

# The Estimation of Owner Occupied Housing Indexes using the RPPI: The Case of Tokyo

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with

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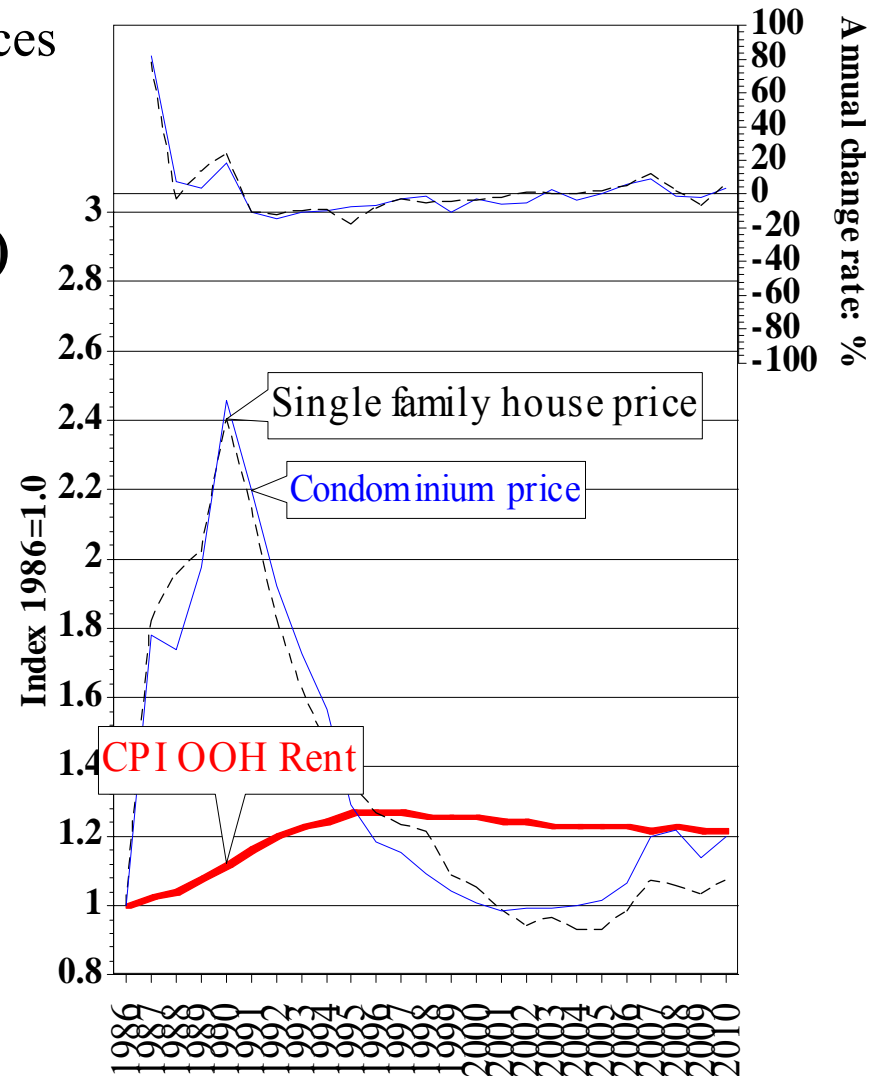
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**Tsutomu Watanabe** (University of Tokyo).

# I . Housing prices and OOH rent for CPI.

The most important link between asset prices and goods & services prices is the one through housing rents (**Diewert and Nakamura 2011, Goodhart 2001**)

1. Housing rents account for **more than one fourth of personal spending.**
2. Imputed Rent for OOH also represents a weight of approximately 10% in the SNA  
**2009= 10.1%, 2010 =9.85%**



## II. How should we estimate OOH Imputed rent?.

### The User Cost Approach

### The Equivalent Rent Approach

$$V_v^t = \frac{y_v^t}{1+r^t} + \frac{y_{v+1}^{t+1}}{(1+r^t)(1+r^{t+1})} + \dots + \frac{y_{m-1}^{t+m-v-1}}{\prod_{i=t}^{t+m-v-1} (1+r^i)}$$

$$- \frac{O_v^t}{1+r^t} - \frac{O_{v+1}^{t+1}}{(1+r^t)(1+r^{t+1})} - \dots - \frac{O_{m-1}^{t+m-v-1}}{\prod_{i=t}^{t+m-v-1} (1+r^i)}$$

- $V_v^t$  : the initial asset value for the period  $t$ .
- $y_v^t$  : the income corresponding to  $V_v^t$ .
- $O_v^t$  : the operating income to be paid at the end of the period  $t$ .
- $r^t$  : the expected nominal discount (interest) rate for period  $t$ .

## Estimation Problems in the User Cost Approach.

**Basic User Cost:** **Asset Value**

$$u_v^t = \underbrace{r^t}_{\text{Interest Rate}} \underbrace{V_v^t}_{\text{Asset Value}} + \underbrace{O_v^t}_{\text{Expense}} - \underbrace{(V_{v+1}^{t+1} - V_v^t)}_{\text{Asset Value Increase}}$$

**Interest Rate**   **Expense**   **Asset Value Increase**

- **Estimation Method:**
- The estimation method is complicated.
- **Negative problem:**
- The value becoming negative during periods of dramatic price increases.
- **Volatility problem:**
- Housing price volatility becoming greater than what it is perceived by market players.

