Testing for Bubbles in Housing Markets: A Panel Data Approach

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Outline

Introduction

Is There a Bubble?

- National data - Mc Carthy and Peach (2004), Galin (2004)
- Panel data - Malpezzi (1999), Galin (2006)
- Regional data - Smith and Smith (2006), Himmelberg, Mayer, Sinai (2005)

Stationarity and Earnings

- Campbell and Shiller (1987), Wang (2000)

Introduction

Panel Data Tests

- Cross section dependence - Pesaran (2004)
- Unit roots - Im, Pesaran, and Shin (2003), Pesaran (2007)
- Cointegration - Pedroni (1999, 2004)
- Causality - Hurlin (2004), Hurlin and Venet (2004)
- Application - Malpezzi (1999), Galin (2006)

Research Objective

- Combine panel data unit root and integration tests - bubble indicator
- US real estate market, house prices and rents
- Changes in house prices and rents

Present Value Model

House Prices and Cash Flows

$$P_{i,t} = E_t \left[\frac{C_{i,t+1} + P_{i,t+1}}{1+D} \right], \quad i = 1, \ldots, N$$

$$P_{i,t} = E_t \left[\frac{C_{i,t+1}}{1+D} + \frac{C_{i,t+2}}{(1+D)^2} + \ldots + \frac{C_{i,t+k}}{(1+D)^k} + \frac{P_{i,t+k}}{(1+D)^k} \right]$$

$$\lim_{k \to \infty} E_t \left[\frac{P_{i,t+k}}{(1+D)^k} \right] = 0$$

$$P^F_{i,t} = \sum_{j=1}^{\infty} \frac{1}{(1+D)^j} E_t[C_{i,t+j}]$$

Present Value Model

Cash Flow Process I(1) and No Bubbles

$$\begin{aligned} S_{i,t} &= P_{i,t} - \frac{1}{D} C_{i,t} \\ &= \frac{1}{D} E_t \sum_{j=0}^{\infty} \frac{\triangle C_{i,t+j+1}}{(1+D)^j} \\ &= \frac{1}{D} E_t \left[\triangle P_{i,t+1} \right] \end{aligned}$$

Rational Bubbles

$$B_{i,t} = \frac{1}{1+D} E_t B_{i,t+1}$$

$$P_{i,t} = P_{i,t}^F + B_{i,t}$$

Present Value Model

Stationarity of house prices and cash-flows

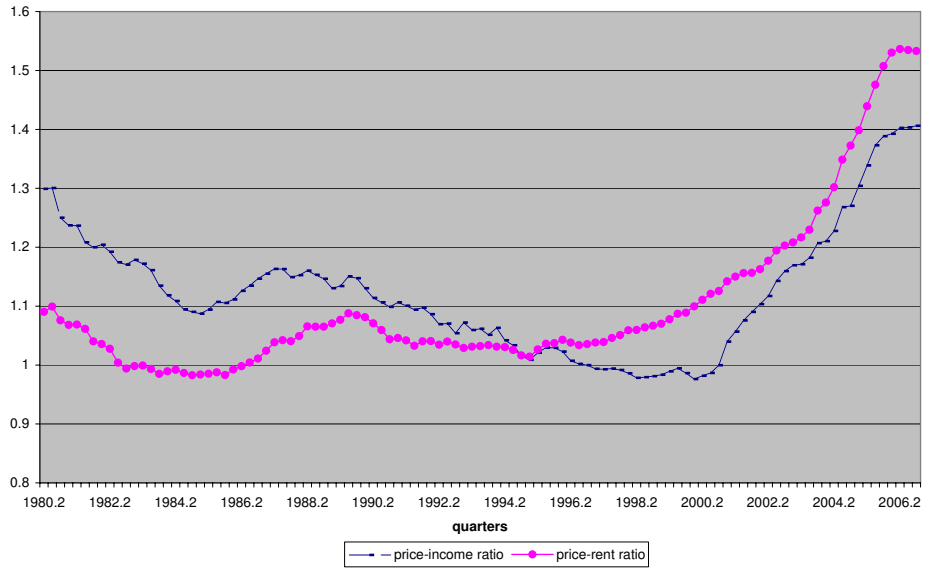
- Case 1: $P_{i,t}$ stationary and $C_{i,t}$ stationary
- Case 2: $P_{i,t}$ stationary and $C_{i,t}$ non-stationary
- Case 3: $P_{i,t}$ non-stationary and $C_{i,t}$ stationary
- Case 4: $P_{i,t}$ non-stationary and $C_{i,t}$ non-stationary

Bubble Indicator

- $=0$ in Case 1, 2
- $=1$ in Case 3
- $=$pvalue of a stationarity test of P/r in Case 4

