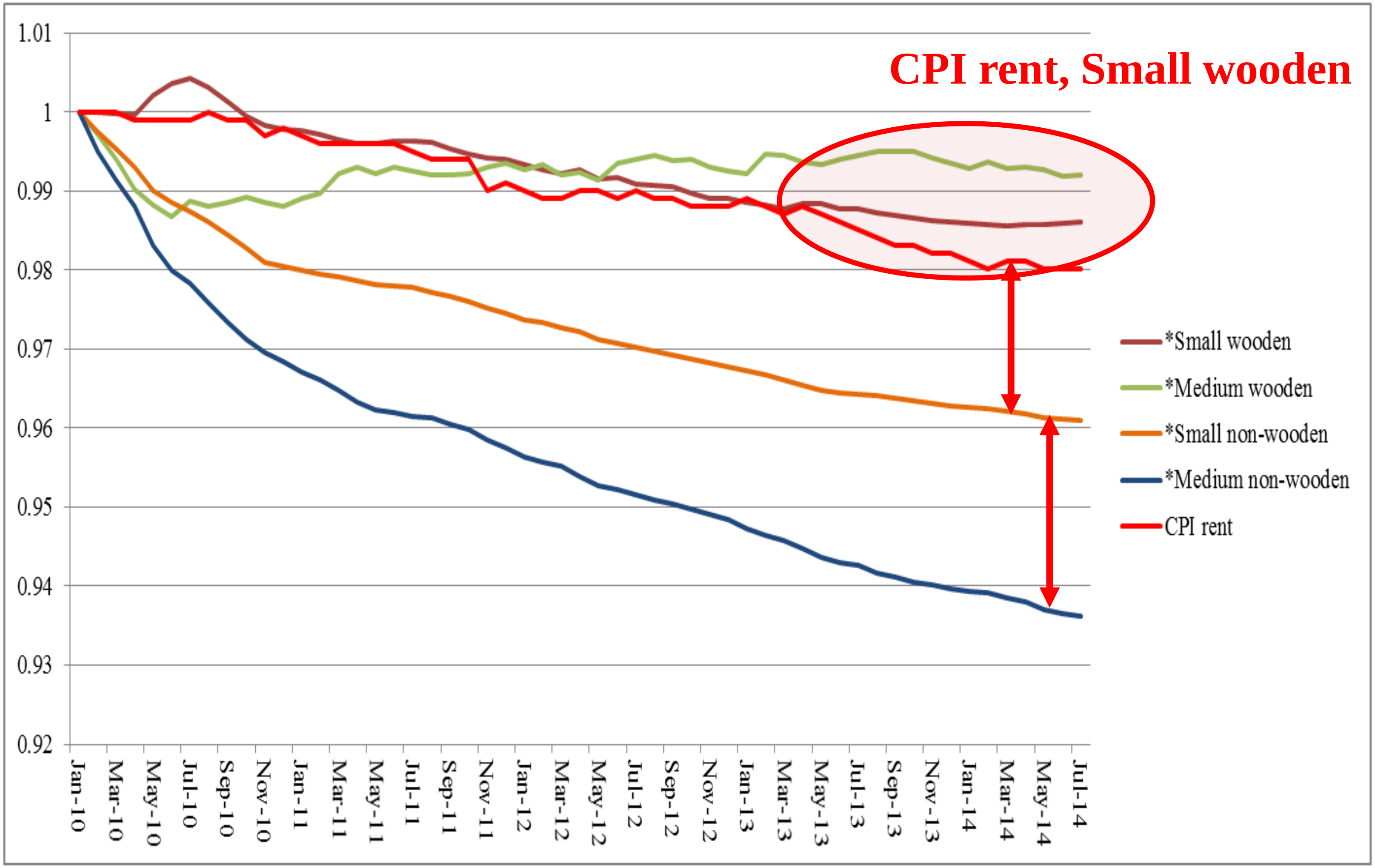
# Official Residential Rent Index or CPI Rent

- CPI rent survey districts are selected from enumeration districts of the Population Census by probability sampling. The number of house rent survey districts is **1,221**.
- Statistics Bureau of Japan says that about **28,000 households** are surveyed (see Annual report on the Retail Price Survey 2013).
- The survey districts are allocated according to scale of sample cities, the Tokyo metropolitan area is allocated **54** districts.
- The survey districts are grouped to three groups and one group is surveyed ***every 3 months***.
- Rent index is calculated separately by 4 classification.- **Wooden small house, wooden medium house, non-wooden small house and non-wooden medium house.**

# Housing Rent Index and CPI Rent 1



# Housing Rent Index and CPI Rent 2



# Frequency of Rent Adjustments

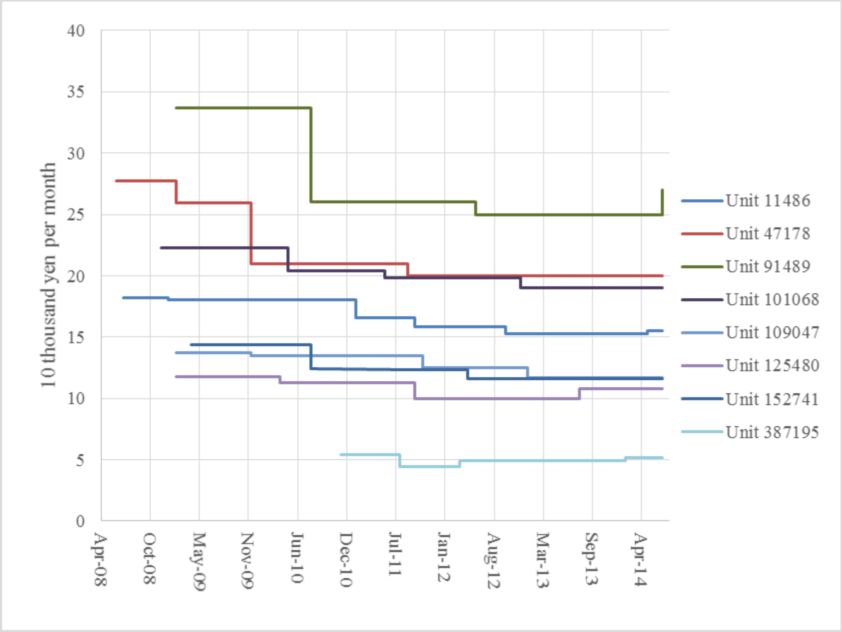
Price Change $\boxed{\Delta R_{it} \equiv R_{it} - R_{it-1}}$

Probability of event on *New Contract* ($I^N$) and *Renewed Contract* ($I^R$)

$$\Pr(\Delta R_{it} = 0) = \left[1 - \Pr(I_{it}^{N} = 1) - \Pr(I_{it}^{R} = 1)\right]$$

$$+ \Pr(\Delta R_{it} = 0 \mid I_{it}^{N} = 1)\Pr(I_{it}^{N} = 1)$$

$$+ \Pr(\Delta R_{it} = 0 \mid I_{it}^{R} = 1)\Pr(I_{it}^{R} = 1)$$





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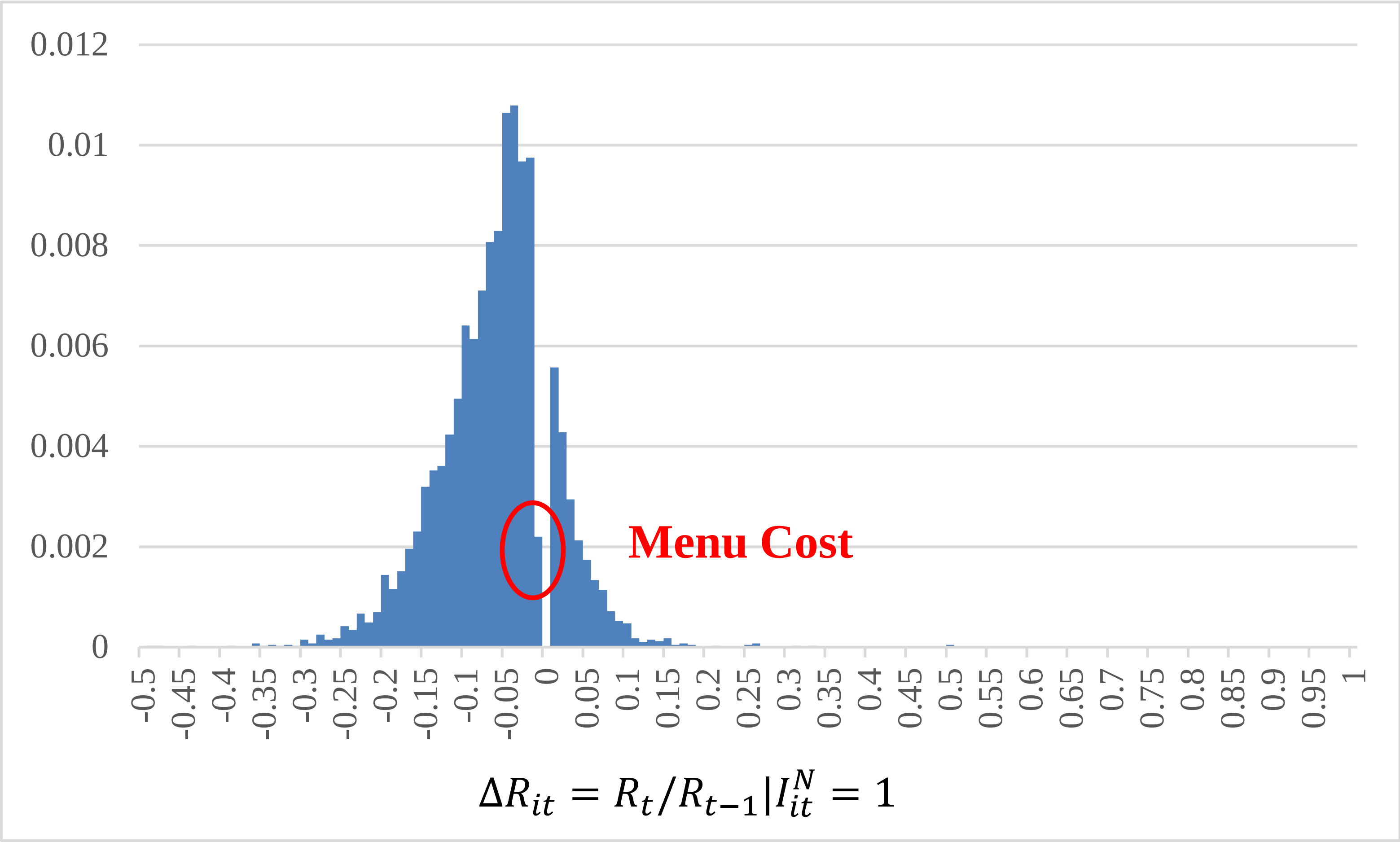
# Frequency of Rent Adjustments:

| | Negative | Zero | Positive | Number of Observations | (Change) |
|---|---|---|---|---|---|
| Turnover units | 4,473 | 34,958 | 967 | 40,398 | 5,440 |
| | (0.111) | (0.865) | (0.024) | (0.535) | (0.135) |
| Rollover units | 1,169 | 33,667 | 303 | 35,139 | 1,472 |
| | (0.033) | (0.958) | (0.009) | (0.465) | (0.042) |
| All units | 5,642 | 68,625 | 1,270 | 75,537 | 6,912 |
| | (0.075) | (0.908) | (0.017) | (1.000) | (0.092) |

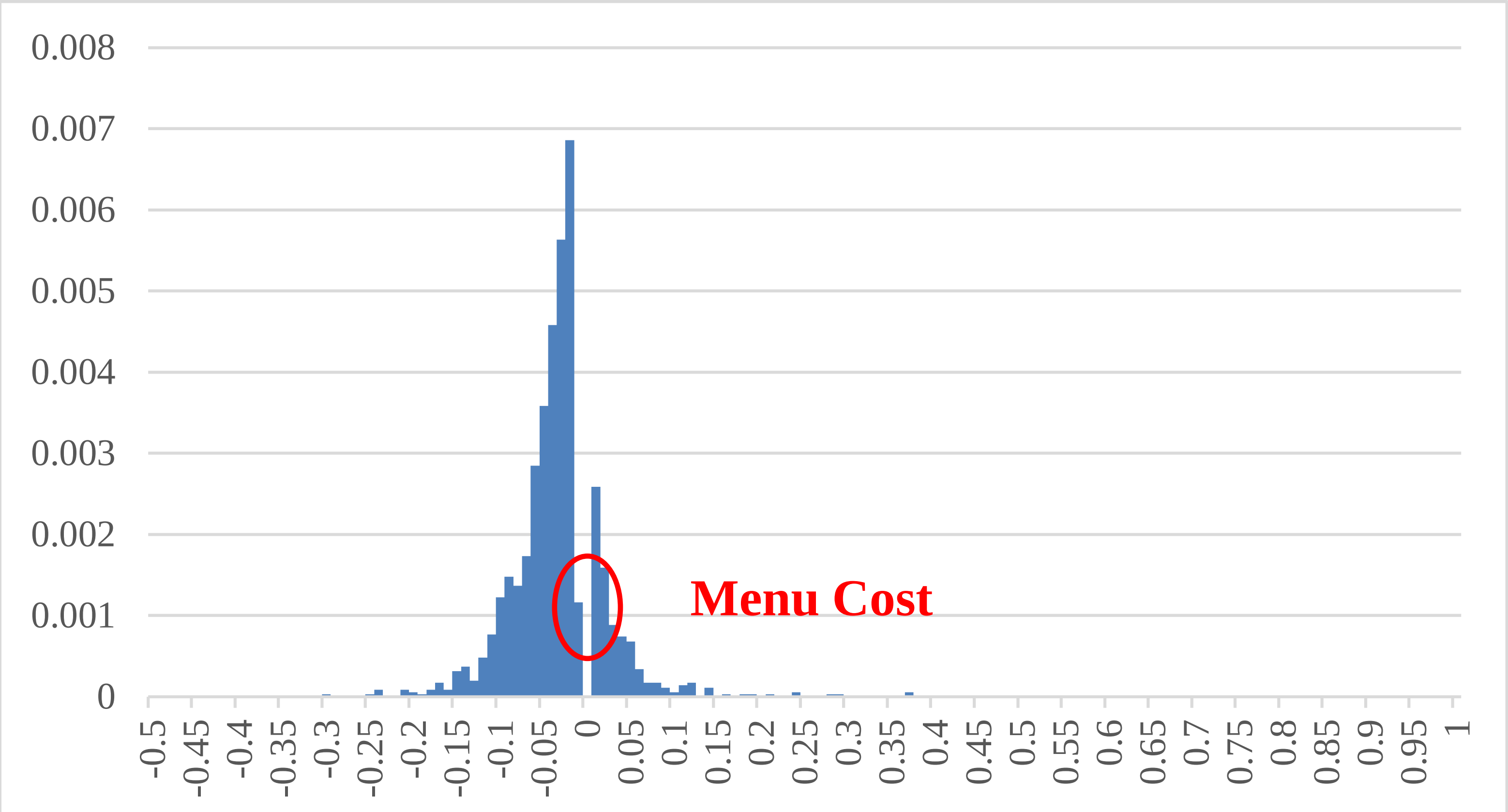
| Fraction of housing units without no rent change per year | | |
|---|---|---|
| US | 29% | Estimated by Genesove (2003) |
| Germany | 78% | Estimated by Kurz-Kim (2006) |
| Japan | 90% | Estimated by this research |

