Journal of Real Estate Finance and Economics, 5: 357–374 (1992)

Estimating Price Trends for Residential Property: A Comparison of Repeat Sales and Assessed Value Methods

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Abstract

The repeat sales methodology for estimating residential price indices is based on actual appreciation of individual properties. On the other hand, the repeat sales method wastes data, typically discarding a large percentage of all sales. This article explores two issues related to the subsample of repeat sales. First, are paired sales representative of the entire population of properties that sold? Second, is there evidence that sample selectivity biases the price trend estimates? Evidence from five metropolitan areas supports a negative answer to the first question and the second question. It appears that a "lemon" or "starter home" effect causes repeat residential sales to be a biased subsample of all transactions. Cumulative price trends for the repeat subsamples can differ from the full samples over periods ranging from two to ten quarters. While short-term price trends can differ widely, there are no systematic differences among the samples over long periods of time (e.g., three years or more).

Key words: Real estate price indices, Repeat sales, Assessed value, Biased samples

The repeat sales methodology estimates real estate price trends from pairs of transactions for properties with unchanged characteristics. The methodology was originally proposed by Bailey, Muth, and Nourse (1963) and later refined by Palmquist (1979, 1982) and Case and Shiller (1989). Price indices based on paired sales have been used by Case and Shiller (1989), Hendershott and Peach (1990), Pollakowski and Wachter (1990), and DiPasquale and Wheaton (1990).

The repeat sales methodology is attractive because it is based on actual appreciation of individual properties [see Case and Shiller (1987) and Palmquist (1982)]. Therefore, it may offer better control over quantitative and qualitative characteristics of the property than alternative methods, such as hedonic regression, that control for these characteristics by using variables and parameters estimated with error.

The most important criticism of the repeat sales methodology is that it wastes data, typically discarding a large percentage of the sample. For example, Case and Shiller started with a universe of 952,606 transactions in four cities over a 16-year period; they found only

39,210 (4.1 percent) repeat transactions with no discernible changes in property characteristics. Thus, while they end up with a lot of transactions per city, the data provide limited ability to disaggregate to the neighborhood level. Abraham and Schauman (1990) found that about 2.5 percent of Federal Home Loan Bank Board sales, during 1970–1989, are repeats. On the other hand, Mark and Goldberg (1984) found that about 40 percent of the sales in Vancouver, 1957–1979, are repeats. As the time period lengthens for a given market area, it is reasonable to expect an increasing percentage of repeat sales, but a decreasing percentage sold without changes in property characteristics.

This article explores two issues related to the subsample of repeat sales. First, are paired sales representative of the entire population of properties that sold? And second, is there evidence that sample selectivity biases the price trend estimates?[1]

Issues related to sample selectivity arise with any transactions-based real estate price index. For example, newly constructed properties are more likely to sell than existing properties. Similarly, "starter homes" and homes suitable for rehabilitation may be more likely to sell. "Lemons" (e.g., houses that have some defect that is not obvious to most buyers) may be more likely to sell for reasons analogous to sales of used cars. On the other hand, Abraham and Schauman (1990) suggest that winners (i.e., properties experiencing capital gains) are more likely to sell than losers. Thus, any transactions-based real estate price index may not be entirely representative of the population of all properties.

In this article we ask whether certain types of real properties are more likely to sell repeatedly and examines the consequences. We search for systematic bias in the repeat sales subsample by starting with all arm's-length transactions of condominiums and one- to three-family properties in the Hartford, Connecticut, metropolitan area. We then isolate the properties with unchanged characteristics that sold only twice, only three times, and so forth. We find that sales prices and assessed values for two repeat sales are lower by about 15 percent than the corresponding figures for single-family properties that sold only once. This relationship holds in almost every quarter of our sample period (1981–1987). Furthermore, those properties that sell three or more times have prices and assessed values that are significantly lower than those that sell only twice. This pattern is confirmed with the data compiled by Case and Shiller (1987, 1989) for four major metropolitan areas over the 1970–1986 period. Thus, there appears to be a negative relationship between the quality, or value, of a property and the frequency of trading that property.

Sample selectivity may not be a problem if the price trends for the repeat subsample are essentially identical to those for properties that sold only once. Remarkably, the evidence suggests that over long periods of time (two to three years or more) price trends based on the repeat subsample track overall price trends. However, for short periods (ranging from two to ten quarters) the repeat price trend may deviate from the overall one.

This article develops a methodology proposed by Clapp (1990) to estimate price trends for the various Hartford samples. The next section presents the price trend methodology. Then we present comparisons of means and standard deviations for the various samples, followed by a comparison among price trend estimates.

1. Methodology

We compare the mean sales prices (and, for the Hartford data, assessed values) for properties that sold only once to the means of the repeat subsamples using standard methods that assume an unknown variance (Box and Tiao, 1973, section 2.5). The same methodology is used to compare properties that sold only twice to those that sold three or more times. There are two reasons for examining the two and three-plus subsamples even though they are not typically used for constructing price indices. First, the "lemon" hypothesis suggests more frequent sales for properties with more serious defects. Thus, the greater the dissatisfaction with the property, the more likely it is to be sold. The nature and extent of the sample selectivity problem can be thoroughly explored by examining properties with three or more sales separately from those with two sales only.[2]

Second, the repeat subsample may be heavily weighted toward properties with three or more transactions. For example, Knickerbocker (1990) found that almost half of the transactions in the Washington, DC, area (a transient community) were for properties that sold three or more times. Similarly, more than half of the Hartford condominium properties sold three or more times. For the Case-Shiller data, the three-plus sales ranged from less than 3 percent in Atlanta to more than 20 percent in Oakland. Thus, any sample selectivity for the three-plus transactions is of interest in its own right.[3]

1.1. Estimating price trends: The Hartford data

To determine if subsample selection biases the price trend estimates, we need a price trend methodology that can be applied to all transactions as well as to repeat transactions. We cannot use the repeat sales methodology on data with only one sale during the sample period. An alternative methodology is required.