Aggregate Data

Aggregate Price-Income and Price-Rent Ratios



Panel Data

Dataset 1 - 23 Metropolitan Statistical Areas (MSA), 1978:1-2006:2

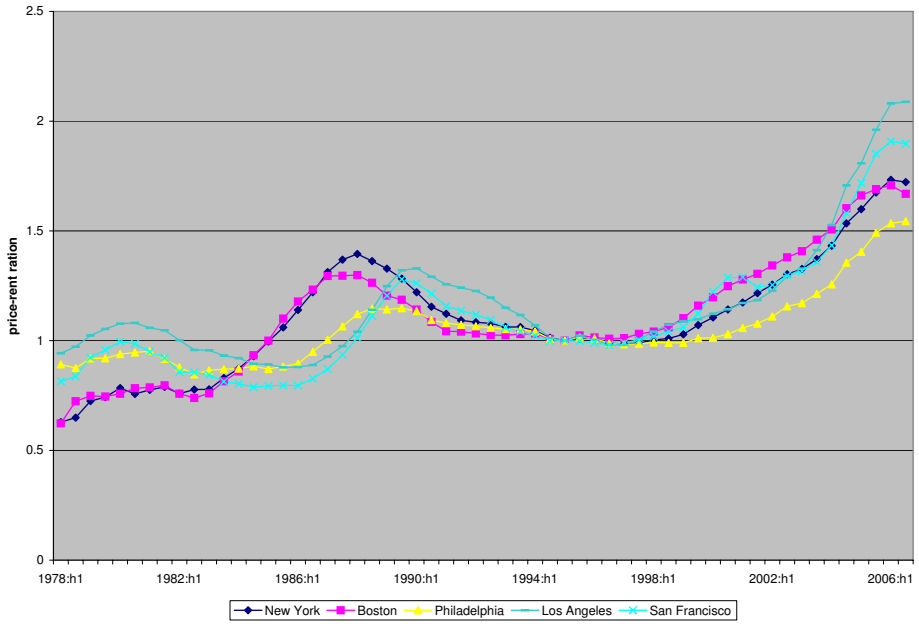
- House price index (HPI) from the Office of Federal Housing Enterprise Oversight (OFHEO) - the weighted repeat sales index based on mortgage contracts
- Rent of primary residence index (RI) estimated by the Bureau of Labor Statistic (BLS)
- Regional CPI from (BLS)

Dataset 2 - 273 Metropolitan Statistical Areas, 1986-2006

- HPI from OFHEO
- The fair market rent, US Department of Housing and Urban Development (HUD)
- Aggregate CPI from BLS

Panel Data

Price-Rent Ratios in 23 MSA



Panel Data

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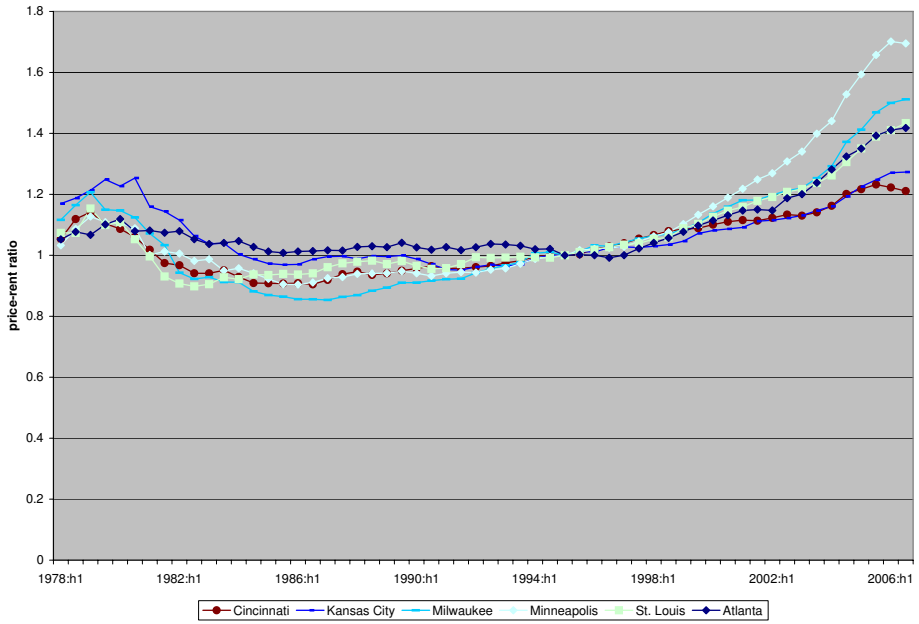
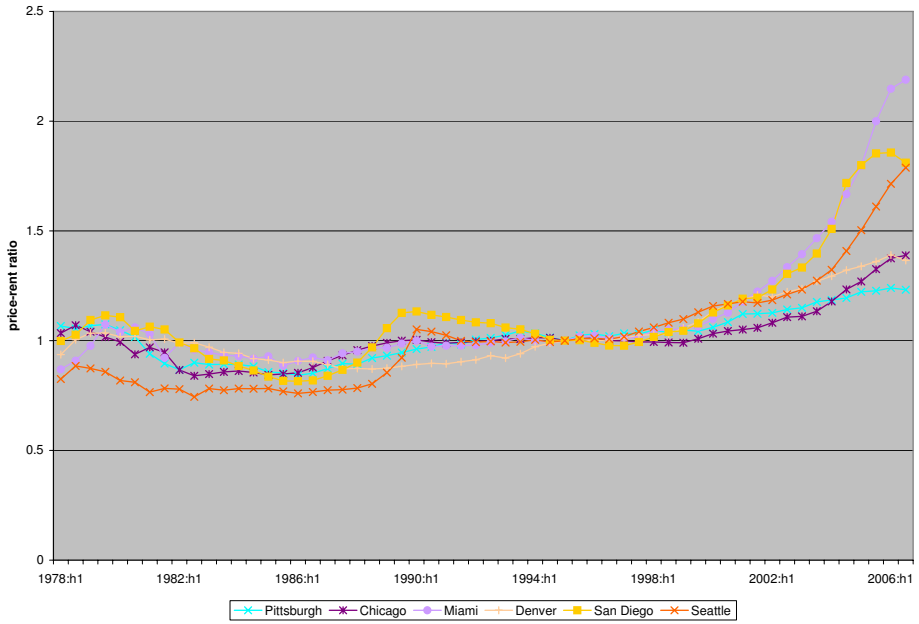