# Monthly rent change distribution in Turnover Contracts




n=5,440

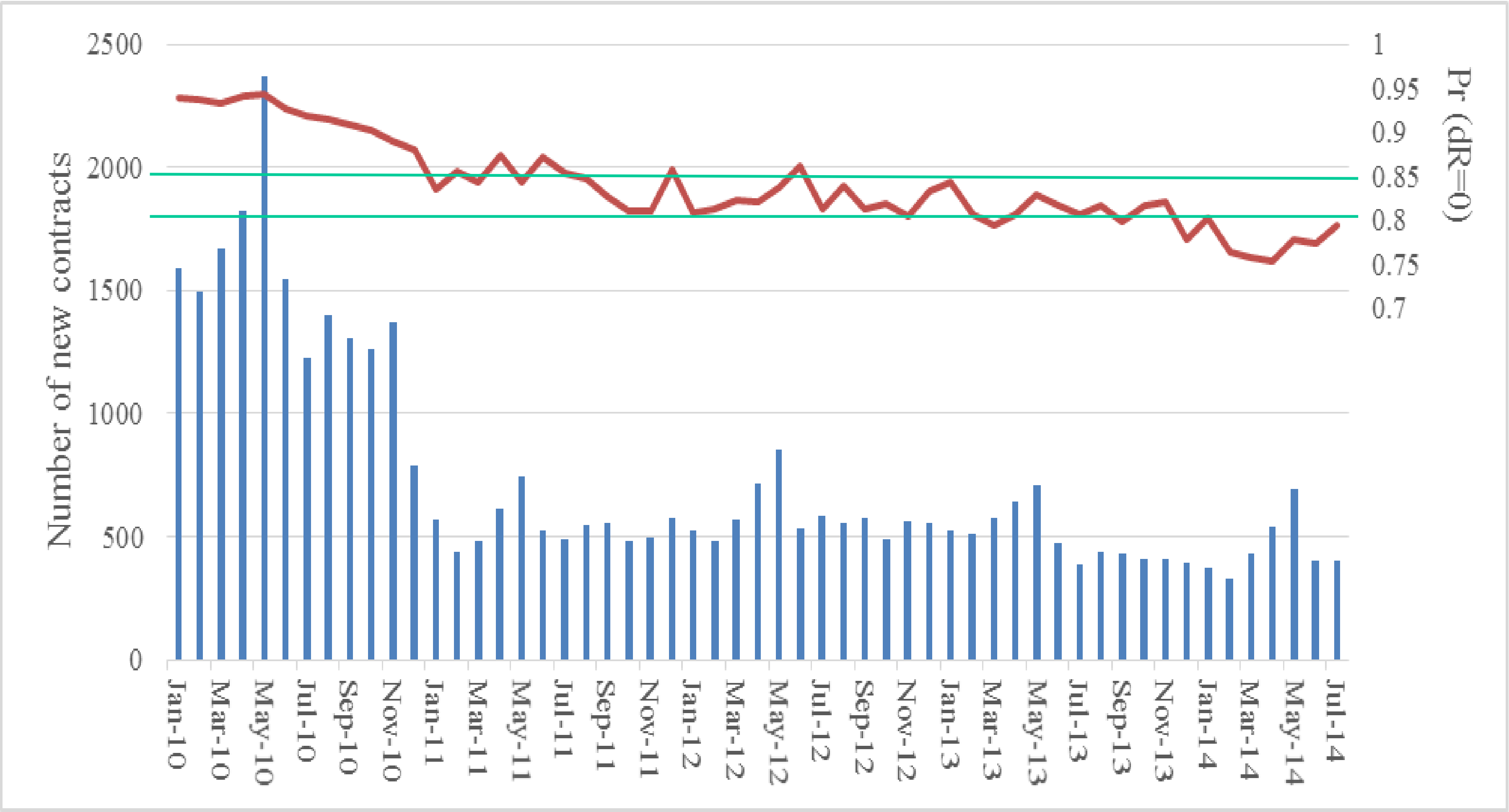
# Monthly rent change distribution in Rollover Contracts




$$\Delta R_{it} = R_t / R_{t-1} | I_{it}^R = 1$$

n=18,582,863

# Probability of No Rent Adjustments in New Contracts : 2010-2014



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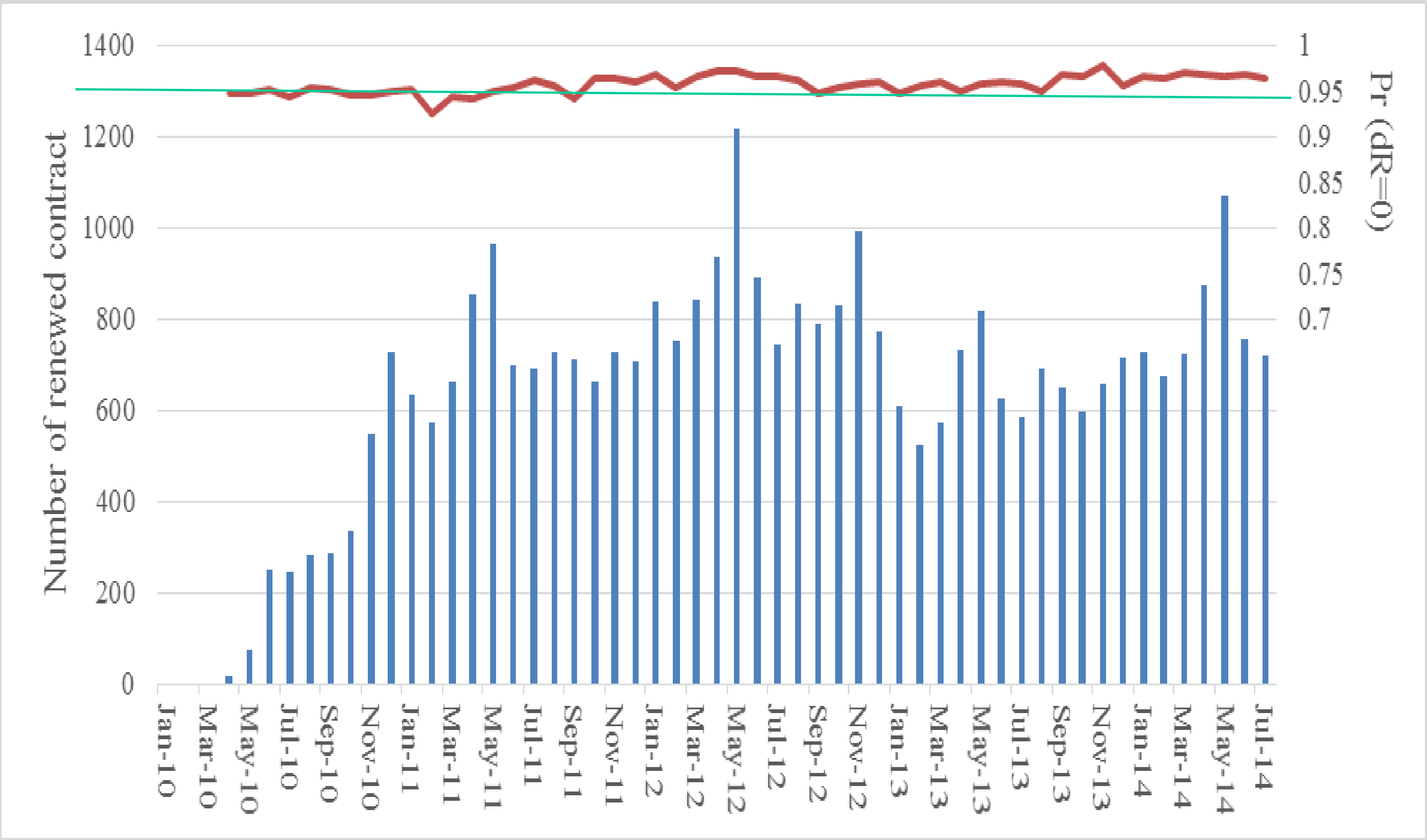
# Probability of No Rent Adjustments in Rollover Contracts : 2010-2014





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# State-Dependent or Time-Dependent Pricing: Caballero-Engel's definition of price flexibility

**-Target Rent Level**

**-Price Gap**

**-Probability of rent adjustments**

$$\Delta \log R_{it}^{*} = \Delta \xi_t + \nu_{it}$$

$$X_{it} \equiv \log R_{it-1} - \log R_{it}^{*}$$

$$\Lambda(x) \equiv \Pr(\Delta R_{it} \neq 0 \mid X_{it} = x)$$

**Caballero-Engel(1993)**

**:Adjustment Hazard Function**

$$\boxed{\lim_{\Delta\xi_t \to 0} \frac{\Delta \log R_t}{\Delta \xi_t}} = \boxed{\int \Lambda(x) h(x) dx} + \boxed{\int x \Lambda'(x) h(x) dx}$$

**Caballero-Engel's measure of price flexibility**

**Intensive margin**

**Extensive margin**

**Caballero-Engel(2007)**

**State-dependent or time-dependent pricing.**

$$\begin{aligned}\Lambda(x) = \; & \Pr(\Delta R_{it} \neq 0 \mid I_{it}^{N} = 1, X_{it} = x) \Pr(I_{it}^{N} = 1 \mid X_{it} = x) \\ & + \Pr(\Delta R_{it} \neq 0 \mid I_{it}^{R} = 1, X_{it} = x) \Pr(I_{it}^{R} = 1 \mid X_{it} = x)\end{aligned}$$

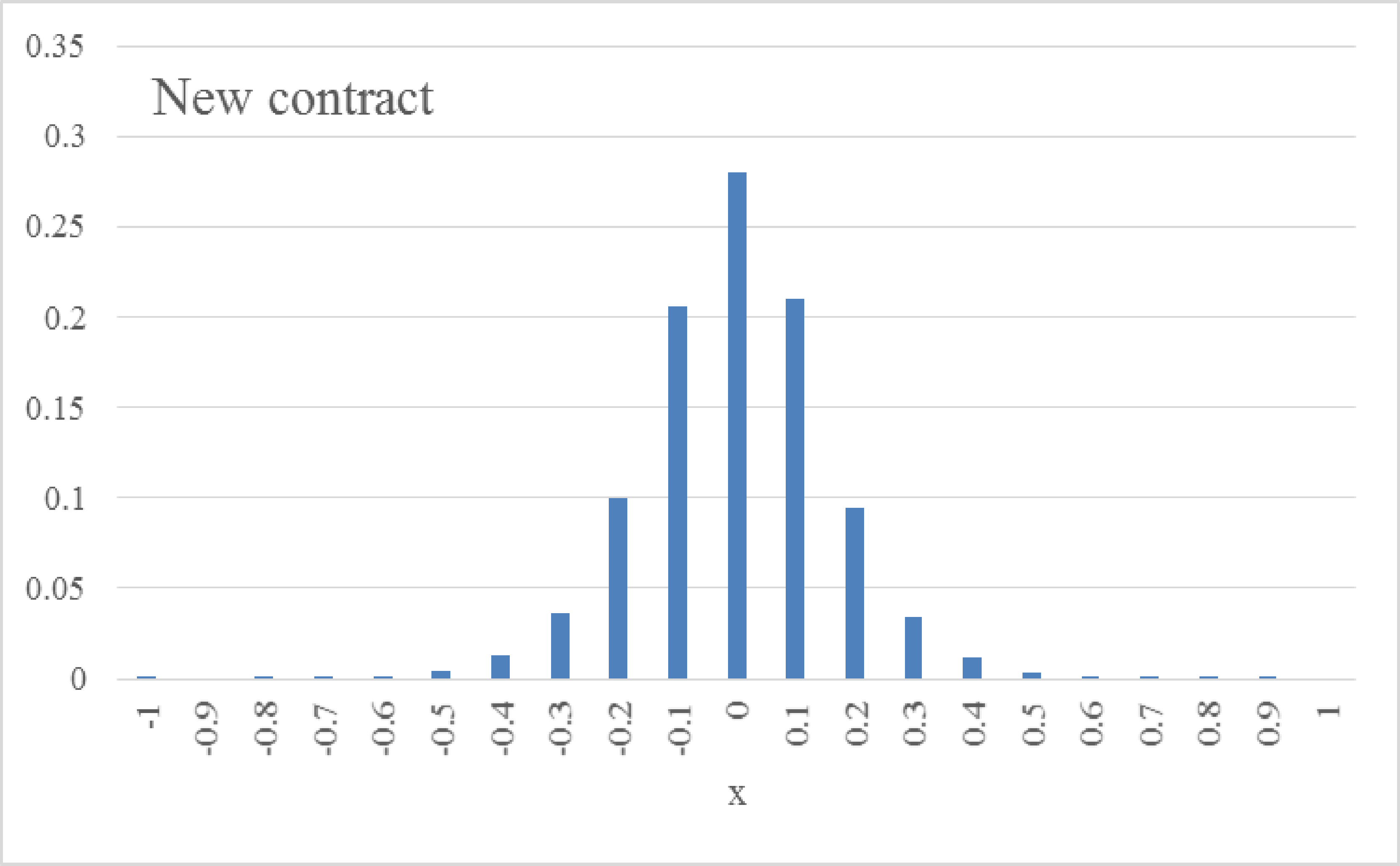
# Estimated Coefficients in Hedonic Regressions

$$R_{it}^{*} = \begin{cases} R_{it} & \text{if} \quad I_{it} = 1 \\ \hat{R}_{it} & \text{if} \quad I_{it} = 0 \end{cases}$$

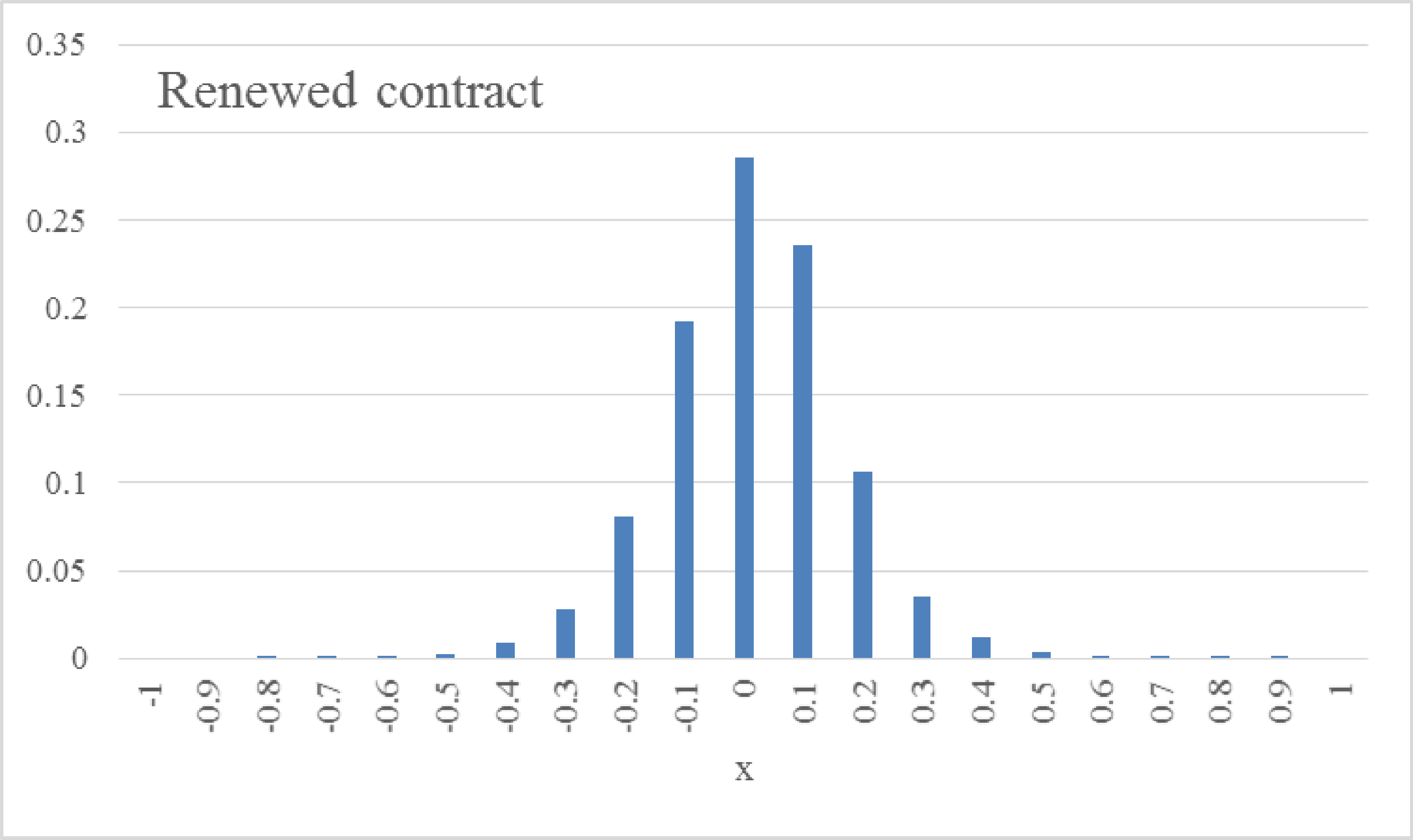
where $\hat{R}_{it} \equiv \hat{\beta}_t x_i + \hat{\gamma}_t TD_t$ $\hat{\beta}_t$ and $\hat{\gamma}_t$ are hedonic estimates