The price index used for the Hartford data is based on an hedonic model:

$$\ln S = f(\ln H, Q1, Q2, \ldots QT) \tag{1}$$

where

S = the sales price of the property at time t (time and property subscripts suppressed), t=1,2,. . .T;
H = a vector of property and locational characteristics at time t;
Qt = quarterly time dummies, each equal to 1 if the sale took place in quarter t, otherwise 0.

Two important characteristics of this hedonic model are: (1) the implicit price of each locational and housing characteristic is held constant throughout the sample period[4]; and (2) the regression coefficient on the quarterly dummy Qt represents a logarithmic price trend, namely the log of the ratio of the market value (for any given H) at time t to market value at time 0.

The "assessed value" methodology employed here is based on the fact that tax assessors estimate market value (or some fraction of value) at the time of general revaluation, designated time zero for convenience ($t = 0$). Since there is some error in the assessment process, assessed value has been represented in the literature as:

$$\ln A = a + g\ln V + f \tag{2}$$

where:

A = assessed value;
V = true market value (most probable sales price);
f = random disturbance term.

The parameter g measures assessment uniformity: $g = 1$ implies uniform assessment, $g < 1$ implies regressivity, and $g > 1$ implies progressivity.

Since the vector $\ln H$ weighted by implicit market prices at time zero represents market value, V, equations (1) and (2) can be solved and expressed as a linear regression equation:

$$\ln S = CONST. + (1/g)\ln A + c_1Q1 + c_2Q2 + \ldots + c_TQT - f/g + e. \tag{3}$$

The "assessed value" approach to estimating price trends uses equation (3) as the estimating equation [see Clapp (1990) for more details]. In Connecticut, there is a general revaluation once every ten years; we take this time to be time zero for convenience. For a given time, t, the coefficient on the time dummy, Qt, represents the logarithmic difference between market value (i.e., expected log of sales price) at time t and assessed value at time 0:

$$c_t = E(\ln S_t) - (1/g)\ln A_0 - CONST. \tag{4}$$

Thus, the c_t's represent a cumulative price trend just as in the hedonic methodology; when A is replaced by S_0 and $g = 1$, equation (1) produces time coefficients with the same interpretation.

Equations (3) and (4) are subject to a potential errors-in-variables problem with assessed value. In general, the analysis of errors-in-variables when there are more than one explanatory variable is not tractable (see Greene, 1990, p. 298). However, in our case the problem is simplified by two characteristics of the model: first, only one variable, the log of assessed value, is measured with error; and second, all of the other variables are 0, 1 time dummies. These two characteristics imply that the maximum bias in the coefficients of the model is proportional to: $g[\mathrm{Var}(e - f/g)\mathrm{Var}(\ln A)]$.[5] Note that the term in brackets is identical to the proportionality factor for the standard textbook treatment of errors-in-variables. Moreover, the main variable of interest is the first difference in the time coefficients: c_t (i.e., price change). Given that the uniformity parameter, g, is close to 1, the bias in this difference can be measured by $[\mathrm{VAR}(e - f/g)/\mathrm{VAR}(\ln A)] \times [\ln A]$. Thus, the extent of the bias is an empirical question. We will examine the above variance ratio and $\ln A$ for our data in order to determine whether we need to be concerned about errors in the measurement of assessed value.

1.2. Price trends methodology for the Case-Shiller data

The data kindly supplied by Case and Shiller (C-S) provide information on properties that sold two or more times. Our purpose is to compare the average sales prices and price trends for the properties that sold only twice to those that sold three or more times. This analysis will allow a test of whether the lemon hypothesis applies generally. That is, we want to find out whether properties that trade more frequently are different than those that trade less frequently. Thus, we will determine whether our results for Hartford are consistent with those of other metropolitan areas.

To examine the trends for the C-S subsample, it is necessary to use the repeat sales methodology proposed by Bailey, Muth, and Nourse (1963). Case and Shiller (1987, 1989) have refined this approach by introducing a random walk noise term as a component of price. In this case, the variance of each observation is proportional to the time between sales, and a correction for heteroscedasticity is necessary to obtain correct standard errors. We take a more general approach by applying the Bailey, Muth, and Nourse regression model exactly, and then using the asymptotically consistent variance-covariance matrix (ACOV) proposed by White (1980). This procedure will produce correct inferences whether or not the random walk component, hypothesized by Case and Shiller, is present, or whether other forms of heteroscedasticity may be present in the data.[6]

One last issue to consider for the repeat sales data is whether to adjust the second sales price for the property's increase in age. Palmquist (1979) proposed a methodology for this adjustment; unfortunately, it relies on an arbitrary depreciation rate. But does it make sense to correct for age? Stock market indices are designed to capture changes in the value of the average firm, including the changing age of its capital stock. In a similar fashion, the repeat sales index should reveal changes in value, including the change due to age.

2. The data and results

The database for this study consists of all residential transactions from the fourth quarter of 1981 to the third quarter of 1988, for four large towns (more than 15,000 residents) in the greater Hartford Connecticut area: East Hartford, Manchester, Rocky Hill, and West Hartford. These four towns were chosen specifically because none of them had revaluation during the sample period. Condominium sales are separated from one- to three-family houses (hereafter, SFR sales).

Properties with changed physical characteristics must be eliminated from the sample. Case and Shiller screened their data using detailed property characteristics from four metropolitan areas: Atlanta, Chicago, Dallas, and Oakland/San Francisco. Their sample covers a longer time period of 1970–1986 and also a greater variety of geographic locations. For the Hartford data, we used assessed value to screen the data. Generally, renovation projects that require a building permit will result in a change of assessed value, making that particular observation unsuitable for the repeat sales methodology.