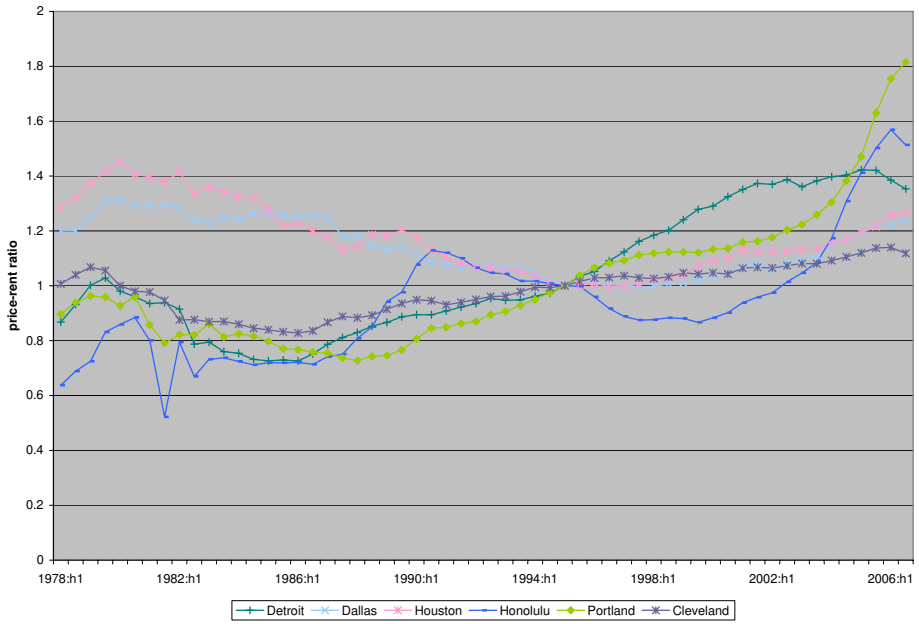
Panel Data

Price-Rent Ratios in 23 MSA



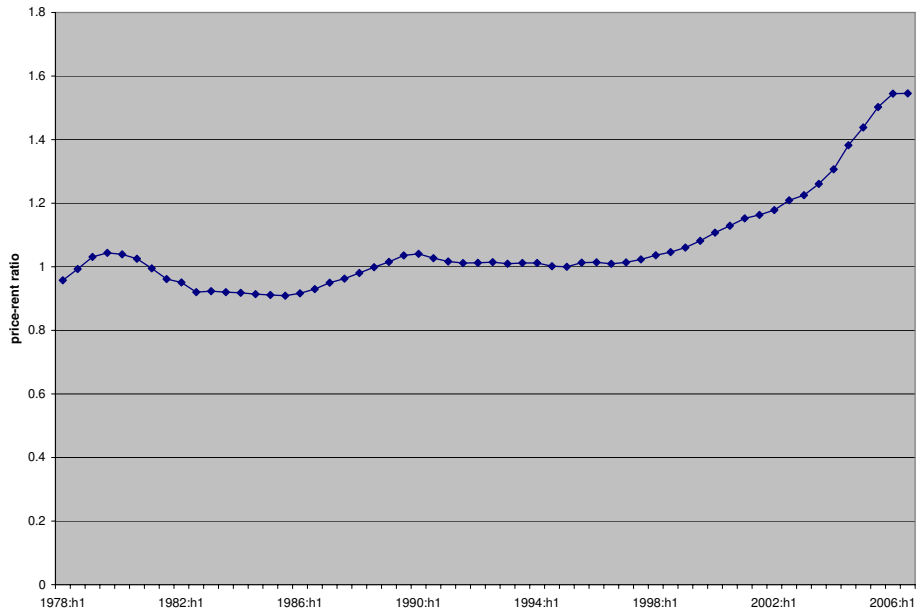
Panel Data

Price-Rent Ratios in 23 MSA



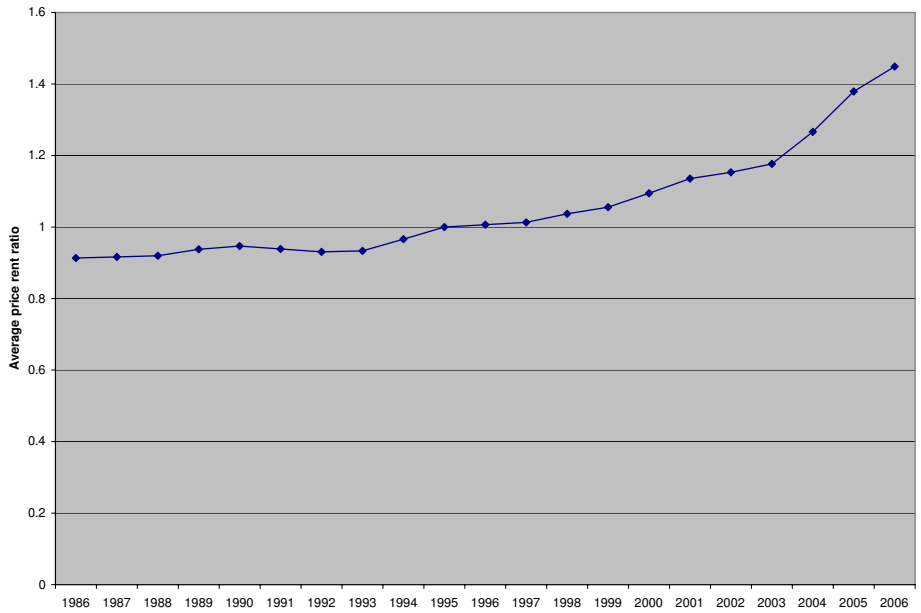
Panel Data

Average Price-Rent Ratios in 23 MSA



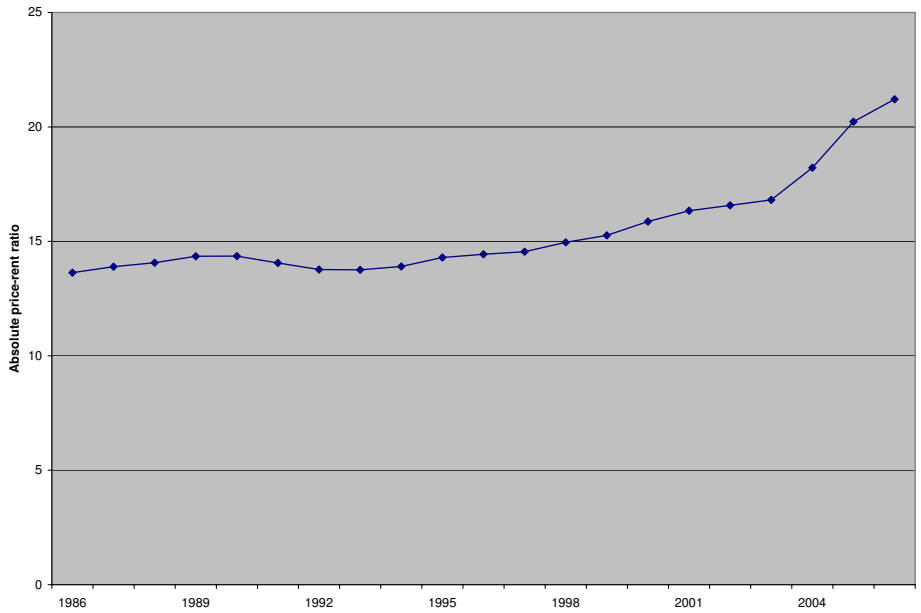
Panel Data

Average Price-Rent Ratios in 273 MSA



Panel Data

Average Absolute Price-Rent Ratios in 273 MSA



Panel Data

Price-rent Ratios Using Indices, 273 MSA's

	P/r>1.5	P/r>1.3	P/r<0.9	P/r<0.8
1986	2	11	142	76
1987	5	15	145	72
1988	7	20	141	76
1989	3	18	130	72
1990	2	16	119	60
1991	1	5	116	50
1992	0	1	116	47
1993	0	0	105	36
1994	0	0	5	0
1995	0	0	0	0
1996	0	0	1	0
1997	0	0	1	0
1998	0	0	2	0
1999	0	5	4	0
2000	2	14	1	0
2001	7	28	3	0
2002	10	39	3	0
2003	16	54	4	0
2004	42	84	3	0
2005	74	118	2	0
2006	97	137	3	1