| Estimation Window | Floor space | Age of building | Time to nearest station | Commuting time to CBD | Adjusted $R^2$ | Number of observations |
|---|---|---|---|---|---|---|
| 201001 - 201012 | 0.0188 | -0.0109 | -0.0087 | -0.0058 | 0.917 | 17,697 |
| 201002 - 201101 | 0.0188 | -0.0109 | -0.0088 | -0.0058 | 0.916 | 16,707 |
| 201003 - 201102 | 0.0188 | -0.0109 | -0.0089 | -0.0059 | 0.917 | 15,670 |
| 201004 - 201103 | 0.0188 | -0.0110 | -0.0090 | -0.0059 | 0.917 | 14,504 |
| 201005 - 201104 | 0.0188 | -0.0110 | -0.0092 | -0.0058 | 0.916 | 13,303 |
| 201006 - 201105 | 0.0189 | -0.0111 | -0.0094 | -0.0058 | 0.915 | 11,684 |
| 201007 - 201106 | 0.0189 | -0.0112 | -0.0096 | -0.0060 | 0.914 | 10,667 |
| 201008 - 201107 | 0.0190 | -0.0114 | -0.0097 | -0.0062 | 0.916 | 9,942 |
| 201009 - 201108 | 0.0189 | -0.0115 | -0.0095 | -0.0065 | 0.918 | 9,099 |
| 201010 - 201109 | 0.0190 | -0.0114 | -0.0099 | -0.0065 | 0.919 | 8,346 |
| 201011 - 201110 | 0.0191 | -0.0113 | -0.0104 | -0.0067 | 0.922 | 7,571 |
| 201012 - 201111 | 0.0191 | -0.0113 | -0.0105 | -0.0066 | 0.924 | 6,698 |
| 201101 - 201112 | 0.0191 | -0.0114 | -0.0104 | -0.0067 | 0.924 | 6,490 |

# Distribution of Price Gap in New Contract



# Distribution of Price Gap in Renewed Contract



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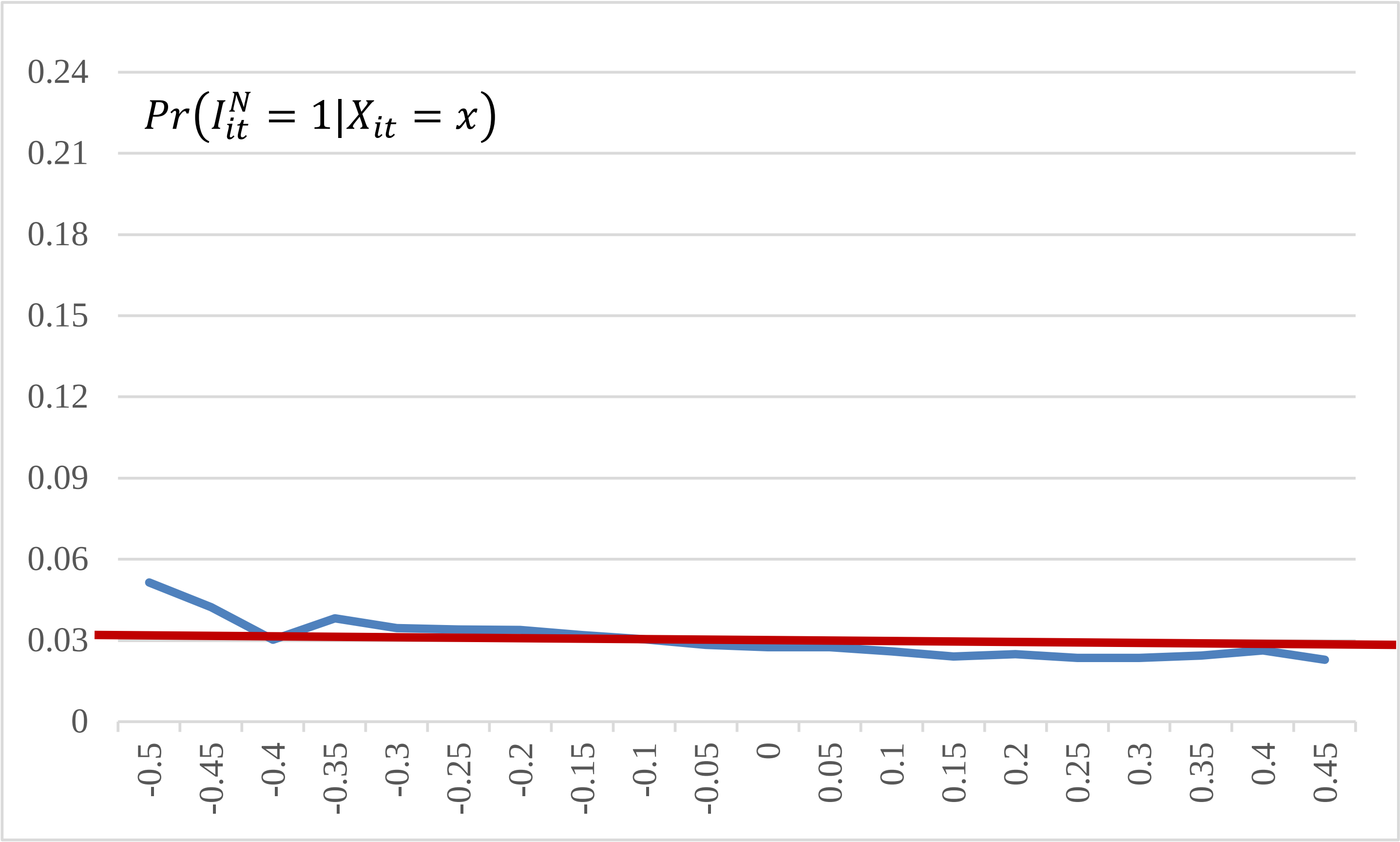
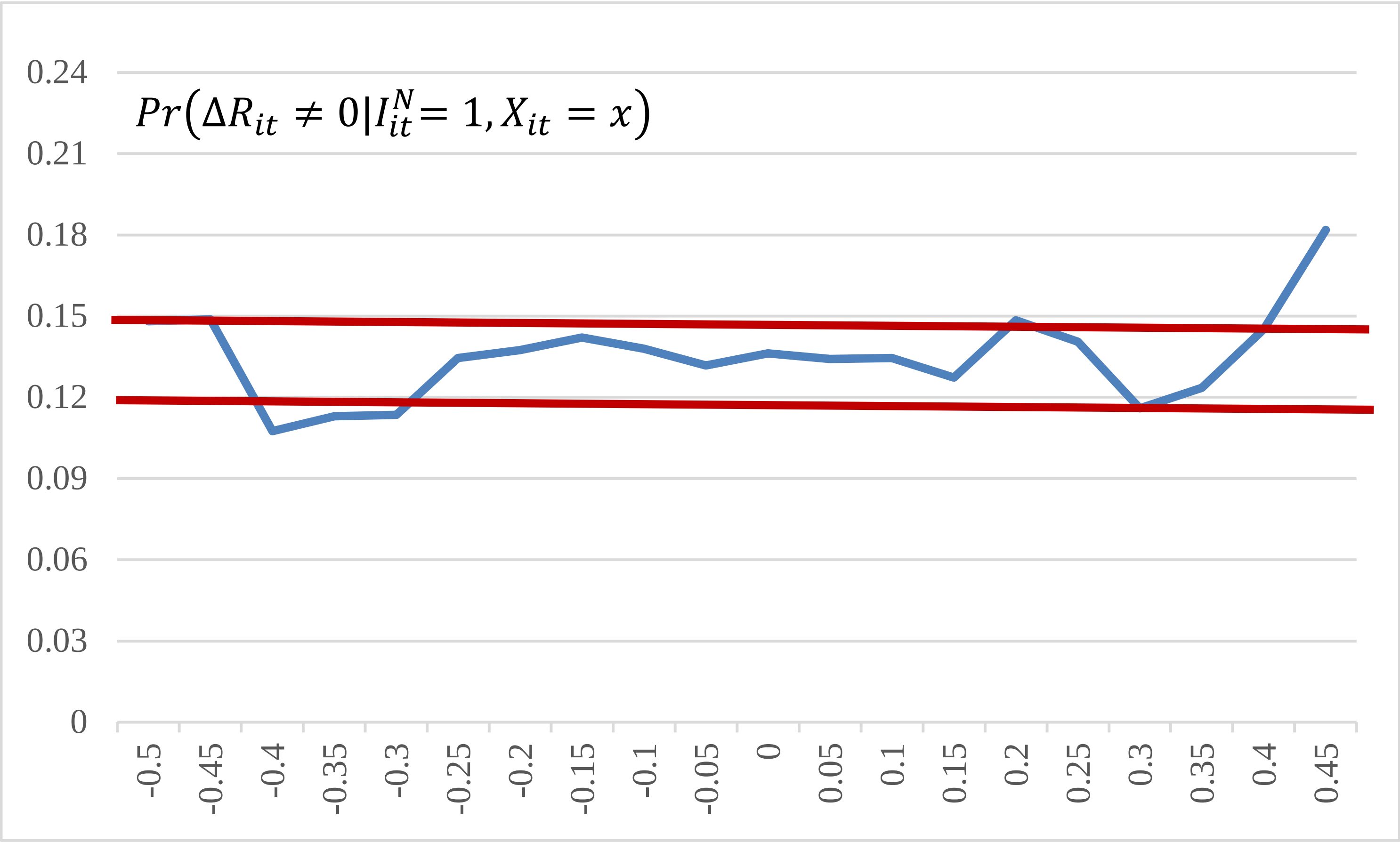
# Adjustment Hazard Function for ***Turnover Units***: Probability of Unit Turnover



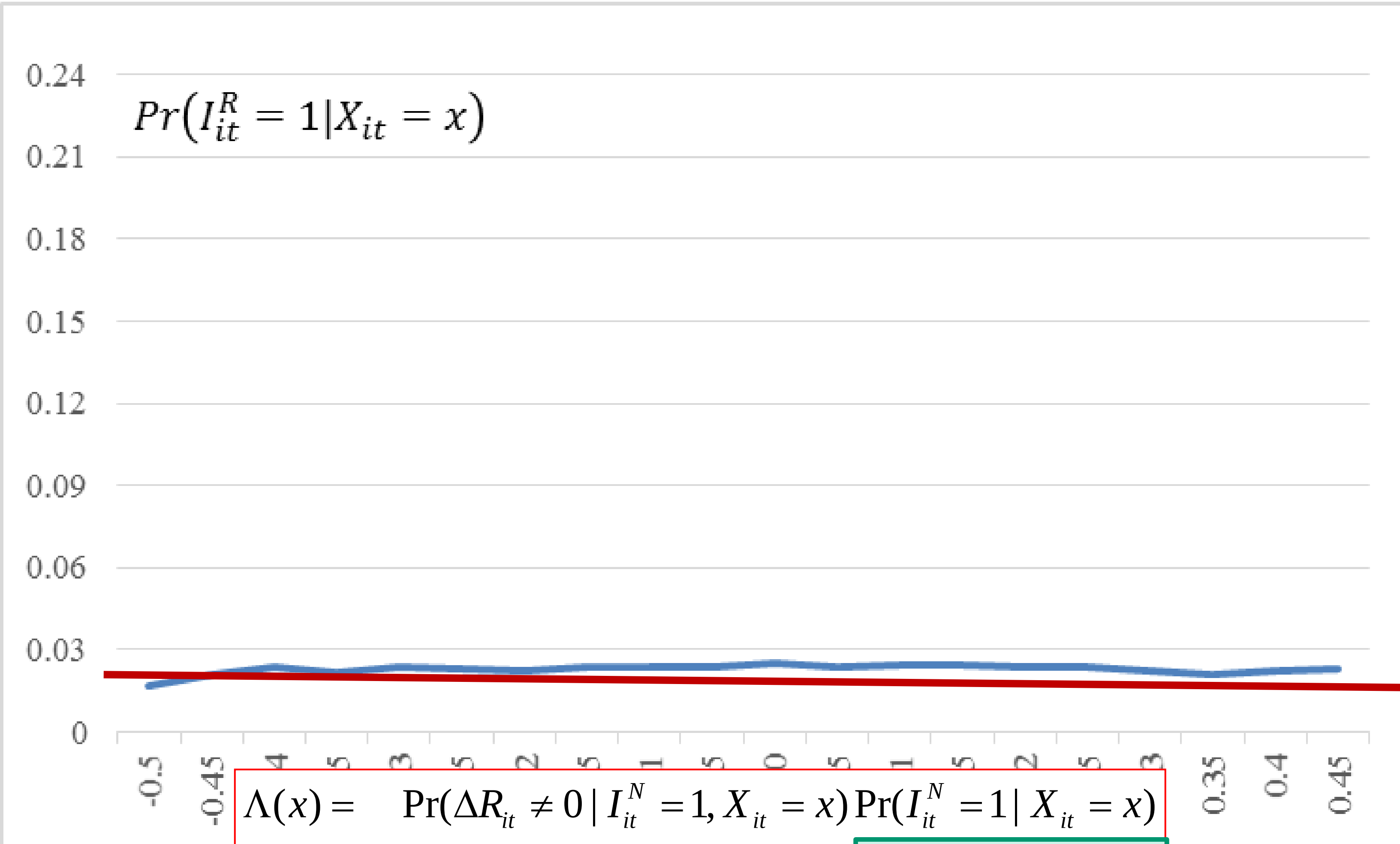

$$\Lambda(x) = \Pr(\Delta R_{it} \neq 0 \mid I_{it}^{N} = 1, X_{it} = x)\boxed{\Pr(I_{it}^{N} = 1 \mid X_{it} = x)}$$
$$+ \Pr(\Delta R_{it} \neq 0 \mid I_{it}^{R} = 1, X_{it} = x)\Pr(I_{it}^{R} = 1 \mid X_{it} = x)$$