## Estimation Problems in the Equivalent Rent Approach.

- **1. Market structure disparities between the owner-occupied housing and the rental housing.**
- The average floor space (size) of housing in Tokyo: **Housing and Land Survey 2008**.
- **Single-family houses:**
- 110.71 square meters for owner-occupied housing and 79.36 square meters for rental housing
- **Condominiums:**
- 65.84 square meters for owner-occupied housing and 36.06 square meters for rental housing
- **2. Problem in Rent Survey.**
- The rent surveyed via consumer price statistics is the household's paying rent, there is a strong possibility that there is a major discrepancy with the rent determined by the current market. Paying rent not opportunity cost.

### III. Diewert's OOH Opportunity Cost Approach.

- **Diewert(2006):**
- “Perhaps the correct opportunity cost of housing for an owner occupier is not his or her internal user cost but the maximum of the internal user cost, which is the financial opportunity cost of housing, and what the property could rent for on the rental market. After all, the concept of opportunity cost is supposed to represent the maximum sacrifice that one makes in order to consume or use some object.”
- **Diewert’s OOH Opportunity Cost Approach:**
- (Financial) User Cost  $>$  or  $<$  Equivalent rent

# Diewert's Financial User Cost.

**Generalized Case:** Type B. Homeowner do not fully own their homes, but have positive home equity:

$$u^t \Big|_{typeB} \equiv r_D^t \boxed{D^t} + r^t (V^t - \boxed{D^t}) + O^t - \underbrace{(V^{t+1} - V^t)}.$$

**Asset Value**
**Expense**

**Interest**
**Interest**
**Debt**
**Expected Capital Gain**

**Rate for**
**Rate for**

**Mortgage**
**Investment**

**Type A. Homeowner owns their home (full equity):**

$$u^t \Big|_{typeA} \equiv r^t V^t + O^t - \overline{(V^{t+1} - V^t)}.$$

**Type C. Homeowner have zero home equity:**

$$u^t \Big|_{typeC} \equiv r_D^t \boxed{D^r} + O^t - \overline{(V^{t+1} - V^t)}.$$

## Diewert's OOH Opportunity Cost Approach.

- The term opportunity cost refers to the cost of the best alternative that must *be forgone in taking the option chosen*.
- **Option0**: Homeowner continue to live the home.
- → *Opportunity Cost* associated with **Option0**.
- **Option1**: Selling at the beginning of period  $t$  and buy back at the  $t+1$  .→ *User Cost*.
- **Option2**: Renting out from  $t$  to  $t+1$ . → *Equivalent Rent*.

- $t+0$ , **Option1 (User Cost)** > **Option2 (E. Rent)** = **Option1**
- $t+1$ , **Option1 (User Cost)** < **Option2 (E. Rent)** = **Option2**



# Estimated Result of Hedonic Equations.

$$\mu_{ijt} = X_{it}\beta_t + \nu_{it}$$

**Housing rent: For Equivalent Rent.**  
**Single family house price, Condominium price, and land price: For User Cost.**

**Housing rent model**

Year	Intercept	logS	logA	logTS	logTT	LGT	Number	Adj.R2
1990	2.83	-0.21	-0.05	-0.03	-0.21	-0.10	33,172	0.71
1991	3.01	-0.22	-0.05	-0.03	-0.21	-0.10	17,622	0.69
1992	3.00	-0.23	-0.06	-0.03	-0.20	-0.08	18,741	0.69
1993	3.03	-0.23	-0.07	-0.03	-0.21	-0.07	22,257	0.70
1994	3.14	-0.21	-0.10	-0.04	-0.22	-0.07	29,477	0.67
1995	3.15	-0.24	-0.10	-0.04	-0.22	-0.07	25,815	0.67
1996	3.11	-0.24	-0.10	-0.04	-0.22	-0.07	28,487	0.67
1997	3.14	-0.24	-0.10	-0.04	-0.22	-0.07	23,718	0.67
1998	3.17	-0.24	-0.10	-0.04	-0.22	-0.07	21,115	0.67
1999	3.18	-0.24	-0.10	-0.04	-0.22	-0.07	20,824	0.67
2000	3.11	-0.24	-0.10	-0.04	-0.22	-0.07	23,297	0.67
2006	3.16	-0.27	-0.03	-0.05	-0.22	-0.03	67,287	0.73
2007	3.18	-0.27	-0.03	-0.06	-0.23	-0.02	50,159	0.75
2008	3.16	-0.29	-0.04	-0.05	-0.20	-0.02	35,409	0.76
2009	3.00	-0.30	-0.04	-0.05	-0.16	0.00	21,700	0.76
2010	2.86	-0.31	-0.05	-0.05	-0.13	-0.01	19,258	0.78

\*The dependent variable in each case is the log price per square meter.

\*\*The table indicate the coefficient of main variables which a part of hedonic estimation results per year.