Panel Data

Price-rent Ratios Using Levels, 273 MSA's

	P/r>22.5	P/r>20	P/r<13	P/r<12
1986	10	13	70	64
1987	11	17	72	65
1988	12	19	71	64
1989	11	20	70	64
1990	13	18	70	63
1991	12	14	71	63
1992	10	14	70	63
1993	11	12	68	61
1994	10	12	71	54
1995	10	14	67	47
1996	10	12	67	47
1997	10	13	65	48
1998	11	16	61	44
1999	12	18	58	41
2000	14	22	54	38
2001	18	23	47	32
2002	19	25	47	30
2003	21	26	44	28
2004	24	32	36	20
2005	33	48	32	23
2006	40	52	26	22

Panel Data Tests

Pesaran (2004): Diagnostic tests for cross section dependence in panels

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \text{Corr}(\hat{\epsilon}_i, \hat{\epsilon}_j) \right) \Rightarrow N(0,1)$$

price-level		price-diff.		rent-level		rent-diff.
CD		*CD*		*CD*		*CD*
23 MSAs, 1978:01-2006:02, semi-annual data						
75.12	***	15.44	***	29.13	***	0.09
273 MSA, 1986-2006, annual data						
566.00	***	-2.58	***	209.01	***	0.63

Stationarity

Panel Data Unit Root Tests - Pesaran (2007)

- Cross-sectionally Augmented Dickey Fuller (CADF):
  $\Delta y_{it} = \mu_i + \omega_i\ t + \alpha_i y_{i,t-1} + \upsilon_i \bar{y}_{t-1} + \sum_{j=1}^{p_i} \lambda_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{p_i} \varpi_{ij} \Delta \bar{y}_{i,t-j} + \varepsilon_{it}$
- $H_0 :\ \alpha_i = 0$
  $H_1 : \begin{cases} \alpha_i = 0 & \text{for } i = 1, 2, \ldots, N_1 \\ \alpha_i < 0 & \text{for } i = N_1 + 1, N_1 + 2, \ldots, N. \end{cases}$
- CADF: $\tilde{t}_{i,T_i,N}(p_i) = \tilde{t}_i(T, N)$
- CIPS: $\bar{t}^{\dagger} = \frac{1}{N} \sum_{i=1}^{N} \tilde{t}_i(N, T)$

CADF, 23 MSA

MSA	price CADF	rent CADF	p/r CADF	p/r rank
Atlanta-Sandy Springs-Marietta, GA	-0.37	-0.41	-1.15	7
Boston-Quincy, MA (MSAD)	-1.90	-3.21	-1.69	8
Chicago-Naperville-Joliet, IL (MSAD)	-6.42 ***	-6.42 ***	-4.42 **	23
Cincinnati-Middletown, OH-KY-IN	-4.73 ***	-1.32	-2.75	19
Cleveland-Arkon, OH (MSAD)	-4.73 ***	-4.53 ***	-2.23	12
Dallas-Plano-Irving, TX (MSAD)	-2.95	-1.68	-2.93	21
Denver-Aurora, CO	0.89	-0.12	-0.78	5
Detroit-Livonia-Dearborn, MI (MSAD)	-1.08	-3.03	-0.72	3
Honolulu, HI	-0.13	-0.79	-0.49	2
Houston-Sugar Land-Baytown, TX	-3.05	-5.18 ***	-2.52	17
Kansas City, MO-KS	-0.01	-2.50	-0.76	4
Los Angeles-Long Beach-Glendale, CA (MSAD)	-1.78	-1.79	-2.5	16
Miami-Miami Beach-Kendall, FL (MSAD)	-0.45	-0.03	-0.91	6
Milwaukee-Waukesha-West Allis, WI	-4.40 **	-2.36	-2.33	15
Minneapolis-St. Paul-Bloomington, MN-WI	0.65	-5.06 ***	-0.42	1
New York-White Plains-Wayne, NY-NJ (MSAD)	-3.39	-3.90 **	-2.82	20
Philadelphia, PA (MSAD)	-1.50	-1.70	-1.87	9
Pittsburgh, PA	-3.32	-2.76	-2.27	13
Portland-Vancouver-Beaverton, OR-WA	-2.08	-2.29	-1.89	10
San Diego-Carlsbad-San Marcos, CA	-2.34	-3.18	-2.63	18
San Francisco-San Mateo-Redwood City, CA (MSAD)	-2.80	-2.00	-2.28	14
Seattle-Bellevue-Everett, WA (MSAD)	-2.96	-2.95	-3.51 *	22
St. Louis, MO-IL	-3.04	-2.08	-2.17	11