# Adjustment Hazard Function for ***Turnover Units***



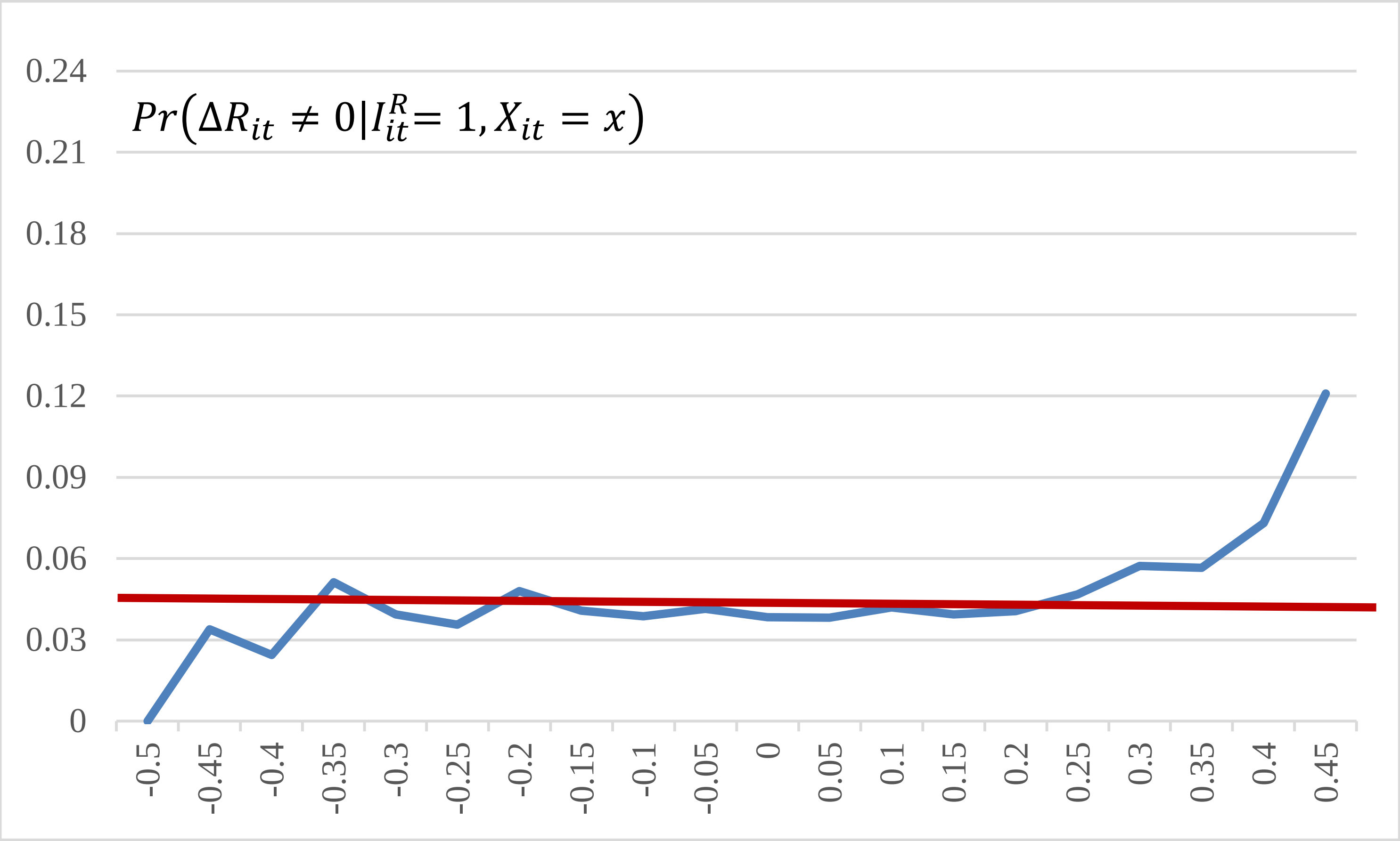

$$\Lambda(x) = \boxed{\Pr(\Delta R_{it} \neq 0 \mid I_{it}^{N} = 1, X_{it} = x)} \Pr(I_{it}^{N} = 1 \mid X_{it} = x)$$
$$+ \Pr(\Delta R_{it} \neq 0 \mid I_{it}^{R} = 1, X_{it} = x) \Pr(I_{it}^{R} = 1 \mid X_{it} = x)$$

# Adjustment Hazard Function for ***Rollover Units***




$$\Lambda(x) = \Pr(\Delta R_{it} \neq 0 \mid I_{it}^{N} = 1, X_{it} = x)\Pr(I_{it}^{N} = 1 \mid X_{it} = x) + \Pr(\Delta R_{it} \neq 0 \mid I_{it}^{R} = 1, X_{it} = x)\boxed{\Pr(I_{it}^{R} = 1 \mid X_{it} = x)}$$

# Adjustment Hazard Function for ***Rollover Units***




$$\Lambda(x) = \Pr(\Delta R_{it} \neq 0 \mid I_{it}^{N} = 1, X_{it} = x)\Pr(I_{it}^{N} = 1 \mid X_{it} = x) + \boxed{\Pr(\Delta R_{it} \neq 0 \mid I_{it}^{R} = 1, X_{it} = x)}\Pr(I_{it}^{R} = 1 \mid X_{it} = x)$$



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# Adjustment Hazard Functions

| | $x \in [-0.4, -0.2)$ | $x \in [-0.2, 0.0)$ | $x \in [0.0, 0.2)$ | $x \in [0.2, 0.4)$ |
|---|---|---|---|---|
| $\Pr\left(I_{it}^{N} = 1 \mid X_{it} = x\right)$ | 0.035 | 0.030 | 0.026 | 0.024 |
| $\Pr\left(I_{it}^{R} = 1 \mid X_{it} = x\right)$ | 0.023 | 0.024 | 0.024 | 0.023 |
| $\Pr\left(\Delta R_{it} \neq 0 \mid I_{it}^{N} = 1, X_{it} = x\right)$ | 0.123 | 0.136 | 0.134 | 0.138 |
| $\Pr\left(\Delta R_{it} \neq 0 \mid I_{it}^{R} = 1, X_{it} = x\right)$ | 0.038 | 0.041 | 0.039 | 0.046 |
| $\Lambda(x)$ | 0.005 | 0.005 | 0.004 | 0.004 |
| $h(x)$ | 0.039 | 0.279 | 0.513 | 0.147 |

**Intensive margin:**

$$\int \Lambda(x) h(x) dx = \boxed{0.055}$$

**Extensive margin:**

$$\int x \Lambda'(x) h(x) dx = \boxed{0.00580}$$

**Caballero-Engel's measure of price flexibility**

$$\lim_{\Delta \xi_t \to 0} \frac{\Delta \log R_t}{\Delta \xi_t} = \boxed{0.0607}$$

# Summary in “Sticky Housing Rent”

1. About ninety percent of the units in our dataset had no change in rents per year, indicating that rent stickiness is three times as high as in the US.
2. The probability of rent adjustment depends little on the deviation of the actual rent from its target level, suggesting that rent adjustments are not state dependent but time dependent.
3. These two results indicate that both intensive and extensive margins of rent adjustments are small, resulting in a slow response of the CPI rent to aggregate shocks.
4. The CPI inflation rate would have been higher by one percentage point during the bubble period, and lower by more than one percentage point during the period of bubble bursting, if the Japanese housing rents were as flexible as in the US.

**→Future work: Depreciation bias in Housing Rent in CPI.**


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# 2. How should different countries construct residential property price indexes?

- In the wake of the release of this *Handbook*,

- **How should different countries construct residential property price indexes?**

- With the start of the *Residential Property Price Indices Handbook project*, the government of Japan set up an Advisory Board through the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) in 2012 and is proceeding with the development of a new Japanese official residential property price index.

# Alternative Methods for Constructing Residential Property Price Indexes

- **Housing**: 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 Residential Property Price Indexes.
- → **Hedonic method and Repeat sales method**

# The Standard Hedonic Regression Model : (1/3)

- House prices and property characteristics for periods t = 1, 2, . . . , T. The price of house i in period t, $P_{it}$, is given by a ***Cobb-Douglas function*** of the lot size of the house, $L_i$, and the amount of structures capital in constant quality units, $K_{it}$:
- $\boxed{(1)\ P_{it} = P_t L_i^{\alpha} K_{it}^{\beta}}$
- where $P_t$ is the logarithm of the *quality adjusted house price index for period t* and α and β are positive parameters.
- Housing capital, $K_{it}$, is subject to *generalized exponential depreciation* so that the housing capital in period t is given by
- $\boxed{(2)\ K_{it} = B_i \exp[-\delta A_{it}^{\lambda}]}$
- where $B_i$ is the floor space of the structure, $A_{it}$ is the age of the structure in period t, δ is a parameter between 0 and 1, and λ is a positive parameter.

# The Standard Hedonic Regression Model : (2/3)

- By substituting (2) into (1), and taking the logarithm of both sides of the resulting equation:

- (3) $\ln P_{it} = \ln P_t + \alpha \ln L_i + \beta \ln B_i - \beta\delta A_{it}^{\lambda}$.

- (4) $\ln P_{it} = d_t + \alpha \ln L_i + \beta \ln B_i - \beta\delta A_{it}^{\lambda} + \gamma \cdot x_i + \upsilon_{it}$

- where **$d_t \equiv \ln P_t$ is the logarithm of the constant quality population price index for period t**, $P_t$, $\gamma$ is a vector of parameters associated with the vector of house i characteristics $x_i$, $\gamma \cdot x_i$ is the inner product of the vectors $\gamma$ and $x_i$ and $\upsilon_{it}$ is an iid normal disturbance.

# The Standard Hedonic Regression Model : (3/3)

- Running an OLS regression of equation (4) yields estimates for the coefficients on the time dummy variables, $d_t$ for t = 1,...,T as well as for the parameters α, β, γ, and δ.

- After making the normalization $d_1 = 0$, the series of estimated coefficients for the time dummy variables, $d_t^*$ for t = 1,...,T, can be exponentiated to yield **the time series of constant quality price indexes, $P_t \equiv \exp[d_t^*]$ for t = 1,...,T.** Note that the coefficients α, β, γ, and δ are all identified in this regression model.

# The Standard Repeat Sales Model : (1/3)

- The underlying price determination model is basically the same as in equation (4).
- (4) $\ln P_{it} = d_t + \alpha \ln L_i + \beta \ln B_i - \beta\delta A_{it}^{\lambda} + \gamma \cdot x_i + \upsilon_{it}$
- Suppose that house i is transacted twice, and that the transactions occur in periods s and t with s < t.
- 
- (5) $\ln(P_{it}/P_{is}) = d_t - d_s - \beta\delta(A_{it}^{\lambda} - A_{is}^{\lambda}) + \upsilon_{it} - \upsilon_{is}$ .
- 
- Note that the terms that do not include time subscripts in equation (4), namely $\alpha \ln L_i$, $\beta \ln B_i$ and $\gamma x_i$, all disappear by taking differences with respect to time, so that the resulting equation is simpler than the original one.

# The Standard Repeat Sales Model : (2/3)

- Furthermore, assuming no renovation expenditures between the two time periods and no depreciation of housing capital so that $\delta = 0$, equation (5) reduces to:
- (6) $\ln(P_{it}/P_{is}) = d_t - d_s + \upsilon_{it} - \upsilon_{is}$ .
- The above equation can be rewritten as the following linear regression model:
- (7) $\ln(P_{it}/P_{is}) = \sum_{j=1}^{T} D_j^{its} d_j + \upsilon_{its}$
- where $\upsilon_{its} \equiv \upsilon_{it} - \upsilon_{is}$ is a consolidated error term and $D_j^{its}$ is a dummy variable that takes on the value 1 when $j = t$ (where t is the period when house i is resold), the value $-1$ when $j = s$ (where s is the period when house i is first sold) and $D_j^{its}$ takes on the value 0 for j not equal to s or t.

# The Standard Repeat Sales Model : (3/3)

- In order to identify all of the parameters $d_j$, a normalization is required such as $d_1 \equiv 0$. this normalization will make the house price index equal to unity in the first period.

- The *standard repeat sales house price indexes* are then defined by $P_t \equiv \exp[d_t^*]$ for $t = 1,2,...,T$, where the $d_t^*$ are the least squares estimators for the $d_t$.

- Thus the regression model defined by (5) does not require characteristics information on the house(except that information on the age of the house at the time of each transaction is required).

# 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).

# Problems for the repeat sales method

- (i) there is ***sample selection bias*** (Clapp and Giaccotto 1992);
- (ii) ***heteroscedasticity***: error terms are likely to become larger when two transaction dates are further apart.
- Case and Shiller (1987, 1989) have proposed a model in which a GLS estimation is performed taking account of ***heteroscedasticity***.
- (ⅲ) 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). →**Depreciation and Renovation.**

# Rolling Window Hedonic Regressions: Structural Change Adjustments to the Hedonic Index: (1/3)

- **Structural-change adjustment to hedonic :**
- We estimated hedonic model ***considering structural change*** by **Overlapping Period Hedonic Model**; OPHM, proposed by Shimizu et.al(1997), (2007) or **Rolling Window Hedonic Regressions**.

- 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.

# Rolling Window Hedonic Regressions: Structural Change Adjustments to the Hedonic Index: (2/3)

- The sequence of final price levels $P_t$ for the first $\tau$ periods is obtained by exponentiating the estimated time dummy parameters taken from the first Rolling Window regression; i.e., $P_t \equiv \exp[d_t^*]$ for $t = 1,2,...,\tau$.

- The next Rolling window regression the data for periods 2, 3,...,$\tau$+1 generates the new set of estimated time parameters, $d_2^{2*} \equiv 1$, $d_3^{2*}$,..., $d_{\tau+1}^{2*}$ and the new set of price levels $P_t^2$ for periods 2 to $\tau$+1, defined as $P_t^2 \equiv \exp[d_t^{2*}]$ for $t = 2,3,...,\tau+1$.

# Rolling Window Hedonic Regressions: Structural Change Adjustments to the Hedonic Index: (3/3)

- Now use only the last two price levels generated by the new regression to define the *final price level* for period $\tau+1$, $P_{\tau+1}$, as the period $\tau$ price level generated by the first regression, $P_{\tau}$, times (one plus) the rate of change in the price level over the last two periods using the results of the second regression model; i.e., define $P_{\tau+1} \equiv P_{\tau}\,(P_{\tau+1}{}^{2}/P_{\tau}{}^{2})$.
- The next step is to repeat the $\tau$ period regression model using the data for the periods 3, 4,...,$\tau+2$ and obtain a new set of estimated time parameters, $d_3{}^{3*} \equiv 1$, $d_4{}^{3*}$,..., $d_{\tau+2}{}^{3*}$.
- $P_t{}^{3} \equiv \exp[d_t{}^{3*}]$ for $t = 3,4,\ldots,\tau+2$ and update $P_{\tau+1}$ by multiplying it by $(P_{\tau+2}{}^{3}/P_{\tau+1}{}^{3})$ so that the final price level for period $\tau+2$ is defined as $P_{\tau+2} \equiv P_{\tau+1}\,(P_{\tau+2}{}^{3}/P_{\tau+1}{}^{3})$. Carry on with the same process until $P_T$ has been defined.

# *Case-Shiller adjustment*:

- Case and Shiller (1987) (1989) address the heteroskedasticity problem in the disturbance term by assuming that the variance of the residual $\upsilon_{its}$ in (7) increases as t and s are further apart; i.e., they assume that $E(\upsilon_{its}) = 0$ and $E(\upsilon_{its})^2 = \xi_0 + \xi_1(t-s)$ where $\xi_0$ and $\xi_1$ are positive parameters.
- First, equation (7) is estimated, and the resulting squared disturbance term is regressed on $\xi_0 + \xi_1(t-s)$ in order to obtain estimates for $\xi_0$ and $\xi_1$.
- Then equation (7) is reestimated by Generalized Least Squares (GLS) where observation i, $\ln(P_{it}/P_{is})$, is adjusted by the weight $[\xi_0^* + \xi_1^*(t-s)]^{1/2}$.
- The Case-Shiller *heteroskedasticity adjusted repeat sales indexes* are then defined by $P_t \equiv \exp[d_t^*]$ for $t = 1,2,\ldots,T$.

# Previous researches about Age-adjusted RS

- Palmquist (1980) proposed a **two-stage method**: first obtain an independent estimate of the deprecation rate from the hedonic price.
- Case and Quigley (1991), Hill,et al (1997), and Englund, et al (1998) offered a similar idea but combined the hedonic and repeat sales regressions into a **hybrid model** for joint estimation.
- Chau, Wong, and Yiu (2005) , Shimizu, Nishimura and Watanabe(2010), Karato, Movshuk and Shimizu (2010) found another instrument to **separate the age and time effects. (cohort effect)**
- Cannaday, Munneke, and Yang (2005) , had to drop two age dummies arbitrarily in order to avoid perfect collinearity, although a high degree of collinearity still remains.