\*\*\*Estimation Method: Robust Regression

# Estimated Result of Hedonic Equation for Condominium Price Indexes

## Condominium price model

Year	Intercept	logS	logA	logTS	logTT	RC	Number	Adj.R2
1986	4.872	-0.019	-0.152	-0.026	-0.179	-0.007	7,604	0.65
1987	5.159	0.061	-0.139	0.004	-0.272	-0.034	6,312	0.71
1988	6.058	-0.072	-0.166	-0.018	-0.295	-0.025	7,368	0.72
1989	6.386	-0.097	-0.176	-0.030	-0.300	-0.020	15,336	0.73
1990	6.803	-0.143	-0.159	-0.017	-0.334	-0.024	13,680	0.75
1991	6.803	-0.143	-0.159	-0.017	-0.334	-0.024	13,680	0.75
1992	6.803	-0.143	-0.159	-0.017	-0.334	-0.024	13,680	0.75
1993	6.803	-0.143	-0.159	-0.017	-0.334	-0.024	13,680	0.75
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2000	6.803	-0.143	-0.159	-0.017	-0.334	-0.024	13,680	0.75
2001	6.803	-0.143	-0.159	-0.017	-0.334	-0.024	13,680	0.75
2002	6.803	-0.143	-0.159	-0.017	-0.334	-0.024	13,680	0.75
2003	6.803	-0.143	-0.159	-0.017	-0.334	-0.024	13,680	0.75
2004	6.803	-0.143	-0.159	-0.017	-0.334	-0.024	13,680	0.75
2005	6.803	-0.143	-0.159	-0.017	-0.334	-0.024	13,680	0.75
2006	5.125	0.020	-0.218	-0.046	-0.193	-0.012	12,853	0.71
2007	4.877	0.054	-0.206	-0.041	-0.163	-0.014	13,693	0.74
2008	4.909	0.067	-0.206	-0.053	-0.158	-0.023	14,150	0.72
2009	5.042	0.072	-0.226	-0.055	-0.196	-0.031	10,920	0.72
2010	5.243	0.034	-0.219	-0.042	-0.224	-0.023	15,468	0.72

\*The dependent variable in each case is the log price per square meter.

\*\*The table indicate the coefficient of main variables which a part of hedonic estimation results per year.

\*\*\*Estimation Method: Robust Regression

# Estimated Result of Hedonic Equation for Single Family House Price Indexes

## Single family house price model

Year	Intercept	logS	logW	logA	logTS	logTT	Number	Adj.R2
1986	4.151	0.036	0.212	-0.051	-0.037	-0.160	2,502	0.53
1987	4.175	0.021	0.283	-0.027	-0.018	-0.086	2,805	0.66
1988	5.015	-0.058	0.261	-0.036	-0.045	-0.132	2,680	0.61
1989	5.524	0.009	0.231	-0.013	-0.094	-0.242	2,430	0.58
1990	6.101	-0.077	0.246	-0.018	-0.074	-0.284	2,414	0.54
1991	5.872	-0.023	0.247	-0.046	-0.185	-0.373	2,485	0.57
1992	4.164	-0.167	0.187	-0.147	-0.155	-0.187	2,747	0.54
1993	4.351	-0.080	0.208	-0.140	-0.124	-0.137	4,890	0.55
1994	4.351	-0.080	0.208	-0.140	-0.124	-0.137	5,890	0.55
1995	4.981	-0.081	0.208	-0.139	-0.144	-0.133	5,890	0.55
1996	4.444	-0.081	0.208	-0.139	-0.144	-0.133	11,717	0.55
1997	4.770	-0.081	0.208	-0.139	-0.144	-0.133	11,717	0.55
1998	4.444	-0.081	0.208	-0.139	-0.144	-0.133	14,717	0.55
1999	4.444	-0.081	0.208	-0.139	-0.144	-0.133	18,717	0.55
2000	4.444	-0.081	0.208	-0.139	-0.144	-0.133	18,717	0.55
2001	4.444	-0.081	0.208	-0.139	-0.144	-0.133	18,717	0.55
2002	4.444	-0.081	0.208	-0.139	-0.144	-0.133	18,717	0.55
2003	4.444	-0.081	0.208	-0.139	-0.144	-0.133	18,717	0.55
2004	4.444	-0.081	0.208	-0.139	-0.144	-0.133	18,717	0.55
2005	4.444	-0.081	0.208	-0.139	-0.144	-0.133	18,717	0.55
2006	4.815	-0.038	0.009	-0.037	-0.045	-0.146	20,805	0.58
2007	5.065	-0.068	0.005	-0.034	-0.040	-0.168	19,208	0.62
2008	5.359	-0.085	0.021	-0.038	-0.066	-0.190	16,177	0.61
2009	5.704	-0.199	0.011	-0.042	-0.060	-0.165	14,429	0.63
2010	5.859	-0.220	0.027	-0.039	-0.060	-0.187	14,620	0.63

\*The dependent variable in each case is the log price per square meter.

\*\*The table indicate the coefficient of main variables which a part of hedonic estimation results per year.