CADF, 273 MSA, Top 25

MSA	price CADF	rent CADF	p/r CADF	p/r rank
Ann Arbor, MI	-0.82	-1.37	0.20	8
Athens-Clarke County, GA	1.48	-1.44	-0.11	12
Barnstable Town, MA	1.44	-1.71	1.70	1
Bend, OR	-0.11	-1.56	0.53	3
Bridgeport-Stamford-Norwalk, CT	-0.06	-1.51	-0.56	19
Canton-Massillon, OH	-1.46	-2.20	-0.46	17
Deltona-Daytona Beach-Ormond Beach, FL	1.16	-1.46	-0.59	20
Des Moines-West Des Moines, IA	-2.68	0.39	0.08	9
El Paso, TX	-2.10	-3.34	-0.52	18
Flint, MI	-0.60	-2.11	-0.59	21
Jackson, MI	0.72	-3.15	0.00	10
Lakeland, FL	0.17	-1.52	0.52	4
Las Vegas-Paradise, NV	-0.96	-2.89	0.23	7
Lexington-Fayette, KY	-1.15	-2.18	0.47	5
Mansfield, OH	-0.90	-2.17	-0.64	23
Monroe, LA	-4.84 **	-1.50	-0.32	14
New Haven-Milford, CT	-1.54	-1.68	-0.70	25
Olympia, WA	-0.19	-1.29	-0.32	15
Poughkeepsie-Newburgh-Middletown, NY	-0.50	-1.36	-0.06	11
Rochester, MN	-1.28	0.98	-0.27	13
Saginaw-Saginaw Township North, MI	0.34	-3.01	1.02	2
Sherman-Denison, TX	-2.81	-1.31	-0.68	24
Spokane, WA	-0.63	-1.00	-0.61	22
St. Joseph, MO-KS	-1.42	-2.42	-0.43	16
Toledo, OH	0.63	-2.17	0.29	6

CADF, 273 MSA, Bottom 25

	price	rent	p/r	p/r
Abilene, TX	-6.42 ***	-2.13	-4.84 **	271
Amarillo, TX	-6.34 ***	-0.18	-4.42 **	268
Atlantic City, NJ	-5.26 **	-2.28	-3.60	255
Beaumont-Port Arthur, TX	-3.62	-2.20	-3.99 *	262
Boulder, CO	-2.97	-1.80	-4.53 **	269
Burlington-South Burlington, VT	-5.79 ***	-1.97	-3.83 *	259
Colorado Springs, CO	-4.27 **	-1.66	-3.47	249
Corpus Christi, TX	-6.07 ***	-1.45	-3.74 *	256
Dayton, OH	-3.77 *	-3.17	-3.47	250
Fort Lauderdale-Pompano Beach-Deerfield Beach, FL (M	0.53	-1.56	-3.58	253
Greeley, CO	-3.51	0.19	-3.97 *	261
Houma-Bayou Cane-Thibodaux, LA	-5.97 ***	-2.22	-3.56	252
Knoxville, TN	-2.87	-2.07	-3.91 *	260
Los Angeles-Long Beach-Glendale, CA (MSAD)	-6.42 ***	-0.82	-3.55	251
Madison, WI	-2.89	-3.02	-4.77 **	270
Ocean City, NJ	-3.90 *	-2.43	-4.10 *	264
Oxnard-Thousand Oaks-Ventura, CA	-5.95 ***	-2.74	-4.10 *	265
Philadelphia, PA (MSAD)	-4.93 **	-1.56	-6.42 ***	273
Phoenix-Mesa-Scottdale, AZ	-3.50	-1.84	-4.02 *	263
Reading, PA	-6.17 ***	-1.42	-4.20 **	267
San Diego-Carlsbad-San Marcos, CA	-3.84 *	-1.03	-3.80 *	258
Santa Cruz-Watsonville, CA	-3.88 *	-2.33	-4.11 *	266
Scranton-Wilkes-Barre, PA	-3.21	-0.28	-5.49 ***	272
Shreveport-Bossier City, LA	-6.42 ***	-1.31	-3.78 *	257
Waterloo-Cedar Falls, IA	-1.91	-2.66	-3.58	254

Panel Data Tests

Unit Roots Tests

23 MSA, 1978:01-2006:02, semi-annual data

Method	price-level	price-diff.		rent-level	rent-diff.		p/r
IPS	1.63	-20.29	***	-2.60	-13.00	***	5.48
CIPS	-2.26	-5.02	***	-2.58	-4.16	***	-2.00

273 MSAs, 1986-2006, annual data

Method	price-level	price-diff.		rent-level	rent-diff.		p/r
IPS	6.17	-19.23	***	5.84	-22.16	***	12.69
CIPS	-2.35	-2.74	***	-1.90	-3.00	***	-2.12

Panel Data Tests

Pedroni (1999,2004) Cointegration Tests

- $y_{i,t} = \mu_i + \omega_i\ t + \psi_i\ x_{i,t} + \zeta_{i,t}$ for $t = 1, ..., T,\ i = 1, ..., N.$
- The null hypothesis of no cointegration: $H_0 : \gamma_i = 1$ for all i where γ_i is the autoregressive coefficient of the residual $\hat{\zeta}_i$
- The alternative hypothesis $H_1 : \gamma_i < 1$ for all i i.e. no common value for the autoregressive coefficient is presumed
- The critical values were generated using 50,000 simulations by bootstrapping to preserve cross-sectional dependence and including autocorrelation.