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# *Age-adjustment* to repeat sales index: (1/2)

- To take account of the depreciation effect, we go back to equation (5) and rewrite it as follows:
- (8) $\ln(P_{it}/P_{is}) = d_t - d_s - \beta\delta[(A_{is} + t - s)^{\lambda} - A_{is}^{\lambda}] + \upsilon_{its}$ .
- Note that repeat sales indexes that do not include an age term (such as the term involving $A_{is}$ on the right hand side of the above equation) will suffer from a downward bias.
- McMillen (2003) considered a simpler version of this model with $\lambda = 1$, so that the depreciation rate is constant over time. When $\lambda = 1$, (8) reduces to (9):
- (9) $\ln(P_{it}/P_{is}) = d_t - d_s - \beta\delta(t - s) + \upsilon_{its}$ .
- Note that there is exact collinearity between $d_t - d_s$ and $t - s$, so that it is impossible to obtain estimates for the coefficients on the time dummies.

# *Age-adjustment* to repeat sales index: (2/2)

- Once the $d_t$ parameters have been estimated by maximum likelihood or nonlinear least squares (denote the estimates by $d_t^*$ with $d_1^*$ set equal to 0), then the *Shimizu, Nishimura and Watanabe repeat sales indexes* $P_t$ are defined as $P_t \equiv \exp[d_t^*]$ for t = 1,2,...,T.
- This is in sharp contrast with the hedonic regression model defined by (4), in which β appears not only as a coefficient of the age term but also as a coefficient on $\ln B_i$, so that β and δ are identified.
- **Shimizu, Nishimura and Watanabe (2010), Chau, Wong and Yui (2005), Wong, Chau, Karato, Shimizu(2013) "Separating the Age Effect from a Repeat Sales Index: Land and structure decomposition"**

# Alternative models: Hybrid Model

- Hybrid Model and Hedonic Model

$$y_{it} \equiv \ln P_{it} = X_i'\beta + \delta A_{it} + \alpha_t + \varepsilon_{it}$$

Hill, Knight, and Sirmans (1997) distinguished the time effect and age effect by refining Case and Quigley's (1991).

$$Y_i = y_{it} - y_{is} = \ln \frac{P_{it}}{P_{is}} = \tau_i \delta + \alpha_t - \alpha_s + v_i$$

$$(i = 1, 2, \cdots, N_R)$$

$$\begin{pmatrix} y \\ Y \end{pmatrix} = \begin{pmatrix} X & A & d \\ 0 & \tau & D \end{pmatrix} \begin{pmatrix} \beta \\ \delta \\ \alpha \end{pmatrix} + \begin{pmatrix} \varepsilon \\ \upsilon \end{pmatrix}$$

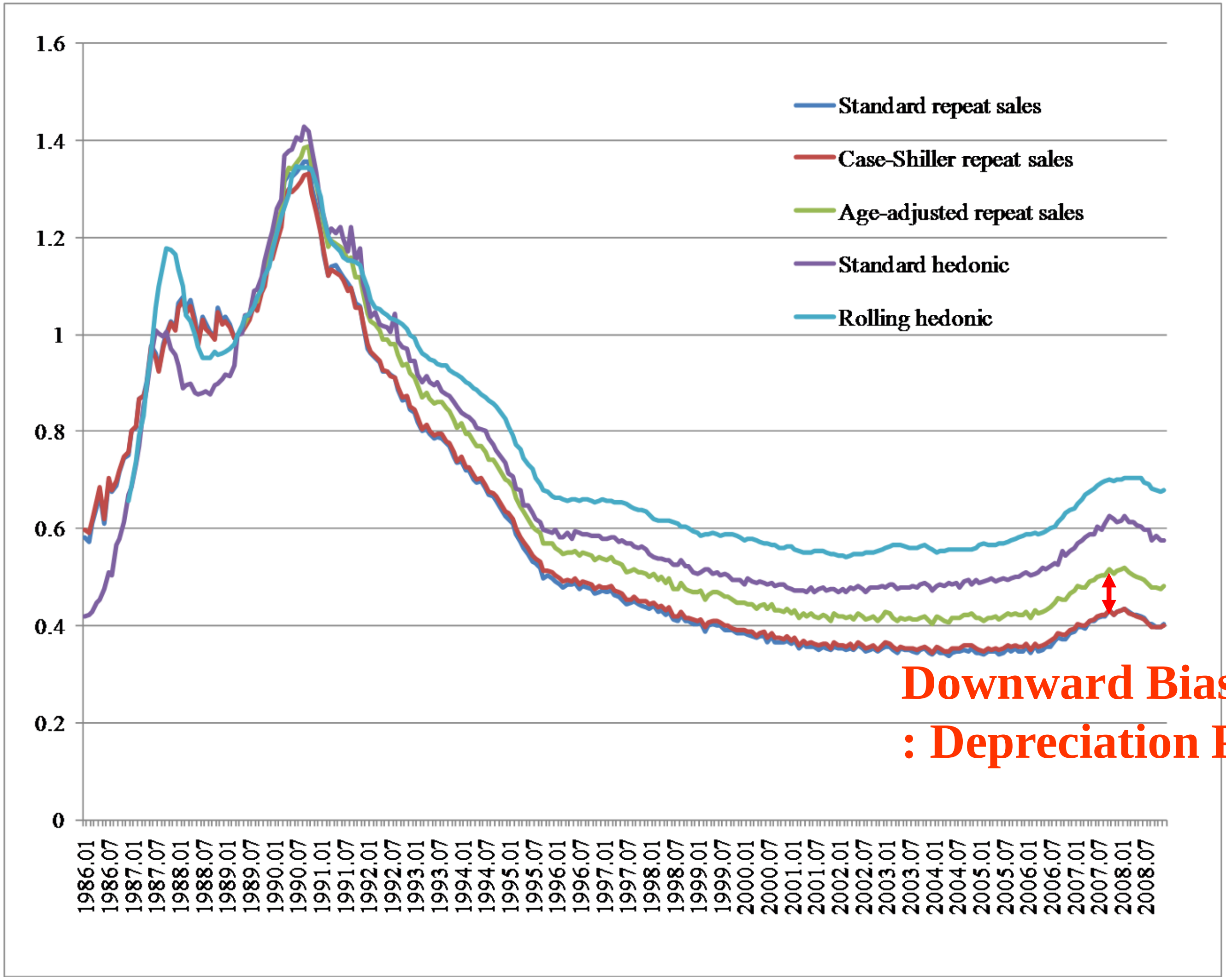
$$\ln P_{it} = X_i'\beta + \delta \frac{A_{it}^{\lambda} - 1}{\lambda} + \alpha_t + \varepsilon_{it}$$

# Alternative models: Builders Model

- *"At the national level, statistical agencies need to construct overall values of land and structures for the National Balance Sheets for the nation. If a user cost approach is applied to the valuation of Owner Occupied Housing services, it is necessary to have a decomposition of housing values into land and structures components* ***since structures depreciate while land does not.*** *"*

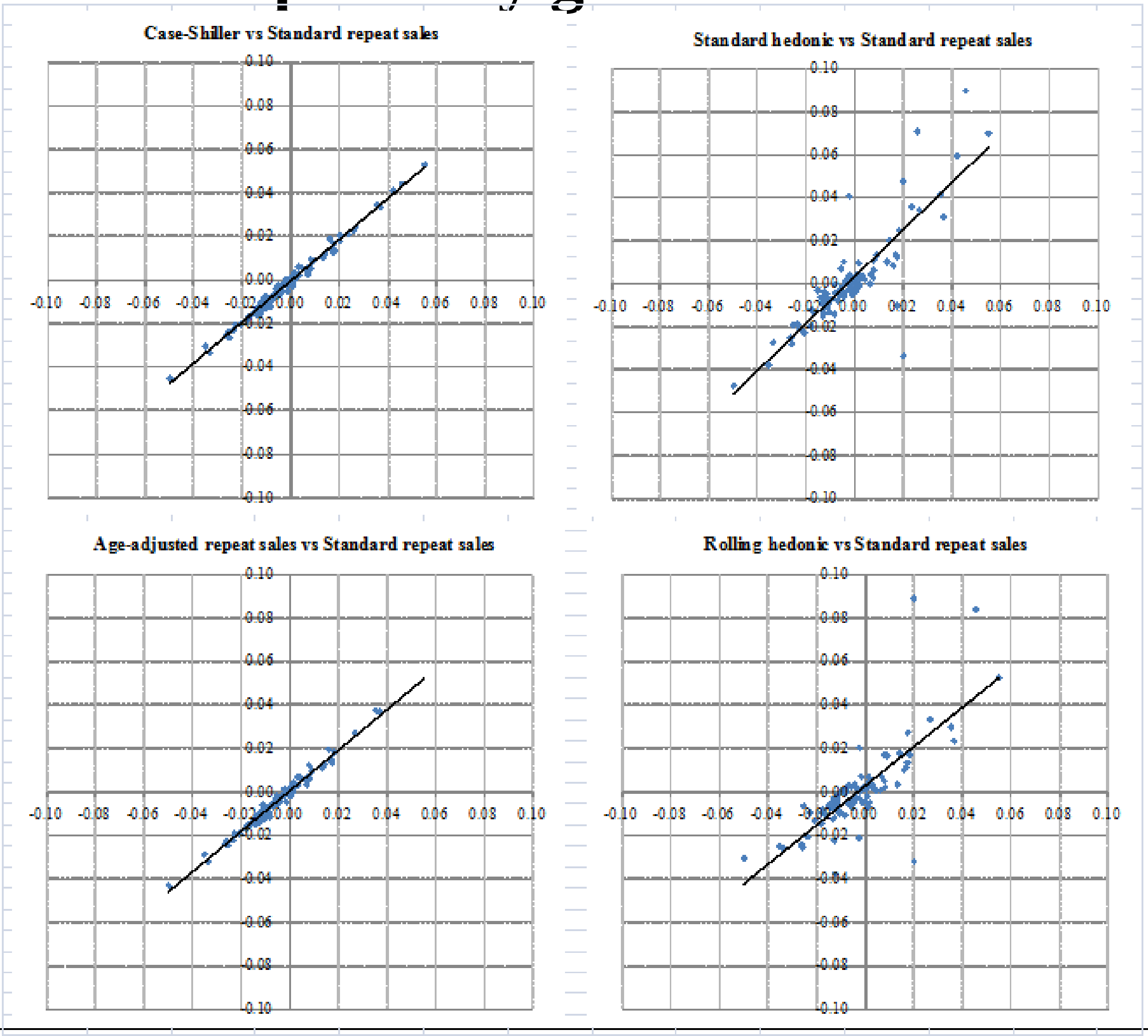
- Diewert, W. E. and C. Shimizu (2013), "Residential Property Price Indexes for Tokyo," Discussion Paper 13-07, Vancouver School of Economics, University of British Columbia. ***Macroeconomic Dynamics***, forthcoming.

# Estimated five indices for condominiums




**Downward Bias**
**: Depreciation Problem**

# Comparison of the five indexes in terms of the quarterly growth rate



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# Pairwise Granger-causality tests

Condominiums

| | Standard repeat sales | Case-Shiller repeat sales | Age-adjusted repeat sales | Standard hedonic | Rolling hedonic |
|---|---|---|---|---|---|
| Standard repeat sales | | 0.0120 | 0.0019 | 0.0039 | 0.0000 |
| Case-Shiller RS | 0.2018 | | n.a. | 0.0398 | 0.0000 |
| Age-adjusted RS | 0.0568 | n.a. | | 0.1258 | 0.0000 |
| Standard hedonic | 0.0004 | 0.0001 | 0.0000 | | 0.0000 |
| Rolling hedonic | 0.0053 | 0.0082 | 0.0022 | 0.1528 | |

Single family houses

| | Standard repeat sales | Case-Shiller repeat sales | Age-adjusted repeat sales | Standard hedonic | Rolling hedonic |
|---|---|---|---|---|---|
| Standard repeat sales | | 0.2726 | 0.4345 | 0.1919 | 0.0048 |
| Case-Shiller RS | 0.2397 | | n.a. | 0.1810 | 0.0088 |
| Age-adjusted RS | 0.3275 | n.a. | | 0.1962 | 0.0078 |
| Standard hedonic | 0.0028 | 0.0028 | 0.0027 | | 0.0048 |
| Rolling hedonic | 0.0812 | 0.0784 | 0.0781 | 0.1089 | |

Note: The number in each cell represents the p-value associated with the null hypothesis that the variable in the row does not Granger-cause the variable in the column.



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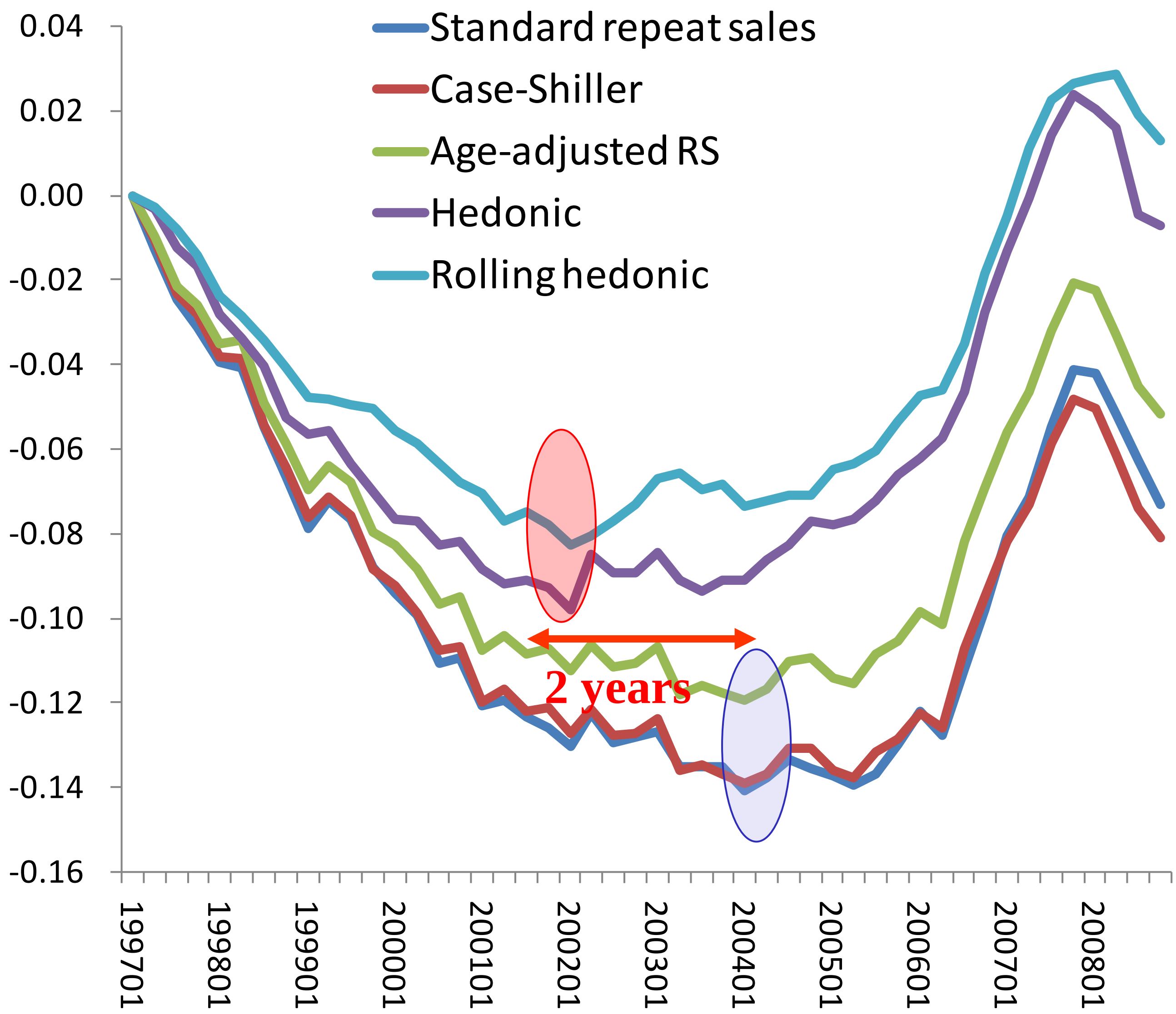
# When did the condominium price hit bottom?