\*\*\*Estimation Method: Robust Regression

# Estimated Result of Hedonic Equation for Land Price Indexes

## Published land price model

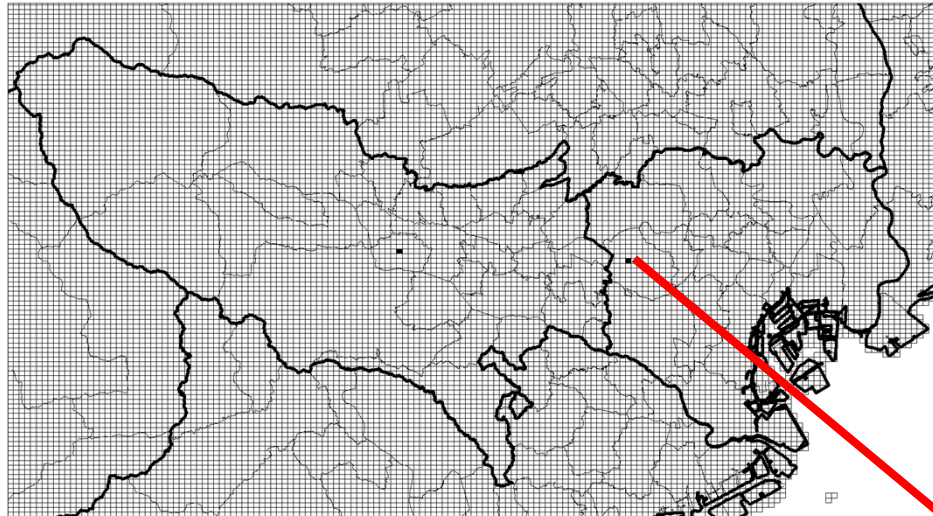
Year	Intercept	logL	logW	logA	logTS	logTT	Number	Adj.R <sup>2</sup>
1990	7.83	0.1974	0.40	-	-0.26	-0.99	1,201	0.85
1991	7.84	0.1993	0.39	-	-0.26	-1.00	1,201	0.85
1992	7.57	0.1839	0.38	-	-0.24	-0.95	1,202	0.85
1993	7.14	0.1568	0.31	-	-0.21	-0.88	1,516	0.86
1994	6.64	0.1297	0.28	-	-0.19	-0.76	1,776	0.86
1995	7.14	0.1568	0.31	-	-0.21	-0.88	1,516	0.86
1996	7.14	0.1568	0.31	-	-0.21	-0.88	1,516	0.86
1997	7.14	0.1568	0.31	-	-0.21	-0.88	1,516	0.86
1998	7.14	0.1568	0.31	-	-0.21	-0.88	1,516	0.86
1999	7.14	0.1568	0.31	-	-0.21	-0.88	1,516	0.86
2000	7.14	0.1568	0.31	-	-0.21	-0.88	1,516	0.86
2001	7.14	0.1568	0.31	-	-0.21	-0.88	1,516	0.86
2002	7.14	0.1568	0.31	-	-0.21	-0.88	1,516	0.86
2003	7.14	0.1568	0.31	-	-0.21	-0.88	1,516	0.86
2004	7.14	0.1568	0.31	-	-0.21	-0.88	1,516	0.86
2005	7.14	0.1568	0.31	-	-0.21	-0.88	1,516	0.86
2006	7.20	0.1227	0.13	-	-0.24	-0.88	1,934	0.86
2007	7.45	0.1403	0.13	-	-0.25	-0.93	1,856	0.87
2008	7.68	0.1513	0.14	-	-0.26	-0.96	1,809	0.87
2009	7.60	0.1582	0.12	-	-0.26	-0.95	1,730	0.86
2010	7.58	0.1454	0.12	-	-0.27	-0.94	1,684	0.86

\*The dependent variable in each case is the log price per square meter.

\*\*The table indicate the coefficient of main variables which a part of hedonic estimation results per year.

\*\*\*Estimation Method: Robust Regression

# Tokyo Prefecture:2010.



## Tokyo:

- Population: **13,161,751**
- Households: **6,403,219**
- SNA: **71.181 trillion JPY**

## All Japan:

- Population: **128,057,352**
- Households: **51,950,504**
- SNA: **490.647 trillion JPY**

### Building Survey

	Single family house		Condominium	
	e)Total*	(units)**	f)Total*	(units)***
1990	148,834,033	1,857,722	107,274,134	367,734
1995	160,654,688	1,854,315	135,778,868	374,807
2000	174,379,864	1,897,345	161,698,203	381,216
2005	181,977,956	2,011,068	186,759,564	417,872



\*unit: square meter

\*\*Number of single family houses

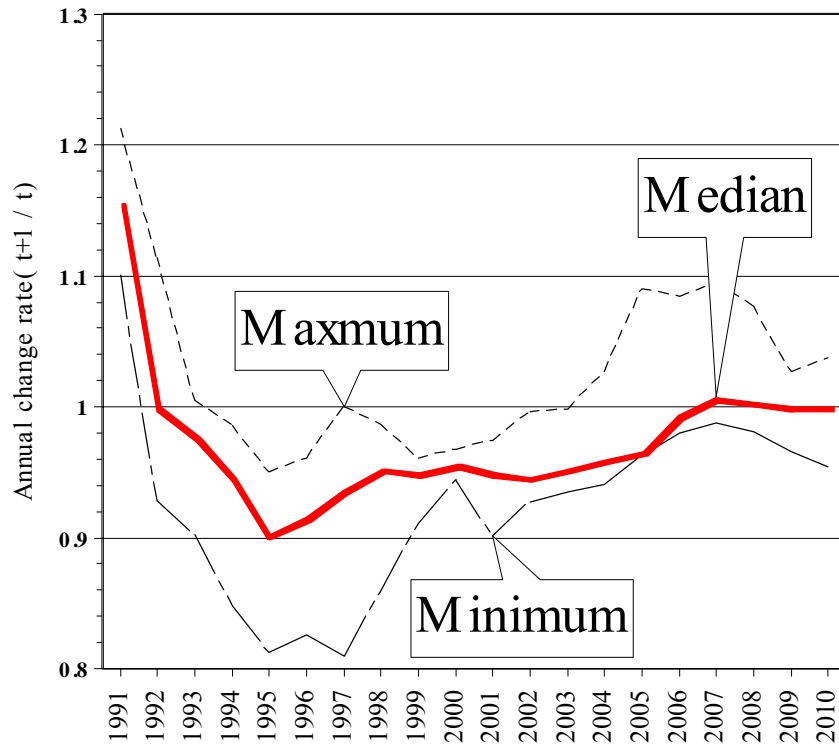
\*\*\*Number of condominium buildings(not unit)