The sample means and standard deviations for Hartford subsamples are presented in table 1. The table reports all SFR transactions (the data used for hedonic and assessed-value methodologies) and all transactions involved in repeat sales (the subsample used for the

Table 1. Summary of sales prices (SP) and assessed values (AV)—all transactions and repeat subsample.

	Single Family Residential						Condominiums					
	Mean Selling Price		Number and Std. Dev. of Mean				Mean Selling Price		Number and Std. Dev. of Mean			
	All	Repeat	All		Repeat		All	Repeat	All		Repeat	
	(1)	(2)	Nu.. (3)	S.D. (4)	Num. (5)	S.D. (6)	(7)	(8)	Num. (9)	S.D. (10)	Num. (11)	S.D. (12)
All	$124,739	$114,702	13,647	$ 613	3,437	$ 1,223	$ 79,896	$ 80,305	4,130	$ 611	2,984	$ 669
Qtrs.												
1	84,918	76,234	232	3,013	90	4,800	58,742	63,726	113	2,432	66	3,564
2	84,964	75,932	199	2,771	71	3,695	61,268	60,932	52	2,775	45	2,913
3	84,356	73,722	252	2,571	75	3,562	54,350	57,499	80	2,191	58	2,868
4	87,863	84,072	352	2,400	107	5,334	54,412	56,197	66	2,371	53	2,659
5	87,650	78,845	313	3,849	110	3,241	61,147	57,131	77	2,503	59	2,382
6	84,362	82,527	372	1,989	114	4,043	60,402	63,996	78	3,936	56	5,403
7	91,021	86,258	526	2,040	145	3,632	68,903	68,937	84	5,180	71	3,968
8	92,933	89,741	599	1,925	154	3,627	65,509	65,626	100	4,128	76	3,404
9	89,800	84,461	382	2,256	103	4,382	62,730	61,343	94	2,289	79	2,403
10	91,963	83,824	308	2,582	66	4,671	55,955	57,748	76	2,466	68	2,665
11	96,919	94,157	638	2,199	149	3,936	61,973	65,567	·111	2,510	79	3,305
12	103,380	96,723	531	2,409	131	4,056	66,179	66,195	84	4,830	71	3,102
13	96,306	88,338	503	1,953	114	4,167	67,723	67,067	109	2,550	76	3,442
14	100,742	93,375	394	2,806	118	3,821	67,845	66,544	79	2,919	81	2,766
15	107,363	99,267	627	1,999	172	3,024	62,990	66,854	146	2,069	102	2,509
16	109,927	110,240	770	1,892	195	4,342	66,738	66,437	141	2,404	110	1,638
17	111,417	110,665	593	1,846	113	3,801	68,624	69,474	185	1,642	112	2,142
18	119,379	115,710	401	3,353	104	8,000	75,338	72,226	116	3,170	92	2,848
19	130,030	119,079	591	2,462	150	4,832	75,677	73,969	160	2,022	154	1,873
20	138,260	129,674	794	2,479	222	5,339	76,020	79,114	283	1,624	190	1,965
21	144,359	130,496	785	2,455	160	5,644	81,002	83,180	385	1,449	201	2,172
22	140,086	124,682	407	2,377	106	4,867	84,587	84,448	171	2,168	147	2,504
23	168,230	158,598	616	3,335	167	6,756	88,747	93,369	260	2,261	192	2,766
24	179,051	171,243	667	3,114	171	6,468	95,095	102,503	262	2,442	174	3,185
25	177,525	167,204	515	3,307	78	8,129	112,770	107,142	234	4,332	167	3,752
26	183,456	203,827	292	5,307	45	21,701	102,569	104,401	198	3,372	130	3,878
27	193,051	192,927	493	3,741	109	9,163	106,072	108,325	220	2,730	156	3,252
28	197,130	194,066	495	4.237	96	10,007	107,132	110,335	166	3,263	101	3,817

repeat-sales methodology). The last six columns of the table report corresponding information for sales and condominium units.

2.1. Differences among sample prices and values: The Hartford data

Table 2 provides more detail on the differences between SFR properties in Hartford that sold only once and those that sold only twice. Prices and assessed values for property sold

Table 2. SFR properties that sold once versus twice: comparison of mean values.