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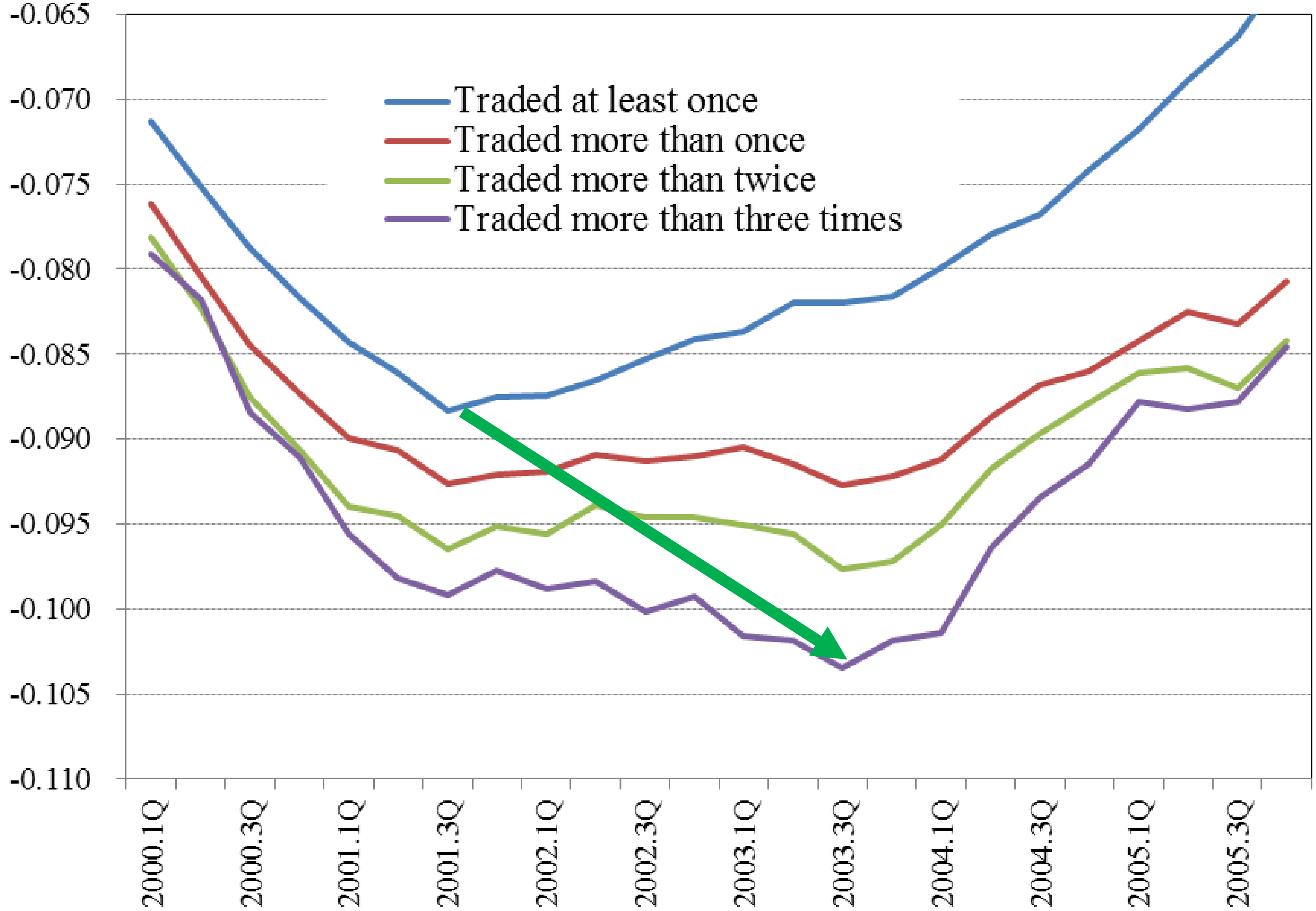
# Hedonic indexes estimated using repeat-sales samples

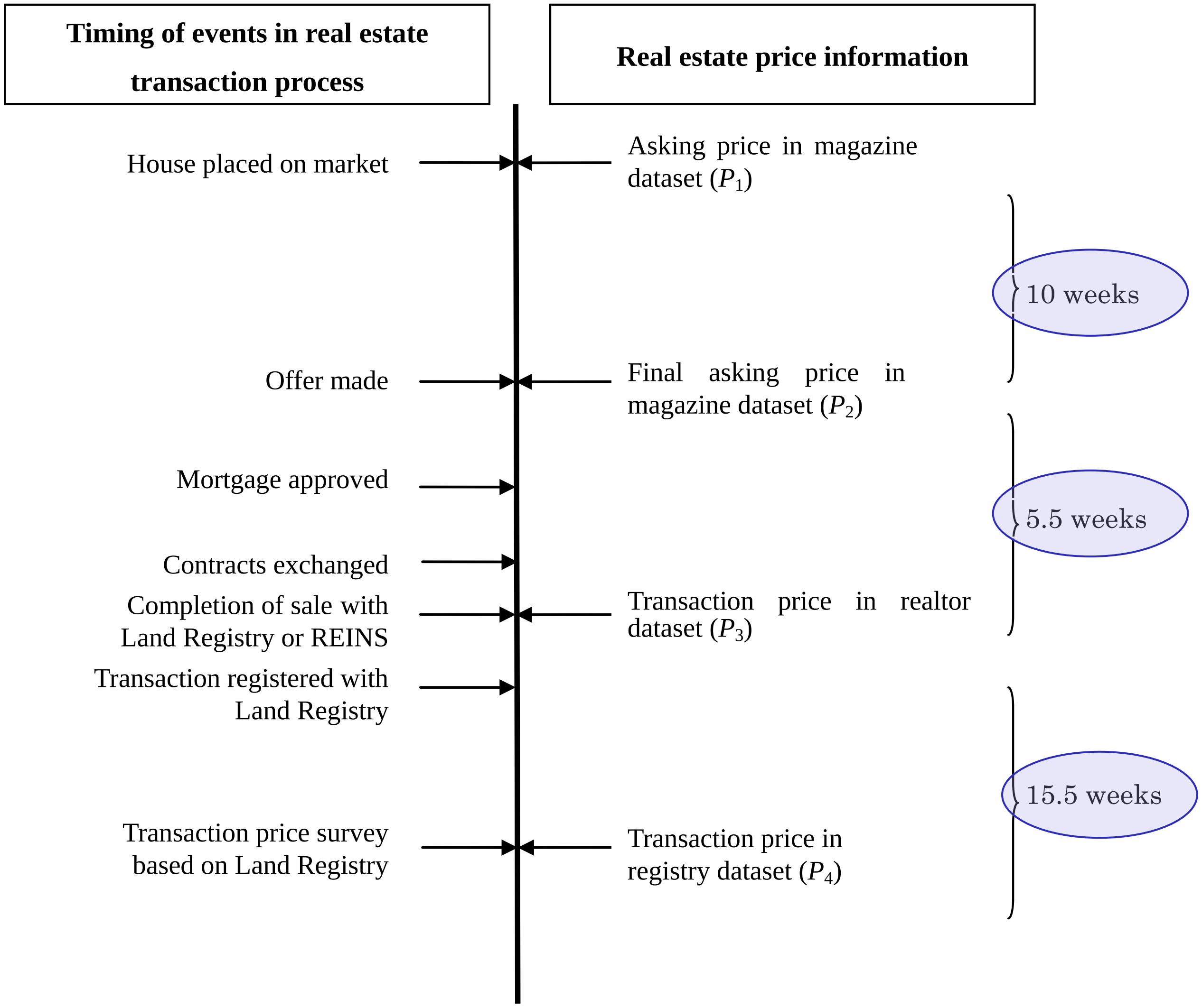


# The Selection of Data Sources for the Construction of Housing Price Indexes

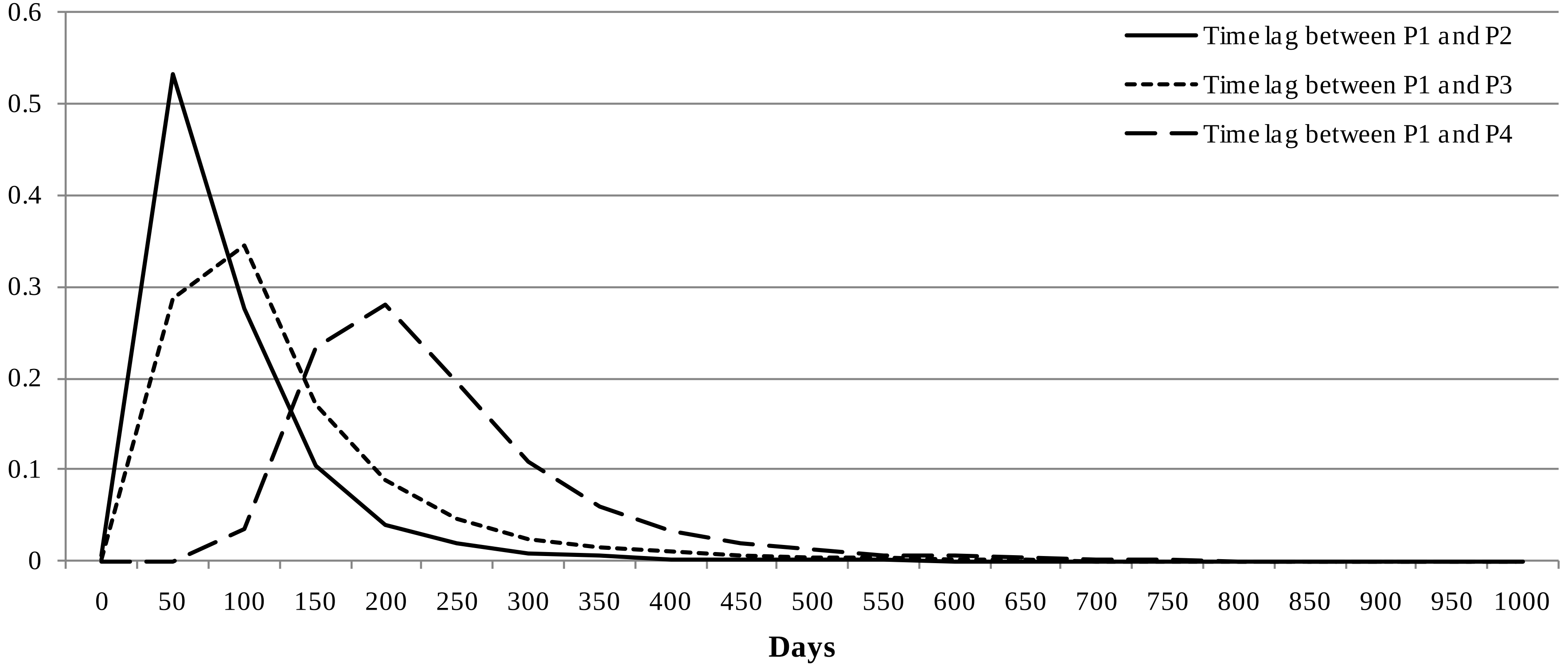
- Are house prices different depending on the stages of the buying/selling process?

- We address this question by comparing the distributions of prices collected at different stages of the buying/selling process, including:
- **(1) initial asking prices listed on a magazine,**
- **(2) asking prices at which an offer is made by a buyer,**
- **(3) contract prices reported by realtors after mortgage approval,**
- **(4) registry prices.**