# The Verbrugge Variant (VV) of the User Cost Approach

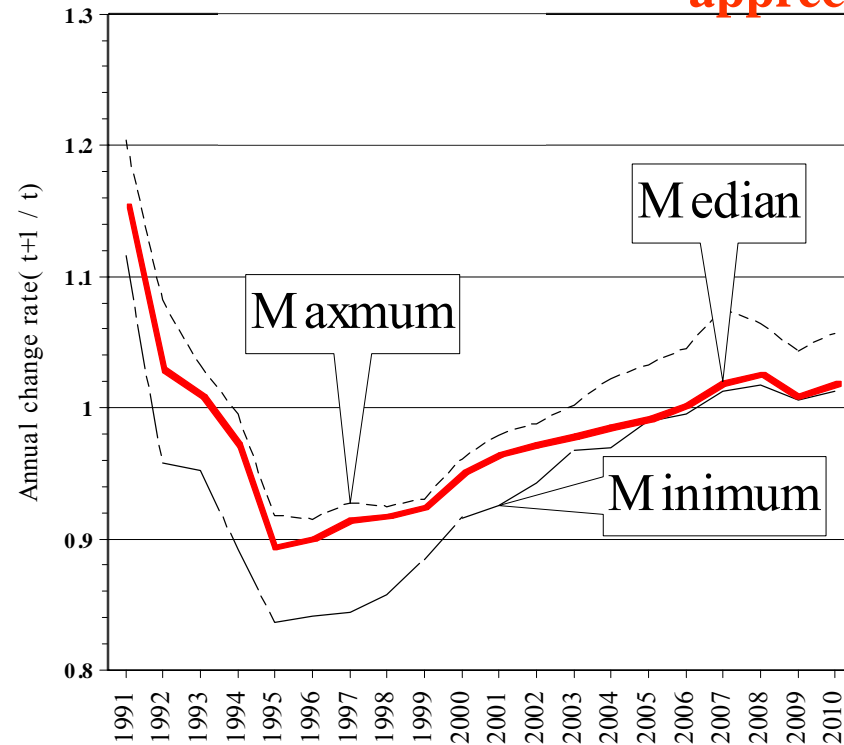
Poole, Ptacek and Verbrugge (2005) , Verbrugge (2008), Diewert (1974)