	Sales Prices				Assessed Values			
	Once Mean	Rpt2 Mean	Pct. Diff.	t-Value	Once Mean	Rpt2 Mean	Pct Diff.	t-Value
All obs	$131,962	$115,042	14.71%	8.66*	$44,802	$39,126	14.51%	10.55*
Quarter:								
1	90,957	76,373	19.10	2.21*	47,976	38,000	26.25	2.91*
2	113,863	76,357	49.12	1.55	54,627	38,470	42.00	1.87*
3	90,294	74,192	21.70	3.26*	46,575	38,812	20.00	3.04*
4	89,689	84,409	6.26	0.85	45,338	41,080	10.36	1.66*
5	92,443	79,967	15.60	1.85*	45,742	40,890	11.87	1.93*
6	85,610	80,995	5.70	0.96	43,390	39,117	10.92	1.99*
7	93,096	86,176	8.03	1.47	44,641	41,363	7.92	1.56*
8	98,782	89,530	10.33	1.38	46,143	41,550	11.05	1.83*
9	96,525	84,892	13.70	1.68*	44,922	40,127	11.95	1.77*
10	119,750	82,905	44.44	1.42*	53,563	39,635	35.14	1.61*
11	98,070	96,554	1.57	0.29	43,848	43,042	1.87	0.37
12	105,813	96,574	9.57	1.72*	45,496	41,647	9.24	1.90*
13	99,326	90,161	10.17	1.77*	42,866	39,015	9.87	1.83*
14	104,287	94,521	10.33	1.77*	43,789	40,235	8.83	1.68*
15	132,544	101,283	30.87	1.75*	50,304	40,433	24.41	2.00*
16	110,934	107,534	3.16	0.66	42,445	41,450	2.40	0.56
17	111,564	110,206	1.23	0.28	41,750	42,948	-2.79	-0.71
18	145,372	119,222	21.93	1.02	50,192	39,887	25.84	1.67*
19	134,214	119,497	12.32	2.45*	44,786	40,953	9.36	1.91*
20	142,036	130,387	8.93	1.81*	43,572	40,052	8.79	2.04*
21	148,683	132,545	12.18	2.32*	42,584	39,241	8.52	1.75*
22	145,481	124,266	17.07	3.71*	40,420	35,470	13.96	2.95*
23	172,293	155,638	10.70	2.02*	44,121	40,163	9.86	1.77*
24	181,991	174,365	4.37	0.96	42,812	40,447	5.85	1.28
25	179,367	169,209	6.00	1.00	41,145	39,853	3.24	0.53
26	185,262	206,870	-10.44	-0.84	42,021	44,131	-4.78	-0.41
27	197,980	194,820	1.62	0.27	42,873	39,775	7.79	1.16
28	200,397	186,981	7.18	1.22	43,270	38,153	13.41	2.34*

Notes: Quarters are numbered with 1 = 81Q4.

Once = properties sold only once.

Rpt2 = properties sold only twice.

The variance used for the t-statistic is calculated as: (total sum of squares over both samples) times ($[n_1 + n_2]/[n_1 + n_2 - 2]$). See Box and Tsiao (1973, section 2.5).

*Significant at 10 percent level or better.

only once differ from the only twice subsamples by about 15 percent, with t-statistics in the neighborhood of 9 or 10. More importantly, these differences are remarkably consistent for each of the 28 quarters in the sample. In no cases are there statistically significant negative differences, whereas over half of the quarters have positive differences that are statistically significant at the 10 percent (two-tail) level or better.

Table 3 compares those SFR properties sold only twice to those sold three or more times. Sales prices and assessed values for the "only-twice" subsample are about 7 percent higher than the corresponding values for the "three-plus" sample. For the whole sample period, the t-statistics are significant. More importantly, the direction of the bias is generally consistent over the 28 quarters of the sample. While there are six or seven negative differences, reversing the general direction of bias, none of these is statistically significant. On the other hand, there are a number of significant positive differences even though the smaller quarterly

Table 3. SFR properties that sold twice versus three or more times: comparison of mean values.

	Sales Prices				Assessed Values			
	Rpt2 Mean	Rpt3+ Mean	Pct. Diff.	t-Value	Rpt2 Mean	Rpt3+ Mean	Pct Diff.	t-Value
All obs	$115,042	$107,277	7.24%	2.65*	$39,126	$36,587	6.94%	3.46*
Quarter:								
1	76,373	72,663	5.11	0.31	38,000	34,938	8.76	0.66
2	76,357	73,543	3.83	0.48	38,470	38,797	-0.84	-0.10
3	74,192	66,542	11.50	0.85	38,812	32,045	21.12	1.68*
4	84,409	74,057	13.98	0.89	41,080	40,349	1.81	0.11
5	79,967	70,358	13.66	1.49	40,890	34,022	20.19	1.83*
6	80,995	90,438	-10.44	-0.69	39,117	43,650	-10.38	-0.68
7	86,176	85,996	0.21	0.02	41,363	41,892	-1.26	-0.14
8	89,530	98,424	-9.04	-0.65	41,550	43,881	-5.31	-0.65
9	84,892	77,568	9.44	0.77	40,127	37,221	7.81	0.63
10	82,905	83,000	-0.11	-0.01	39,635	36,563	8.40	0.70
11	96,554	79,541	21.39	2.69*	43,042	35,166	22.40	2.81*
12	96,574	96,248	0.34	0.04	41,647	39,987	4.15	0.50
13	90,161	73,130	23.29	2.36*	39,015	31,408	24.22	2.48*
14	94,521	74,973	26.07	2.33*	40,235	32,310	24.53	1.85*
15	101,283	85,882	17.93	2.91*	40,433	33,457	20.85	3.07*
16	107,534	105,971	1.48	0.15	41,450	38,935	6.46	0.71
17	110,206	113,475	-2.88	-0.39	42,948	41,584	3.28	0.51
18	119,222	92,777	28.50	2.07*	39,887	30,150	32.29	2.59*
19	119,497	114,583	4.29	0.44	40,953	38,643	5.98	0.56
20	130,387	122,385	6.54	0.72	40,052	37,160	7.78	1.01
21	132,545	114,291	15.97	2.07*	39.241	33,809	16.07	2.12*
22	124,266	133,430	-6.87	-0.52	35,470	36,586	-3.05	-0.23
23	155,638	169,565	-8.21	-0.74	40,163	39,031	2.90	0.28
24	174,365	140,605	24.01	2.74*	40,447	31,366	28.95	3.21*
25	169,209	156,179	8.34	0.73	39,853	30,923	28.88	2.45*
26	206,870	161,233	28.30	1.36	44,131	31,233	41.29	1.72*
27	194,820	188,442	3.38	0.28	39,775	37,273	6.71	0.54
28	186,981	255,000	-26.67	-1.25	38,153	44,853	-14.94	-0.81

Notes: Rpt3+ = properties that sold three or more times. See notes to table 2 for further details.

samples (and correspondingly larger standard deviations) make it difficult to find significant differences between means.