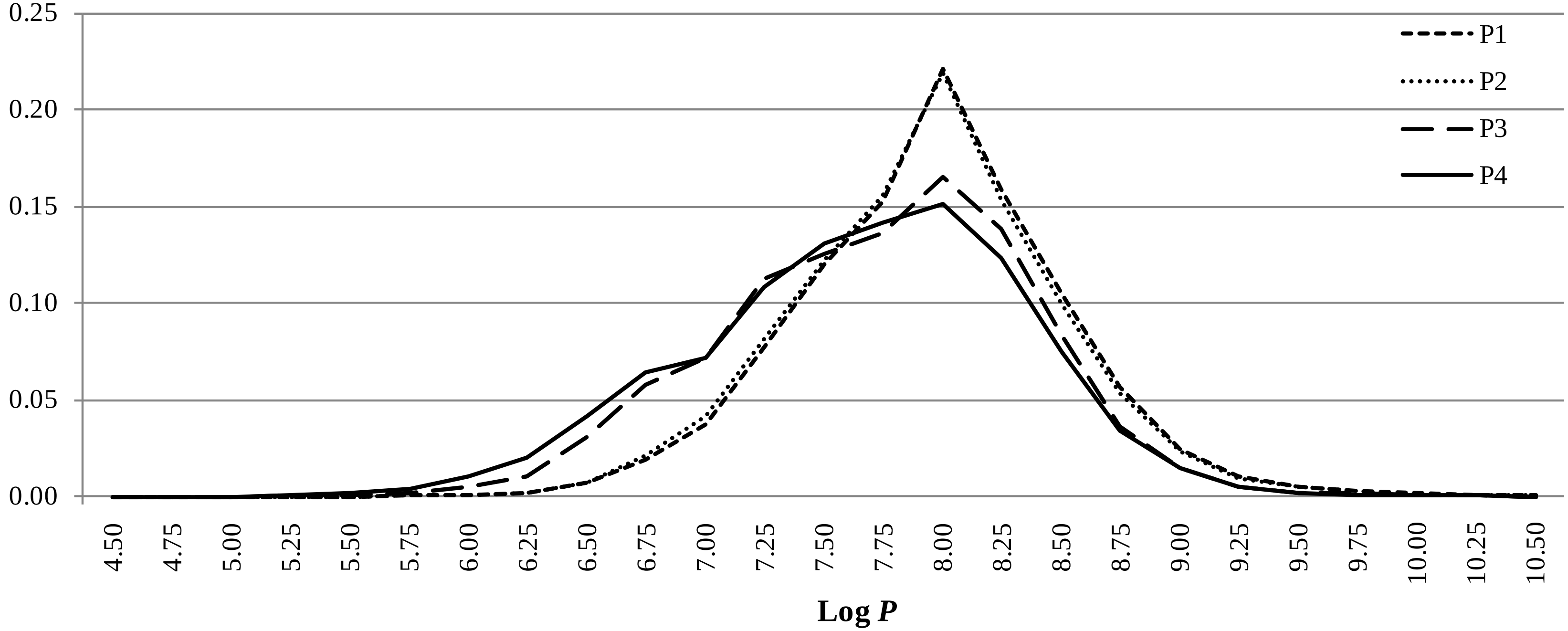
# House purchase timeline



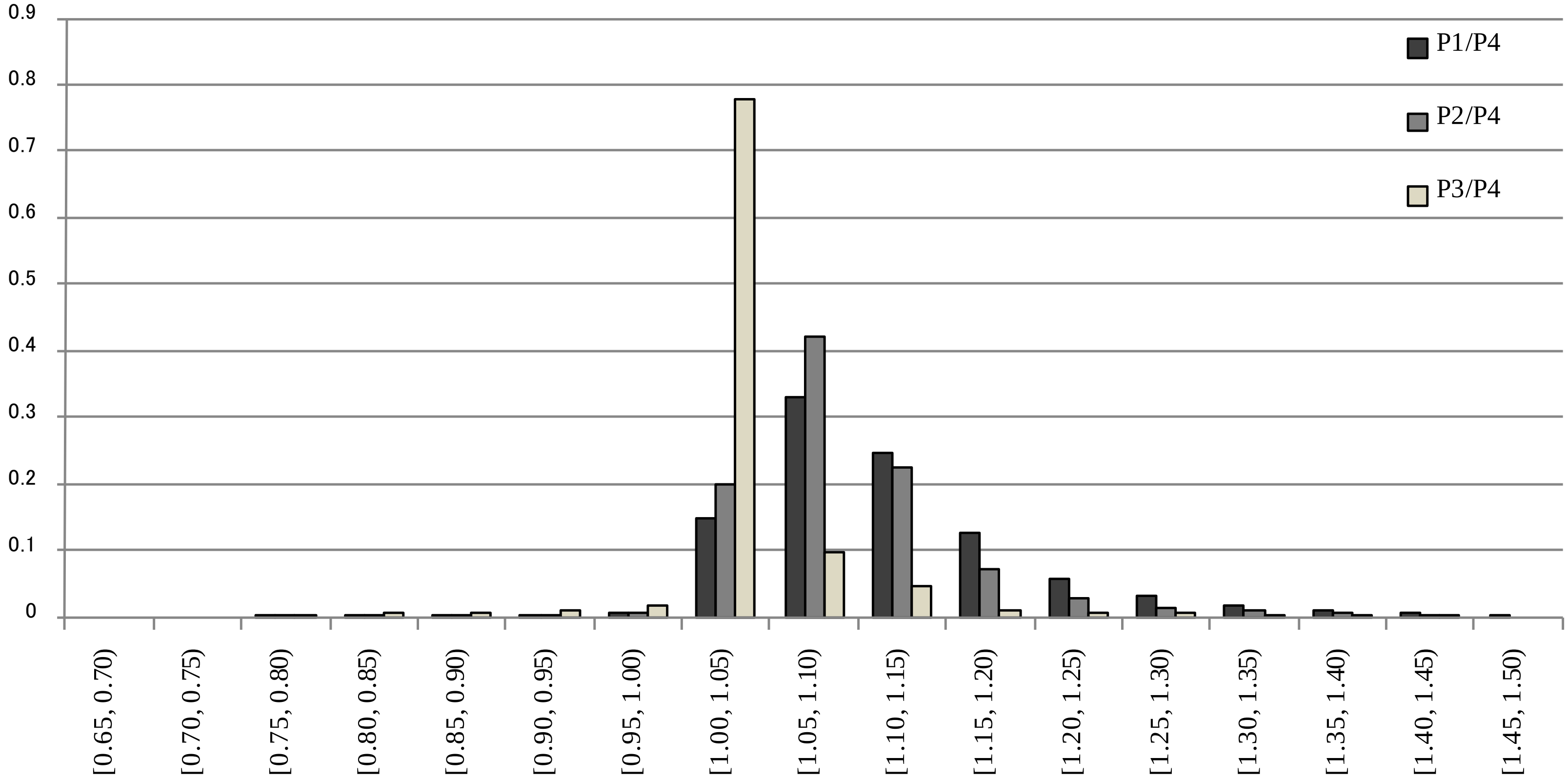
# Intervals between events in the house buying/selling process



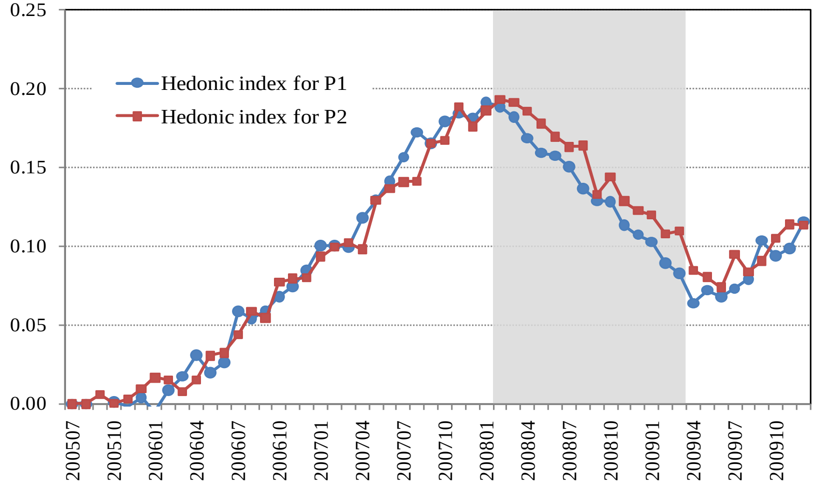
# Price densities for $P_1$, $P_2$, $P_3$, and $P_4$

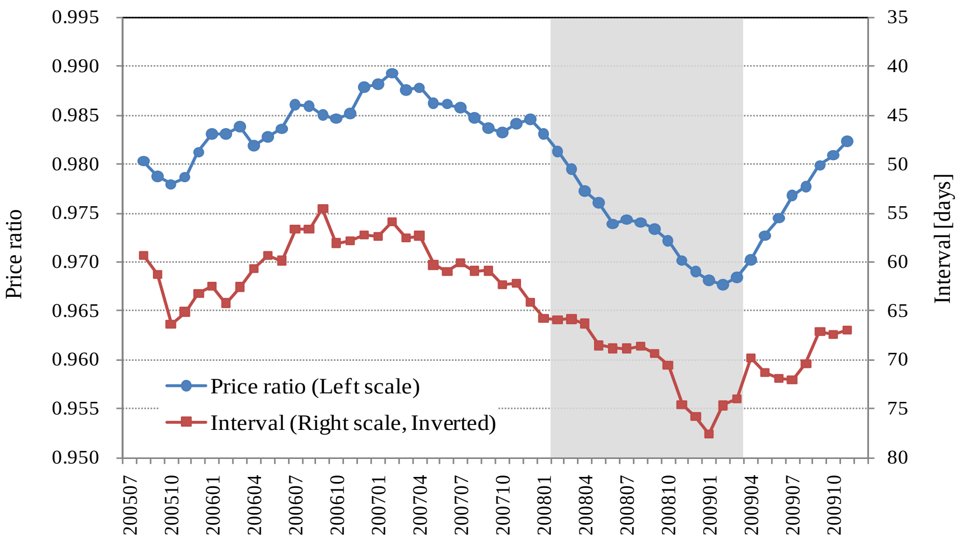


# Densities for relative prices



# Fluctuations in the price ratio and the interval for $P_1$ and $P_2$



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# Turning point of two indicators

- The hedonic index for P1 declined by more than ten percent during the period between March 2008 and April 2009 indicated by the shaded area.
- 
- During this downturn period, the price ratio exhibited a substantial decline, and more interestingly, changes in the price ratio preceded changes in the hedonic indexes.
- The price ratio started to decline in December 2007, three months earlier than the hedonic index for P1, and bottomed out in February 2009, two months earlier than the hedonic index for P1.

# 3. Conclusions:

- By the stickiness or rigidity of housing rent, CPI does not work well as a mirror of housing prices.
- In the wake of the release of the *Residential Property Price Indices Handbook*, the following questions arise:
- Q1: Do the different methods suggested in the Eurostat Handbook lead to different estimates of housing price changes?
- Q2: If the methods do generate different results, which method should be chosen.
- Q3: Which data source should be used for housing information?
- **RPPI to CPPI, Commercial Property Price Indexes.**



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# Response to Q1 and Q2: Methods for RPPI

- 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**.


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# Case of Japanese RPPI: Methods

- The question of which method is "***best***" remains open but the depreciation bias in the standard repeat sales method tends to lead us to prefer ***hedonic methods***.

- **Given these results, the government of Japan decided to prepare an official residential property price index based on the hedonic method.**

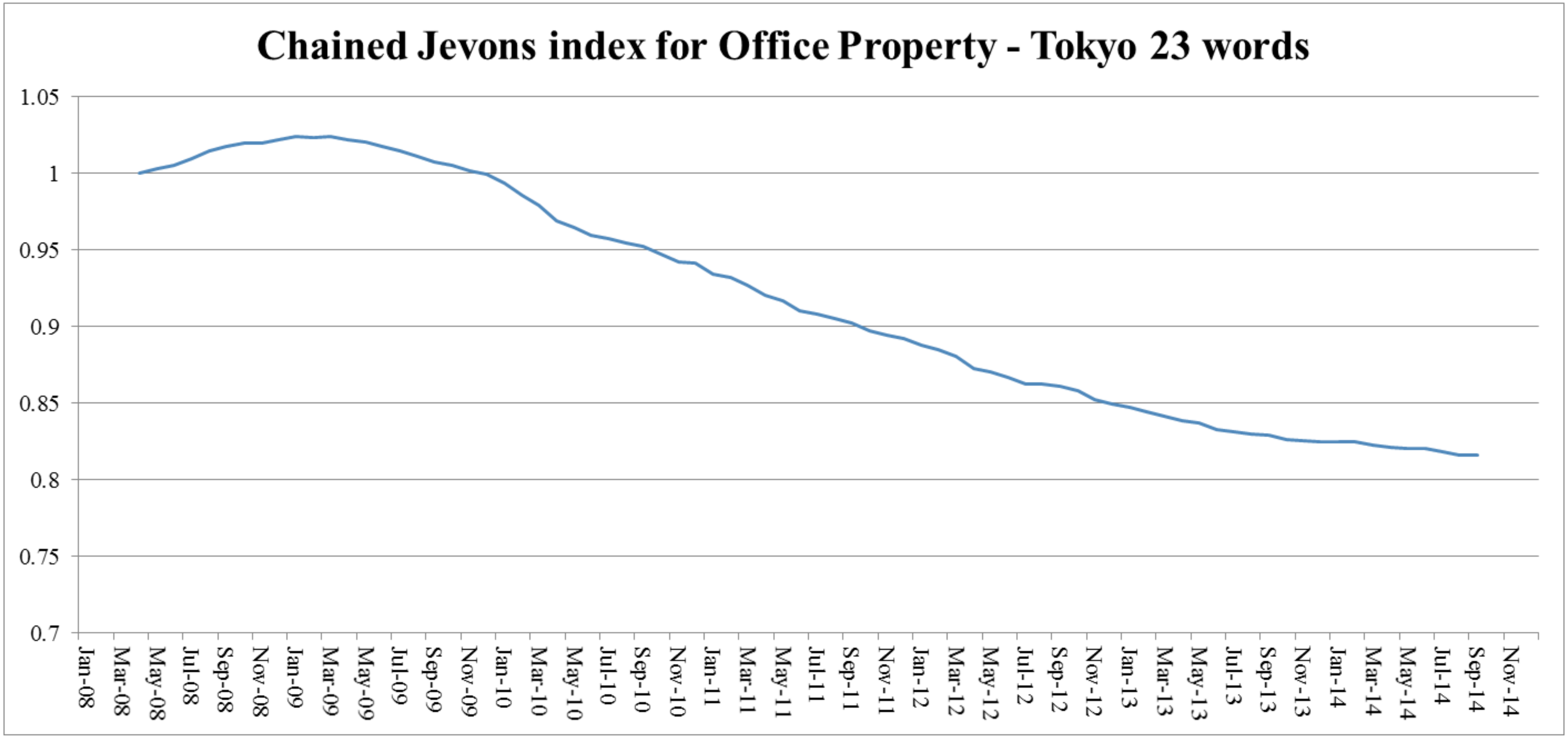
- In particular, it has been determined that it will be estimated with the ***rolling window hedonic method*** proposed by Shimizu, Takatsugi, Ono and Nishimura (2010) and Shimizu, Nishimura and Watanabe (2010) and system development is underway.

# Annex:

# Future Work:
# "Rigidity of *Office* Rent" and "*Office* Rent and PPI"

| | | | | | | |
|---|---|---|---|---|---|---|
| Sample period | April 2008 - September 2014 | | | | | |
| Frequency | Monthly | | | | | |
| Geographical scope | Tokyo 23 wards | | | | | |
| Data type | Actual rent | | | | | |
| Coverage | New contract and renewed contract | | | | | |
| Provider | XYMAX | | | | | |
| No. of rooms | 2,975 | | | | | |
| Sample size | Whole sample | | New contract | | Renewed contract | |
| | 115,529 | | 3,774 | | 3,056 | |
| | mean | s.d. | mean | s.d. | mean | s.d. |
| Rent | 2,119,543.2 | 3,815,365.2 | 2,051,398.8 | 4,260,888.4 | 2,144,011.2 | 3,014,086.9 |
| $m^2$ | 405.8 | 415.4 | 383.3 | 395.6 | 424.0 | 434.9 |
| $m^2$ unit rent | 5,048.5 | 15,568.8 | 5,132.8 | 18,285.7 | 4,815.4 | 3,300.3 |

# Chained Jevons Index for Office Property



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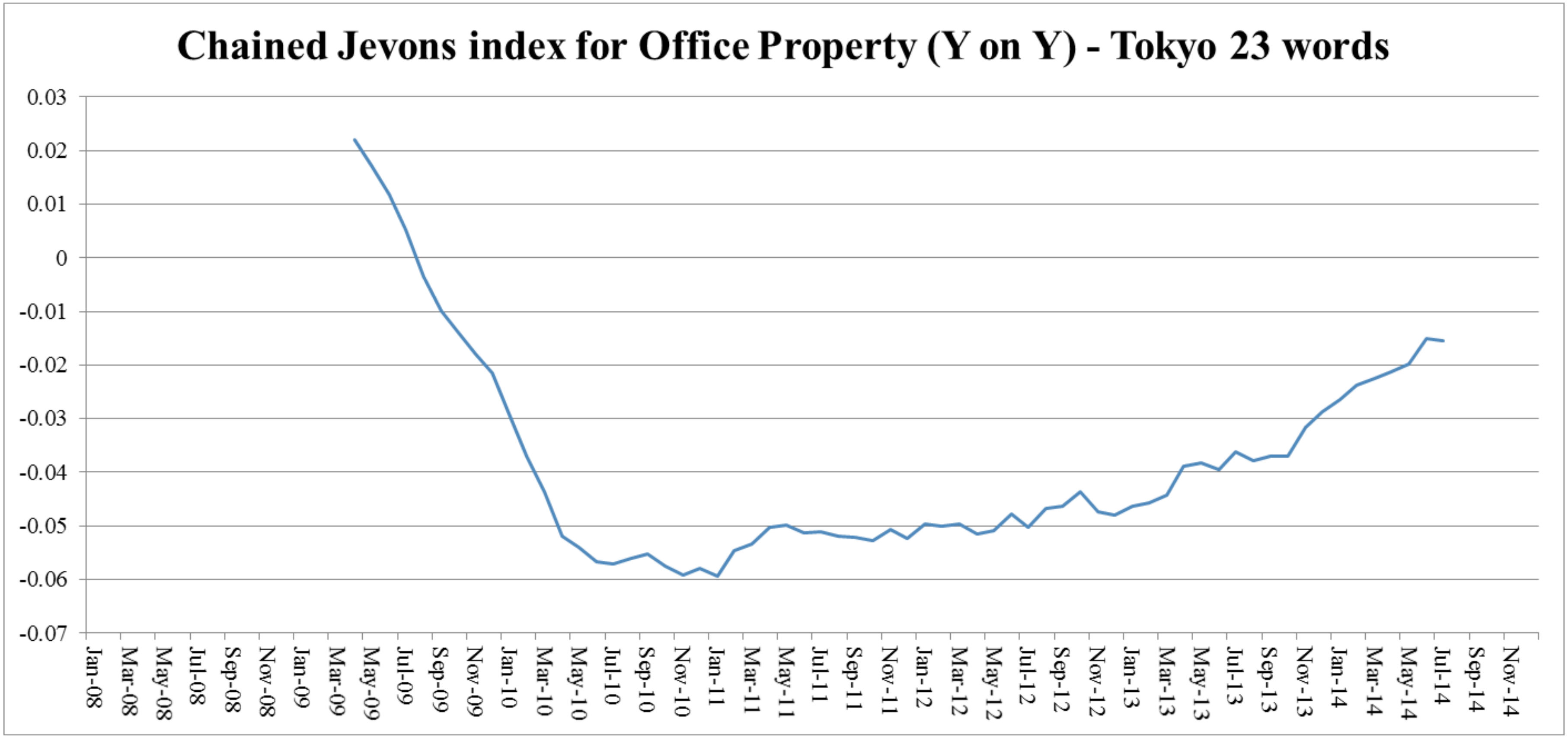
# Chained Jevons Index for Office Property (Y on Y)