$$u^t = r^t V^t + \gamma_H^t V^t - E[\pi] V^t$$

⇒ **The rate of expected house price appreciation**



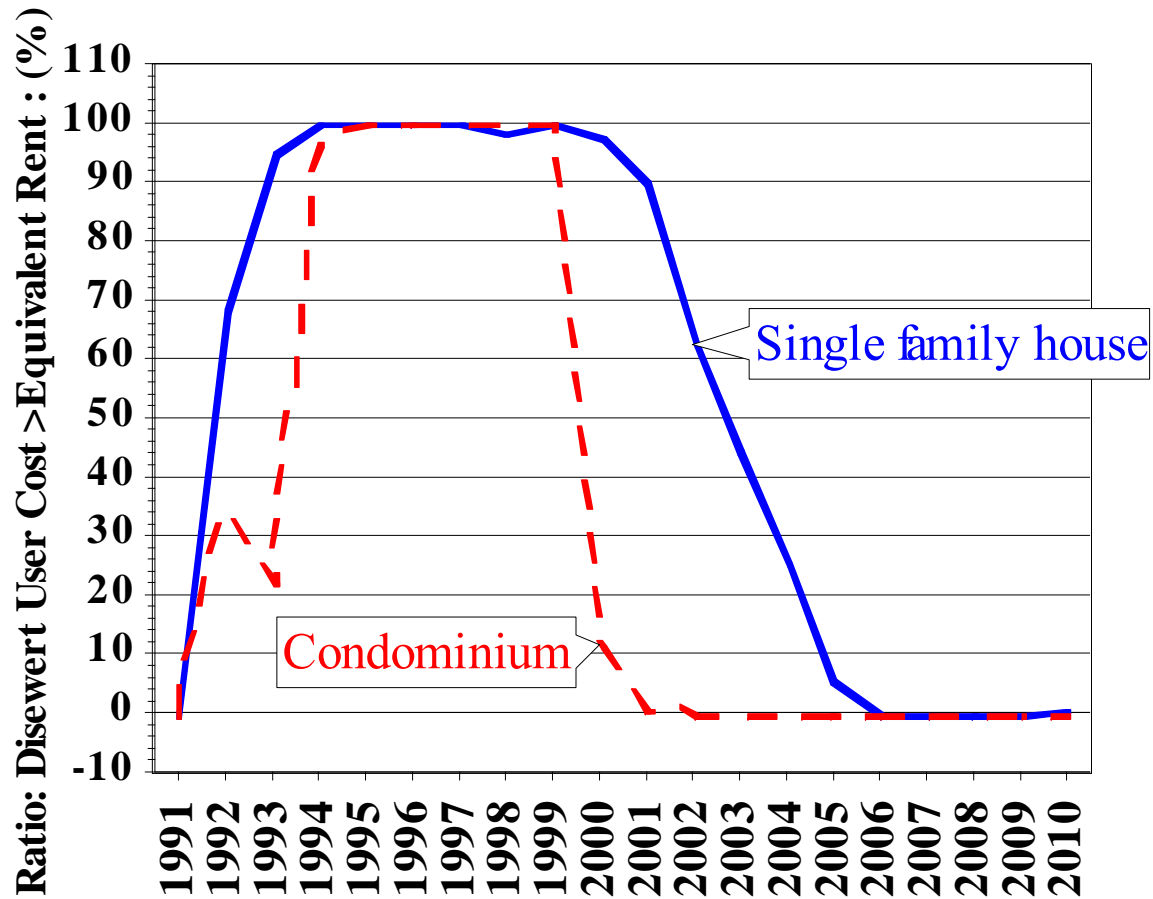
**Single family house**



**Condominium**

# Ratio: Diewert User Cost >Equivalent Rent: (%)

**Ratio: Option1 (User Cost) > Option2 (E. Rent) = Option1**



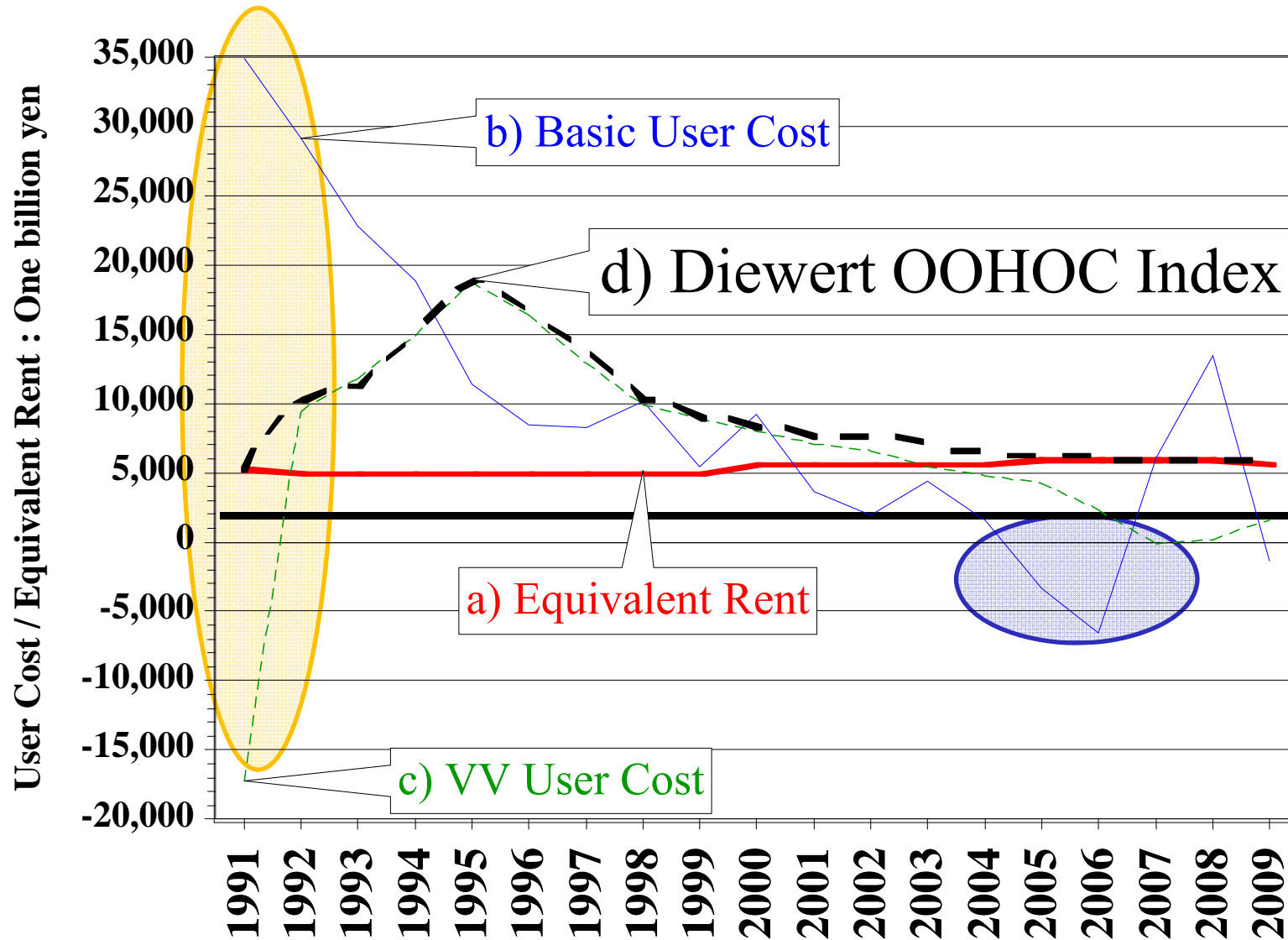
## Estimation results of User Costs.

Year	a) Equivalent Rent*	b) Basic User Cost*	c) VV User Cost*	d) Diewert Financial User Cost*	e) Diewert OOHOC Index*	d) - b)*	d) - c)*	e) - a)*
1991	5,381.91	34,917.15	-17,249.25	-16,969.24	5,381.91	-51,886.39	280.01	0.00
1992	5,283.60	29,172.85	9,414.64	9,141.06	10,419.92	-20,031.78	-273.58	5,136.32
1993	5,021.95	22,840.21	11,742.15	11,524.01	11,589.21	-11,316.20	-218.14	6,567.26
1994	4,933.06	18,828.92	14,916.87	14,639.22	14,639.23	-4,189.69	-277.64	9,706.16
1995	5,268.97	11,404.91	18,786.03	18,624.62	18,886.70	7,219.71	-161.42	13,617.73
1996	5,256.77	8,446.97	16,425.49	16,498.50	16,498.50	8,051.53	73.01	11,241.73
1997	5,219.79	8,231.11	12,849.09	13,223.56	13,223.57	4,992.45	374.47	8,003.78
1998	5,155.46	10,184.68	9,831.25	10,367.09	10,368.52	182.41	535.84	5,213.06
1999	5,157.14	5,429.53	8,858.19	9,112.25	9,127.37	3,682.72	254.06	3,970.22
2000	5,864.61	9,214.74	7,984.24	8,189.68	8,494.76	-1,025.07	205.43	2,630.15
2001	5,831.36	3,620.13	7,063.19	7,673.58	7,729.83	4,053.45	610.39	1,898.46
2002	5,925.69	1,923.76	6,600.24	7,223.75	7,427.48	5,299.99	623.51	1,501.79
2003	5,818.97	4,383.36	5,395.85	6,012.84	6,714.04	1,629.48	617.00	895.07
2004	5,782.20	1,577.33	4,767.56	5,376.14	6,331.98	3,798.81	608.58	549.78
2005	6,001.29	-3,359.14	4,168.27	5,011.60	6,446.76	8,370.73	843.33	445.47
2006	6,062.71	-6,546.35	2,303.28	3,323.47	6,082.47	9,869.83	1,020.20	19.76
2007	6,113.83	6,050.27	-111.39	1,053.99	6,114.15	-4,996.28	1,165.38	0.32
2008	5,951.92	13,441.22	129.20	1,376.28	5,952.16	-12,064.94	1,247.07	0.24
2009	5,815.37	-1,388.15	1,594.28	2,877.89	5,817.18	4,266.04	1,283.61	1.80