Table 4 analyzes the differences between condominium units that sold only once and those that sold only twice during the sample period. These results substantially reverse the findings for SFR sales (table 2): the data indicate that condominiums that sell only twice generally sell for higher prices, and have higher assessed values, than those that sell only once. At the 10 percent (two-tail) level, all of the significant differences in table 4 are negative; however, the t-values are not as strong as the corresponding ones for SFR properties.

Table 4 analyzes differences between condominium units that sold only twice and those that sold three or more times. Surprisingly, these results are even stronger than those for SFR properties: condominiums that sell three or more times have substantially and significantly lower sales prices and assessed values than those that sell only twice. This finding holds when the quarterly data are examined.

We conclude that for the Hartford data there are persistent significant differences among the subsamples of repeat sales and all sales. These differences do not seem to depend on the stage of the real estate cycle: periods of low and negative growth in prices during the early '80s showed differences that are similar to a period of rapid growth after 1985. But the differences do depend on property type. It is also possible that they depend on local market conditions. To examine this, we turn to the Case and Shiller data for four major metropolitan areas.

Table 4. Hartford condominiums: comparison of mean sales prices and assessed values.

	Differences Between Means: All 28 Quarters			Number of Quarters with +/− Differences	
Number of Sales	Diff.	Std. Dev.	t-Value	Pos.	Neg.
One–two					
Price	($11,700)	$1,532	-7.64	1	27
AV	($ 3,986)	$ 536	-7.44	0	28
Two–three plus					
Price	$13,222	$1,485	8.90	28	0
AV	$ 4,353	$ 515	8.45	27	1

Notes: Between 40 percent and 70 percent of the quarterly differences are not significant; the number of significant differences confirms the pattern reported above. Mean values for all quarters follow:

	Sales Price	Assessed Value (AV)
One only	$80,518	$29,339
Two only	$92,218	$33,325
Three plus	$78,996	$28,972

Table 5. Mean single-family residential sales prices: repeat sales in four metropolitan areas.

		Difference: two only–three plus					
		All 66 Quarters*			Number of Quarters with +/− Differences		
	Mean for two only	Diff.	Std. Dev.	t-Value	Pos.	Neg.	Missing
Atlanta	$ 66,300	$13,895	$1,813	7.67	43	20	3
Chicago	$ 54,727	$ 2,633	658	4.00	39	26	1
Dallas	$ 64,080	$ 3,593	$1,564	2.30	40	24	2
Oakland	$140,132	$72,710	$5,589	13.00	59	7	1

**There are 67 quarters in Oakland, 66 for the other cities.*
Source: Compiled from data provided by Robert Shiller. There are few significant differences for the quarterly data. All missing data caused by one or no observations for three plus sales.

2.2. *Differences among prices: The Case-Shiller data*

Table 5 summarizes differences between SFR properties that sold only twice and those that sold three or more times for the four major metropolitan areas. The analysis was done for the whole time period and for all quarters with available data. The last three columns of the table summarize the quarterly information in terms of the number of quarters with significantly difference average sales prices.

The pattern in table 5 is similar to the one for the Hartford data: properties that sold three or more times have lower sales prices than those that sold only twice. This difference is unusually strong for Oakland, whereas Dallas shows a much smaller difference but still in the same direction. We conclude that the data support the notion that there is a lemon or starter-home phenomenon present.

2.3. *Comparison of price trends*

Table 6 reports the first differences in the time-dummy coefficients obtained from fitting equation (3). The error ratio reported on the last line is a proportionality factor for possible bias in price changes. As discussed in section 1.1. this error ratio is a maximum for the true error ratio. The error ratio, together with the first difference in log of assessed value (the latter is typically about plus or minus .05, rarely as high as .1), indicates that the typical bias caused by measurement error is substantially less than 1 percent. It is rarely as high as 2 or 3 percent. Also, measurement error is a greater problem for smaller sample sizes.

We conclude that a few of the positive and negative spikes in price changes may be partly the result of measurement error. Moreover, the error can take on both positive and negative values, and that adds noise to the price trends estimates. However, the amount of noise added is not enough to warrant elaborate (and imperfect) adjustment.

Table 6. Quarterly price changes for the Hartford housing market, 1982–1988.