# Comparison of Frequency of Rent Adjustments: Office vs. Residential

## Office

| | Negative | Zero | Positive | Number of Observations | (Change) |
|---|---|---|---|---|---|
| Turnover units | 226 | 3,032 | 516 | 3,774 | 742 |
| | (0.060) | (0.803) | (0.137) | (0.553) | (0.197) |
| Rollover units | 677 | 2,214 | 165 | 3,056 | 842 |
| | (0.222) | (0.724) | (0.054) | (0.447) | (0.276) |
| All units | 903 | 5,246 | 681 | 6,830 | 1,584 |
| | (0.132) | (0.768) | (0.100) | (1.000) | (0.232) |

## Residential

| | Negative | Zero | Positive | Number of Observations | (Change) |
|---|---|---|---|---|---|
| Turnover units | 4,473 | 34,958 | 967 | 40,398 | 5,440 |
| | (0.111) | (0.865) | (0.024) | (0.535) | (0.135) |
| Rollover units | 1,169 | 33,667 | 303 | 35,139 | 1,472 |
| | (0.033) | (0.958) | (0.009) | (0.465) | (0.042) |
| All units | 5,642 | 68,625 | 1,270 | 75,537 | 6,912 |
| | (0.075) | (0.908) | (0.017) | (1.000) | (0.092) |



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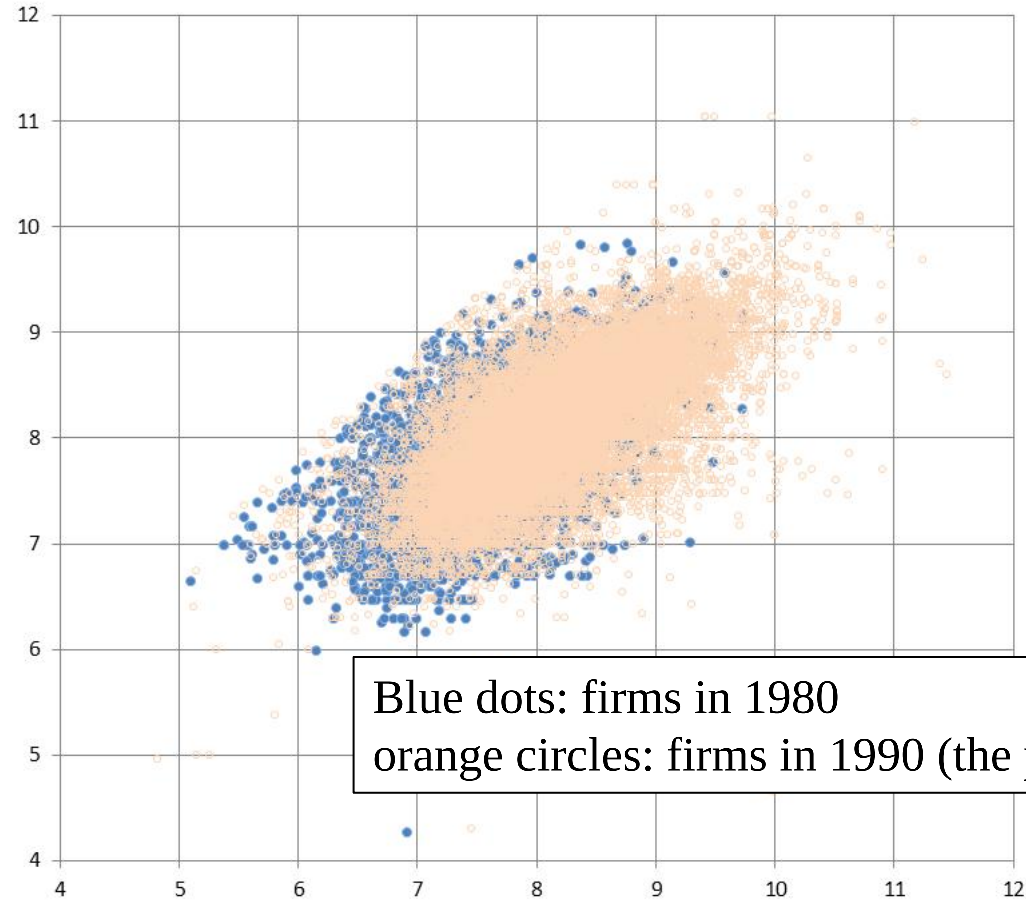
# Scatter plot of property values and bank lending in 1980 and 1990

Bank lending to firms [in log]




Blue dots: firms in 1980
orange circles: firms in 1990 (the peak of the bubble)

Value of land pledged as collateral by firms [in log]



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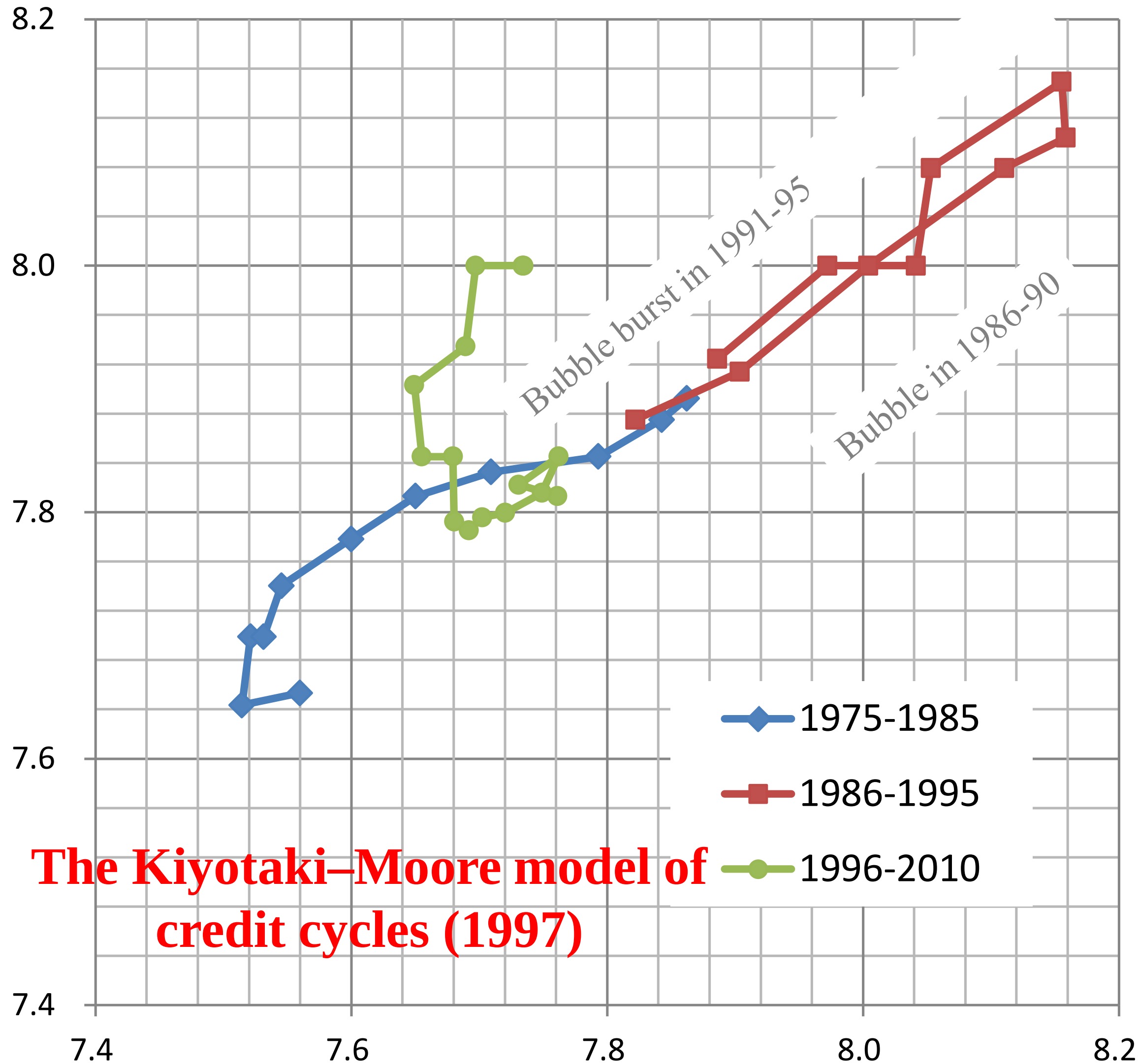
Bank lending to median firm [in log]




Value of land pledged as collateral by median firm [in log]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# Reestimates of CPI Inflation
# Imputed rent for owner occupied housing

## The rental equivalence approach:

"The rental equivalence approach values the services yielded by the use of a dwelling by the corresponding ***market value*** for the same sort of dwelling for the same period of time (if such a rental value exists)." (Diewert and Nakamura 2008)

"If someone were to rent your home ***today***, how much do you think it would rent for monthly, unfurnished and without utilities?" (BLS)


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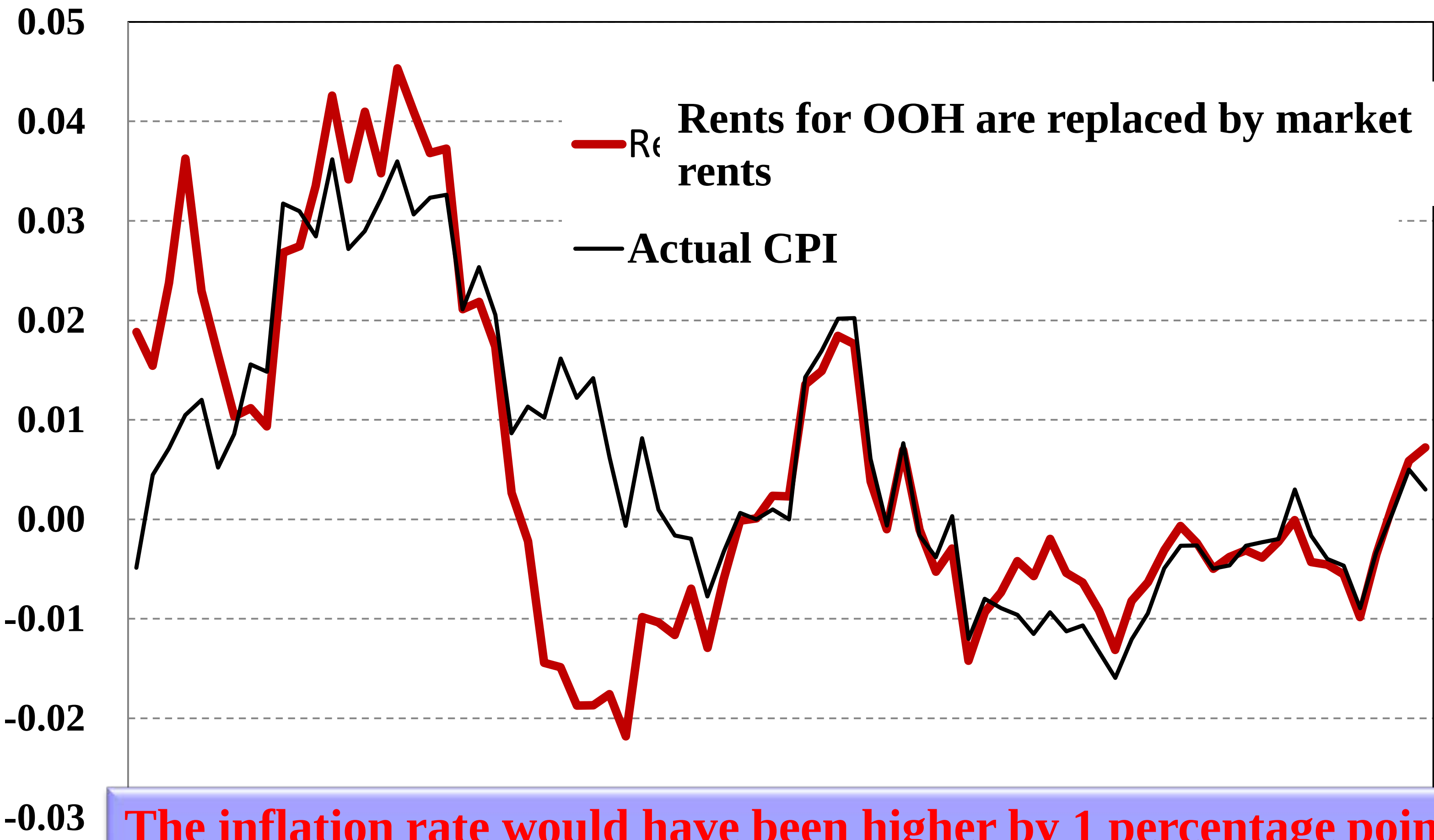
# Alternative measures of CPI inflation




**The inflation rate would have been higher by 1 percentage point during the bubble period and lower by 2 percentage points during the post-bubble period, if the market price were used in estimating the rent index for owner occupied housing**

# An age-adjusted repeat sales model

- Value (P) is the sum of land value (L) and structure value (S). The value of a new property is:

- $P(0) = L + S(0)$

- After A periods, the property reaches age A.
- $P(A) = L + S(0) \times (1 - \delta \boldsymbol{A})$

- $P(A) = L + S(0) \times [1 - \delta \boldsymbol{g}(\boldsymbol{A})]$

# Depreciation for Property

***Ratio of new structure value to new property value**

- $$\frac{P(A)-P(0)}{P(0)} = -\underbrace{\boxed{\frac{\boldsymbol{S(0)}}{\boldsymbol{P(0)}}}}_{\boldsymbol{R(0)}}\delta g(A)$$

(a) The same δ (e.g. building technology) for all structures, properties in a high land value area would depreciate more slowly than those in a low land value area.

(b) If the structure depreciates at a constant rate, the property's depreciation rate is likely to be time-varying because structure and land values do not move at the same pace.

# Price Structure

- Hedonic price equation:
- Age term: $\frac{P(A)-P(0)}{P(0)} = -\frac{\boldsymbol{S(0)}}{\boldsymbol{P(0)}}\delta g(A)$
- $$lnP_{it} = X_i\beta + \alpha_t - \delta \boldsymbol{R_t} g(A_{it}) + \varepsilon_{it}$$
- A non-linear depreciation pattern of the structure, the age function, ***g(A$_{it}$)***, adopts the Box-Cox transformation as shown in Equation6
- $$g(A_{it}) = \frac{A_{it}^{\lambda}-1}{\lambda}$$

# An age-adjusted repeat sales model

- Property *i* is sold twice at time ***s*** and ***t*** (where *t*>*s*) and there is no change in property attributes between the sales.
- Age-adjusted repeat sales model can be derived from the (*t*-*s*)th difference of Equation 5:

- $$\ln\left(\frac{P_{it}}{P_{is}}\right) = (\alpha_t - \alpha_s) - \delta[R_t g(A_{it}) - R_s g(A_{is})]$$
- $$+ (\varepsilon_{it} - \varepsilon_{is})$$

- ($t$) $lnP_{it} = X_i\beta + \alpha_t - \delta \boldsymbol{R_t} g(A_{it}) + \varepsilon_{it}$
- ($s$) $lnP_{is} = X_i\beta + \alpha_s - \delta \boldsymbol{R_s} g(A_{is}) + \varepsilon_{is}$