\*One billion yen



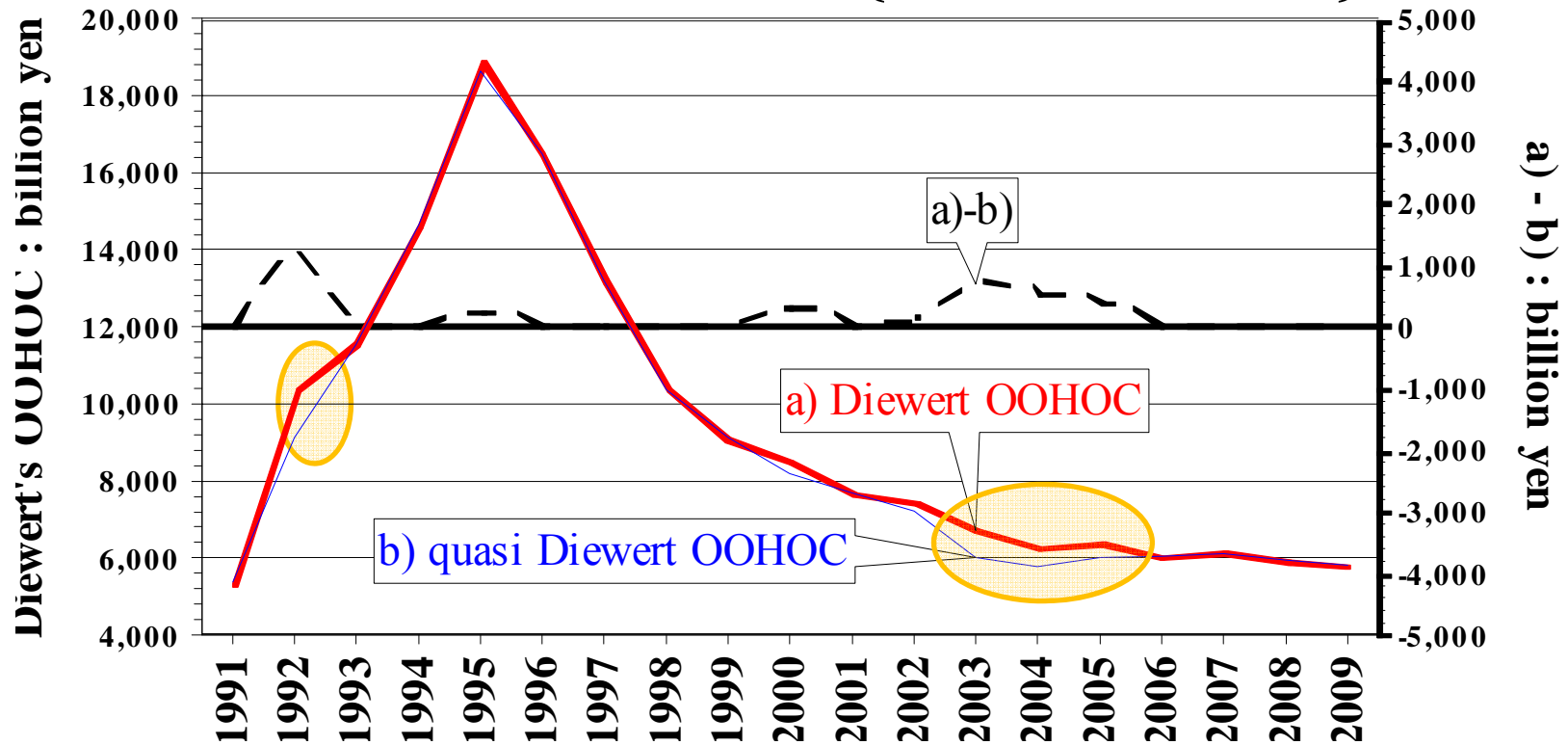
# Diewert's OOHOC Index and User Cost Indexes.



## quasi Diewert's OOHOC Index.

$$Diewert \ OOHOC_t = \sum_I Max\{UC_{it}, ER_{it}\}$$

$$quasi \ OOHOC_t = Max\left\{\sum_I UC_{it}, \sum_I ER_{it}\right\}$$



## IV. Conclusions:

- Having an extremely large weight in national accounting and consumer price statistics, **imputed rent for owner-occupied housing plays an important role.**
- Traditional **equivalent approach** and **user cost approach** have a several problem in estimating it.
- **Diewert's OOH Opportunity Cost Approach** is one of the a powerful estimation method for imputed rent of OOH.
- **quasi** Diewert's OOH Opportunity Cost Index *can be approximated* with **true** Diewert's OOH Opportunity Cost.
- **In the coming new RPPI**, we should consider **to improve the estimation of the OOH imputed rent** in National Account and CPI.