		Single-Family Residential (SFR)				Condominiums			
Quarter	Date	All %	Rpt %	Rpt2 %	Rpt3+ %	All %	Rpt %	Rpt2 %	Rpt3+ %
2	82Q1	0.4	0.1	0.4	-3.8	2.1	1.2	3.9	0.6
3	82Q2	0.5	0.3	0.5	4.1	0.8	0.9	-3.3	2.7
4	82Q3	2.1	1.7	2.3	-11.4	0.0	-0.7	3.7	-1.0
5	82Q4	-1.7	-2.8	-3.5	13.3	0.0	0.6	-0.3	0.9
6	83Q1	1.9	4.6	4.8	-3.2	2.5	2.4	1.0	1.5
7	83Q2	4.6	2.1	1.9	3.6	3.2	2.1	0.5	3.4
8	83Q3	0.8	1.3	0.9	3.9	-0.7	-0.3	0.9	-1.4
9	83Q4	0.9	-0.4	0.0	-3.0	1.0	-0.3	0.4	0.1
10	84Q1	1.1	1.4	0.9	5.7	-3.1	-0.2	-9.1	-0.4
11	84Q2	4.7	5.9	5.3	5.9	0.7	0.6	7.6	-0.6
12	84Q3	1.8	2.4	2.5	0.9	3.2	2.6	6.0	3.3
13	84Q4	0.9	-0.7	-0.5	-4.6	2.6	0.8	0.3	0.3
14	85Q1	3.0	1.2	1.1	-1.6	-0.3	0.1	-1.0	0.7
15	85Q2	5.2	6.6	5.8	14.0	0.5	3.9	2.2	3.8
16	85Q3	3.5	3.2	3.1	3.8	4.3	0.3	0.8	-0.2
17	85Q4	3.9	4.0	3.2	1.5	-1.0	0.2	0.7	0.5
18	86Q1	3.3	6.9	7.5	5.9	4.4	4.1	-1.3	5.8
19	86Q2	7.2	2.3	2.3	0.5	3.5	4.8	11.1	3.3
20	86Q3	9.3	8.1	7.2	6.1	10.4	8.4	7.8	8.4
21	86Q4	5.8	5.6	5.1	7.8	2.3	4.0	1.5	5.3
22	87Q1	4.3	4.4	2.9	5.1	2.9	4.1	7.3	2.9
23	87Q2	9.1	10.1	10.2	16.1	7.2	7.0	6.3	6.3
24	87Q3	7.3	10.8	11.6	4.3	7.7	8.7	5.6	8.9
25	87Q4	2.6	-2.7	-0.6	10.1	7.3	5.8	6.9	7.6
26	88Q1	2.4	3.7	4.5	6.8	6.5	5.5	11.1	1.8
27	88Q2	4.6	6.8	7.9	-4.6	4.3	4.9	-0.5	5.9
28	88Q3	-1.0	1.1	0.8	8.1	2.3	-0.4	-5.3	1.0
R^2		.996	.984	.969	.999	.997	.993	.990	.989
SEE		.145	.156	.162	.170	.167	.200	.267	.167
SD(ln*A*)		.383	.413	.415	.400	.383	.366	.399	.354
Error ratio		.143	.143	.152	.181	.190	.299	.448	.222
Avg. $\|\Delta \ln A\|$		.0235	.047	.040	.127	.059	.038	.092	.038
Max $\|\Delta \ln A\|$		.071	.187	.136	.354	.181	.125	.342	.161

Notes: The R^2 and SEE are from estimating equation (3). For each quarter we present $(\hat{C}_t - \hat{C}_{t-1}) \times 100$. These are approximately percentage changes: the antilogs of these numbers in decimal terms minus one give exact percentage changes. These price changes are for all transactions (All), the repeat subsample (Rpt), the sub-subsample involved in only two transactions (Rpt2) and the sub-subsample involved in three or more transactions (Rpt3+). The error ratio, a proportionality factor for measurement error, is equal to $[\text{SEE}/\text{SD}(\ln A)]^2$, where SEE is the standard error of the estimate and SD(ln*A*) is the standard deviation of log-assessed value.

The noise introduced by small sample size is apparent from table 7, which reports the simple correlation coefficients for the SFR price changes. All, repeat and repeat 2, where sample sizes are large, are highly correlated. The three-plus price index, where sample size is a maximum of 24 observations, is not highly correlated with any of the other indices.

Table 7. Correlations among samples—Hartford price changes ($\hat{c}_t - \hat{c}_{t-1}$), 1981–1988.

	All	Rpt	Rpt2	Rpt3+	Average Observations per Quarter
All	1	.797	.78	.24	487
Rpt		1	.978	.23	123
Rpt2			1	.17	108
Rpt3+				1	15

Differences between cumulative price indices are plotted in figure 1.[7] For example, we summed the numbers in table 6, creating cumulative indices, and then subtracted the cumulative price index for the repeat subsample from the cumulative index for the entire sample. The zero line in figure 1 (where the two cumulative prices indices are equal) is arbitrarily set near the beginning of the time period. The reader is free to draw horizontal lines anywhere in order to evaluate how the two indices move differently from any arbitrary starting point.

Figure 1 reveals that the price index based on the repeat subsample tends to differ from the full sample for a period of two to as many as ten quarters. The clearest example can be seen beginning with quarter 18 (1986, first quarter) where the differences between pairs of indices are approximately zero. By the third quarter of 1986, the difference in all minus repeat is about 5 percent, whereas repeat three-plus (repeat-two-only) is lower than all by 12 percent (8 percent). It takes three quarters to eliminate the first two gaps and eight quarters to eliminate the all minus repeat-two-only gap. We conclude that, for this sample, the repeat index would give reliable estimates of price trends over long periods of time, but systematic discrepancies are common for short time periods.

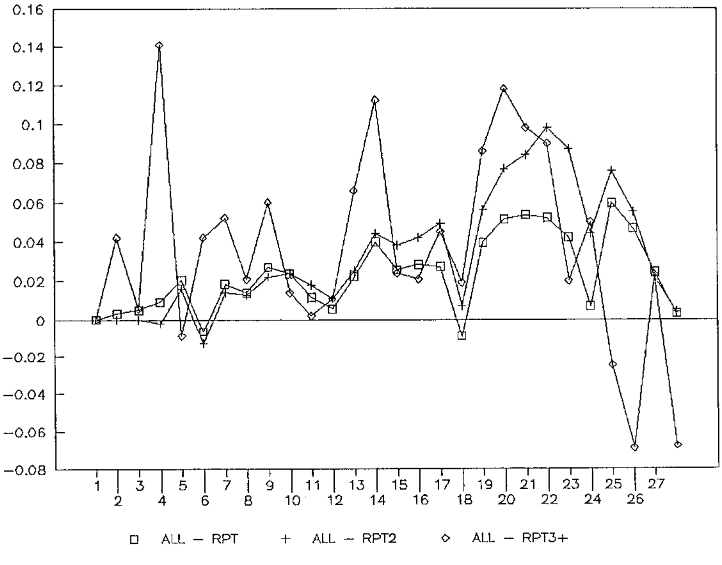

Figure 1. Hartford, SFR, 82Q1–88Q3.