Stat.	23 MSA	273 MSA
group adf-stat	1.82	28.69

Panel Data Tests

Panel Data Granger Causality - Hurlin (2004) and Hurlin and Venet (2004)

- Let y_i and x_j be two stationary variables.
  $y_{it} = \mu_i + \sum_{l=1}^{L} \varphi_i^{(l)} y_{i,t-l} + \sum_{l=1}^{L} \delta_i^{(l)} x_{i,j,t-l} + \xi_{it}$
  ξ_{it} are normally i.i.d. with zero mean and finite heterogeneous variances and $\xi_i = (\xi_{i1}, ..., \xi_{iT})'$ are independently distributed across groups.
- Homogeneous Non Causality (HNC):
  $H_0 : \ \delta_i = 0, \ \ \forall i = 1, ..., N, \ \delta_i = (\delta_i^{(1)}, ..., \delta_i^{(L)})'$
  $H_1 : \ \ \delta_i = 0, \ \ \forall i = 1, ..., N_1,$
  $\delta_i \neq 0, \ \ \forall i = N_1 + 1, ..., N,$
  where $N_1 \in [0, N)$ is not known.

Panel Data Tests

- $W_{NT}^{HNC} = (1/N)\sum_{i=1}^{N} W_{iT}$ where W_{it} denotes the Wald statistic associated with the individual test of H_0 for each $i = 1, \ldots, N$
- $Z_{NT}^{HNC} = \sqrt{\frac{N}{2\times L} \times \frac{(T-2L-5)}{(T-L-3)}} \times \left[\frac{(T-2L-3)}{(T-2L-1)} W_{NT}^{HNC} - L\right]$ converges in distribution to $N(0,1)$ as $N \to \infty$ for a fixed $T > 5 + 2L$

Panel Data Tests

Hurlin Tests for Homogeneous Non-Causality in Panel Data

H_0	Z_{NT}^{HNC}	P-value
22 MSAs, 1978:01-2006:02, semi-annual data		
price-diff. does not Granger cause rent-diff.	-1.70	0.09
rent-diff. does not Granger cause price-diff.	-1.57	0.12
243 MSAs, 1986-2006, annual data		
price-diff. does not Granger cause rent-diff.	-5.51	0.00
rent-diff. does not Granger cause price-diff.	-5.74	0.00

Bubble Indicator, 23 MSA

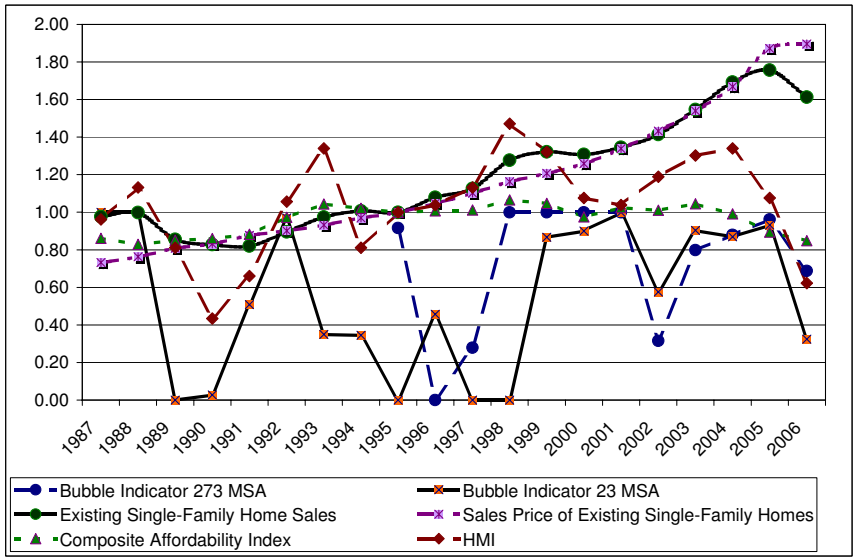
Year	price CIPS	price-dif. CIPS	rent CIPS	rent-dif. CIPS	coint. Pedroni	p/r CIPS	bubble indicator
1987	-2.21		-2.71 *		-1.32	-2.62	1.00
1988	-1.75	-2.72 *	-2.65 *	-2.42	1.64	-2.62	1.00
1989	-2.71 *	-2.46	-3.22 ***	-2.35	0.56	-2.89 **	0.00
1990	-2.41	-2.67 *	-2.14	-2.60	0.95	-2.82 **	0.03
1991	-1.51	-2.75 **	-1.89	-2.56	0.66	-2.18	0.51
1992	-1.52	-3.02 ***	-1.55	-2.64 *	-3.11	-1.63	0.97
1993	-2.11	-2.56	-1.64	-2.63 *	-2.68	-2.31	0.35
1994	-2.21	-2.61	-1.53	-2.55	-1.74	-2.32	0.34
1995	-2.71 *	-2.95 ***	-1.83	-2.44	-2.81	-2.53	0.00
1996	-2.23	-2.55	-1.83	-2.51	-2.05	-2.22	0.46
1997	-2.79 **	-3.29 ***	-1.72	-3.11 ***	-4.08	-2.44	0.00
1998	-2.96 ***	-3.15 ***	-2.08	-3.15 ***	-6.44 ***	-2.70 *	0.00
1999	-1.91	-3.07 ***	-2.25	-2.79 **	-2.35	-1.85	0.87
2000	-1.69	-2.90 **	-2.50	-2.84 **	-0.97	-1.80	0.90
2001	-2.07	-3.59 ***	-2.66 *	-2.87 **	0.16	-1.88	1.00
2002	-1.83	-3.48 ***	-1.89	-2.51	0.39	-2.13	0.58
2003	-1.46	-3.59 ***	-1.37	-2.54	0.16	-1.80	0.90
2004	-1.58	-3.23 ***	-0.81	-2.41	0.69	-1.85	0.87
2005	-1.71	-3.14 ***	-0.71	-2.69 *	-0.81	-1.75	0.93
2006	-2.28	-3.03 ***	-0.94	-3.07 ***	-3.86	-2.34	0.32