## Contact:

- Chihiro Shimizu (Reitaku University & University of British Columbia)
  - W. Erwin Diewert (University of British Columbia),
  - Kiyohiko G. Nishimura (The Deputy Governor of Bank of Japan),
  - Tsutomu Watanabe (University of Tokyo)
- 
- Our paper and presentation slides are available at:
  - **<http://www.cs.reitaku-u.ac.jp/sm/shimizu/English.html>**

# Imputed Rent for OOH in National Account

Year	National Account (All Japan)					Tokyo		
	A.GDP*	B.Imputed rent(National Account)*	B/A	C. Imputed rent(Prefecture Account)**	C/B	D.Prefecture Account*	E: Equivalent Rent Estimate*	E/D
1990	442,781.0	27,654.6	6.25%	8,300.06	30.01%	441.84	4,925.89	11.15
1991	469,421.8	29,595.3	6.30%	9,310.11	31.46%	496.36	5,381.91	10.84
1992	480,782.8	31,429.6	6.54%	11,283.75	35.90%	700.54	5,283.60	7.54
1993	483,711.8	33,324.3	6.89%	13,600.33	40.81%	1,036.05	5,021.95	4.85
1994	488,450.3	35,052.7	7.18%	14,985.10	42.75%	1,217.25	4,933.06	4.05
1995	495,165.5	36,627.2	7.40%	15,783.43	43.09%	1,352.16	5,268.97	3.90
1996	505,011.8	38,211.6	7.57%	16,542.84	43.29%	1,442.76	5,256.77	3.64
1997	515,644.1	39,895.8	7.74%	17,240.48	43.21%	1,660.33	5,219.79	3.14
1998	504,905.4	41,144.5	8.15%	17,789.45	43.24%	1,834.53	5,155.46	2.81
1999	497,628.6	41,866.3	8.41%	18,699.03	44.66%	2,066.12	5,157.14	2.50
2000	502,989.9	42,772.5	8.50%	19,453.62	45.48%	2,175.39	5,864.61	2.70
2001	497,719.7	43,615.6	8.76%	20,280.92	46.50%	2,444.75	5,831.36	2.39
2002	491,312.2	44,202.3	9.00%	21,007.48	47.53%	2,467.59	5,925.69	2.40
2003	490,294.0	44,754.0	9.13%	22,007.81	49.18%	2,769.56	5,818.97	2.10
2004	498,328.4	45,170.6	9.06%	22,998.95	50.92%	3,046.95	5,782.20	1.90
2005	501,734.4	45,570.9	9.08%	23,766.05	52.15%	3,256.63	6,001.29	1.84
2006	507,364.8	46,025.5	9.07%	24,315.62	52.83%	3,398.76	6,062.71	1.78
2007	515,520.4	46,358.9	8.99%	25,017.20	53.96%	3,524.97	6,113.83	1.73
2008	504,377.6	46,660.3	9.25%	25,587.85	54.84%	3,595.95	5,951.92	1.66
2009	470,936.7	46,724.1	9.92%	26,411.03	56.53%	3,621.54	5,815.37	1.61
2010	-	-	-	-	-	-	5,655.68	-

\*Unit: One billion yen

\*\*Sum of 47 prefectures

## Comparison with Official Statistics

Year	a) Prefecture Account	b) Equivalent Rent*	c) Basic User Cost*	d) Diewert Financial User Cost*	e) Diewert OOHOC Index*	e) / a)
1991	496	5,381.91	34,917.15	-16,969.24	5,381.91	10.84
1992	701	5,283.60	29,172.85	9,141.06	10,419.92	14.87
1993	1036	5,021.95	22,840.21	11,524.01	11,589.21	11.19
1994	1217.25	4,933.06	18,828.92	14,639.22	14,639.23	12.03
1995	1352.16	5,268.97	11,404.91	18,624.62	18,886.70	13.97
1996	1442.76	5,256.77	8,446.97	16,498.50	16,498.50	11.44
1997	1660.33	5,219.79	8,231.11	13,223.56	13,223.57	7.96
1998	1834.53	5,155.46	10,184.68	10,367.09	10,368.52	5.65
1999	2066.12	5,157.14	5,429.53	9,112.25	9,127.37	4.42
2000	2175.39	5,864.61	9,214.74	8,189.68	8,494.76	3.90
2001	2444.75	5,831.36	3,620.13	7,673.58	7,729.83	3.16
2002	2467.59	5,925.69	1,923.76	7,223.75	7,427.48	3.01
2003	2769.56	5,818.97	4,383.36	6,012.84	6,714.04	2.42
2004	3046.95	5,782.20	1,577.33	5,376.14	6,331.98	2.08
2005	3256.63	6,001.29	-3,359.14	5,011.60	6,446.76	1.98
2006	3398.76	6,062.71	-6,546.35	3,323.47	6,082.47	1.79
2007	3524.97	6,113.83	6,050.27	1,053.99	6,114.15	1.73
2008	3595.95	5,951.92	13,441.22	1,376.28	5,952.16	1.66
2009	3621.54	5,815.37	-1,388.15	2,877.89	5,817.18	1.61

\*One billion yen