We tested the statistical significance of the differences shown in figure 1 using the ACOV matrix discussed in section 1. For example, confidence intervals were calculated for the cumulative index based on all transactions (a typical confidence range of ± 2 percent) and for the index based on repeat sales (a typical confidence range of ± 4 or 5 percent). These confidence intervals (and similar intervals for other pairs reported in figure 1) overlapped in virtually every quarter. However, the failure to find statistically significant differences among indices is a function of the small number of observations available for the repeat subsamples (table 1).[8] The large magnitude of the differences in the price indices, and their systematic and persistent character, are more important than statistical significance.

For Hartford condominiums (figure 2), the general pattern is similar to SFR properties, even though the average price for properties sold only twice was equal to or higher than the average price for properties that sold only once. The explanation for this is apparent from figure 3 and from the observation that more than half of all repeat transactions were for properties that sold three or more times. Thus, most of the systematic differences between all properties and the repeat subsample appear to be due to the three-plus part of the database. Also, figure 3 indicates that the three-plus subsample moves differently than the two-only subsample; the former has larger swings away from equilibrium over shorter periods of time than the latter.

Similar graphs are presented for the Case-Shiller data (figures 4–7). The three-plus subsample can give price trends that swing away from the full repeat subsample for two to five quarters. Differences are larger for Atlanta and smaller for Chicago and Oakland. Thus, the general pattern observed in Hartford is confirmed.

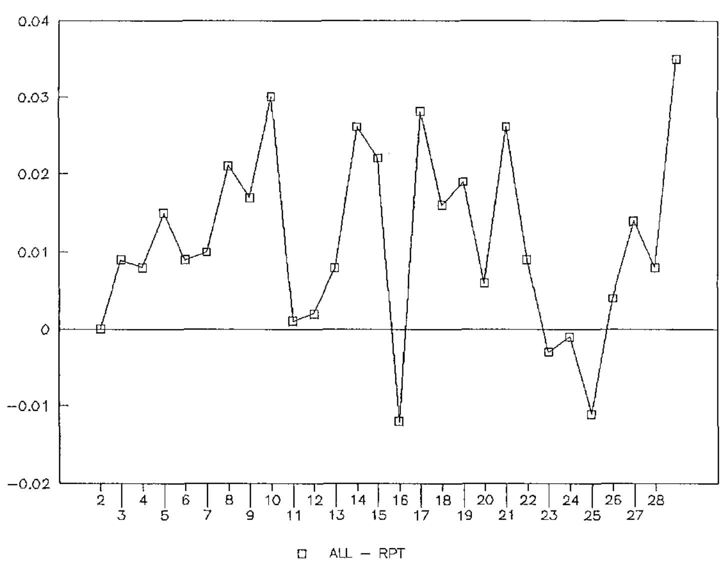

Figure 2. Hartford, Condos, 82Q1–88Q3.

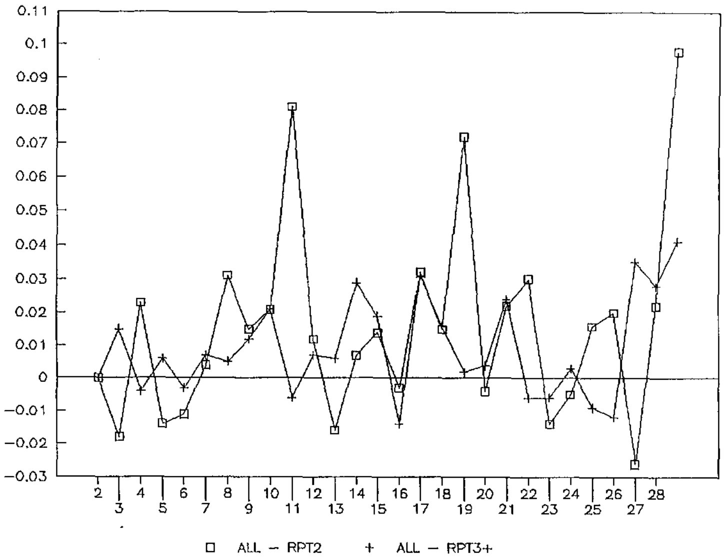

Figure 3. Hartford, Condos, 82Q1–88Q3.

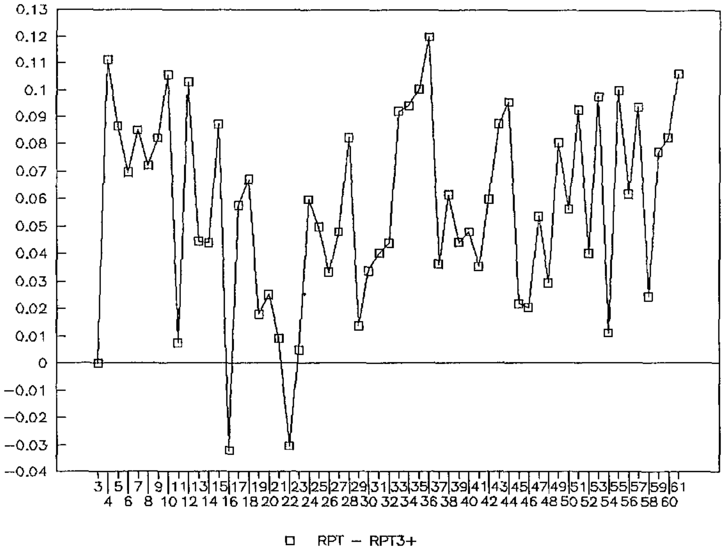

Figure 4. Atlanta, 71Q1–86Q2.