Bubble Indicator 273 MSA

Year	price CIPS	price-dif. CIPS	rent CIPS	rent-dif. CIPS	coint. Pedroni	p/r CIPS	bubble indicator
1995	-2.03		-1.48		-18.05	-1.88	0.92
1996	-2.62	-3.19 ***	-1.57	-2.05	-16.32	-4.14 ***	0.00
1997	-2.39	-3.09 **	-2.35	-1.93	-14.06	-2.54	0.28
1998	-2.56	-2.85 *	-2.31	-2.73	-2.86	-0.85	1.00
1999	-2.74	-2.92 *	-3.33 ***	-2.67	-3.85	-1.18	1.00
2000	-2.75	-2.21	-1.94	-2.68	-6.92	-0.71	1.00
2001	-2.75	-2.28	-3.39 ***	-2.97 **	4.88	-2.74	1.00
2002	-2.56	-2.11	-2.22	-2.49	9.12	-2.50	0.31
2003	-1.42	-2.05	-2.21	-2.29	-0.46	-2.04	0.80
2004	-2.12	-2.11	-1.81	-2.65	-3.45	-1.94	0.88
2005	-2.40	-1.95	-1.40	-2.16	7.11	-1.78	0.96
2006	-2.37	-1.85	-1.26	-2.23	8.23	-2.15	0.69

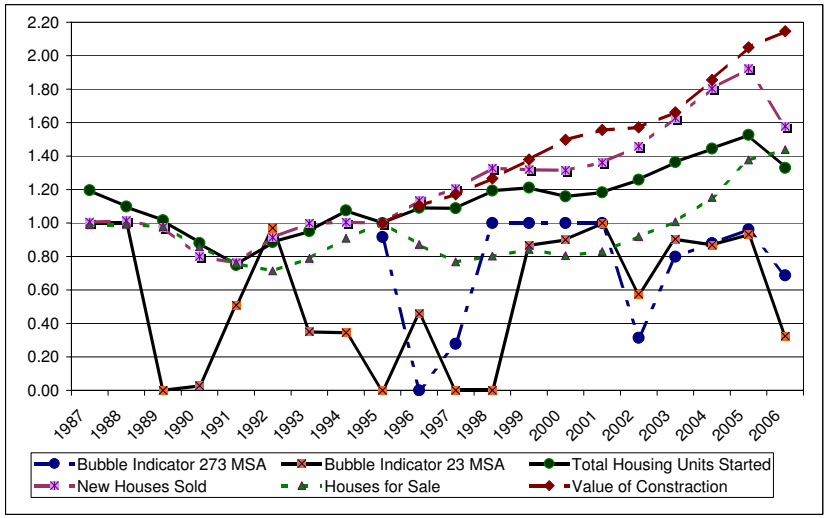
Comparison

Bubble and Other Indicators 1/2



Comparison

Bubble and Other Indicators 2/2



Summary

Panel Data - Stationarity

- Relationship between house prices and fundamentals is not stationary over the whole sample.

Bubble Indicators

- Rational bubbles in several periods but mainly in the late 1980s and the early 2000s up to 2005.
- Our bubble indicators coincide fairly well with the pattern of price-rent ratios, the HMI and the value of construction index.

Panel Data - Causality

- Changes in prices predict changes in rents and viceversa