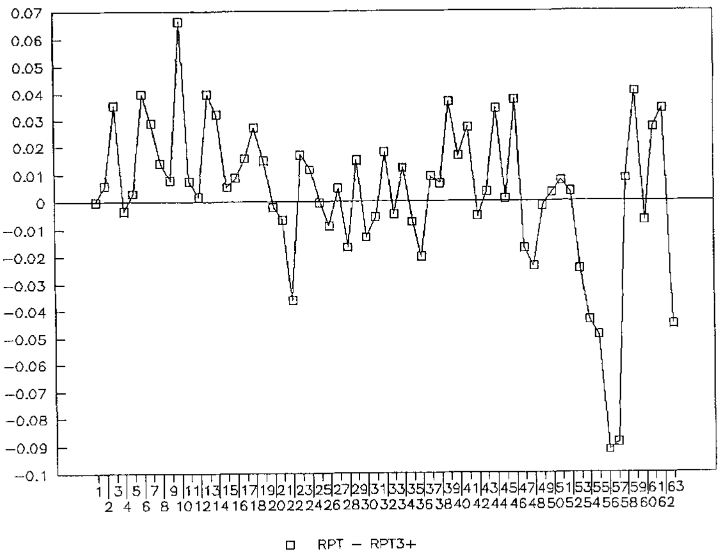

Figure 5. Chicago, 70Q3–86Q1.

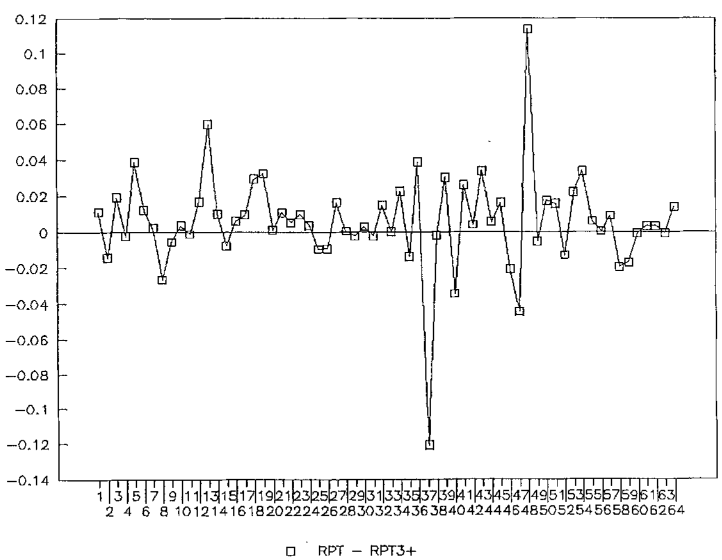

Figure 6. Oakland, 70Q3–86Q2.

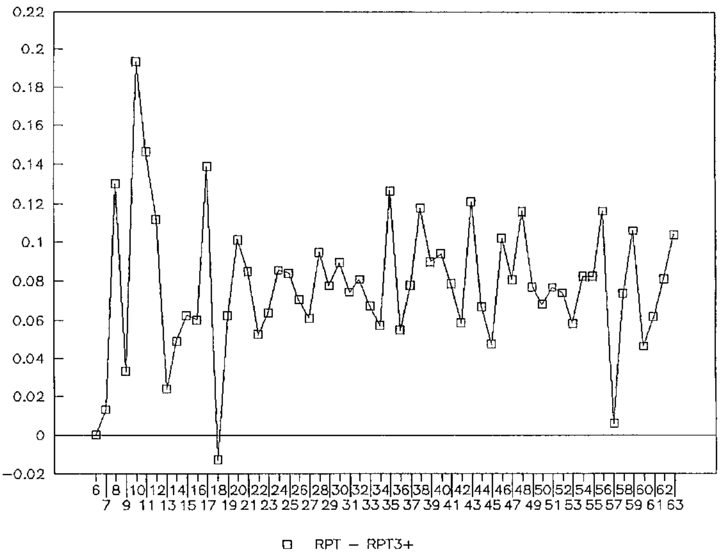

Figure 7. Dallas, 71Q3–86Q1.

The difference in the cumulative price index is relatively small and unsystematic for Oakland despite a large difference in average price. For Atlanta, the difference in the cumulative index is large and persistent despite a relatively small difference in average price. We conclude that there is no simple relationship between market value (measured by average price) and differences in price trends. Instead, the relationship appears to depend on the time period, local market conditions, and property type.

The discussion in this section should be viewed as tentative and exploratory. As we pointed out, there are no statistically significant differences among the price indices reported in table 6, or between the repeat two and repeat three-plus samples for the four Case-Shiller cities. The three-plus sample is small in most quarters, typically below 30 observations. Although we do not have enough data to report definitive results, we believe, nonetheless that figures 1–7 and related data suggest systematic short-run differences between pairs of price indices.

3. Conclusions

Evidence from five metropolitan areas supports the hypothesis that a lemon or starter home effect causes repeat residential sales (both condominiums and SFR) to be a biased subsample of all transactions. In general, the average market value (measured by sales prices and assessed values) for repeat sales is less than for all sales.[9] Since properties that sell three or more times have significantly lower market values than those that sell only twice, we conclude that the differences are systematically relate to some characteristic associated with repetitive sales. The starter home and lemon hypotheses are capable of explaining this relationship.[10]

Cumulative price trends for the repeat subsamples can differ from the full samples over periods ranging from two to ten quarters. Gaps ranging from 1 to 15 percent open up, persist, and are typically closed. However, although short-term movements can differ widely, there are no systematic differences among the samples over long periods of time (e.g., three years or more).

Based on these findings, we recommend that those using repeat sales for estimating price trends should consider eliminating properties that sold three or more times. In addition to biasing the repeat subsample further, these properties introduce nonzero covariances into the error term. They also introduce the problem of how to pair the sales in the repeat database (*see* Palmquist 1982 and Bailey, Muth, and Nourse, 1963). The pairing of these multiple repeat sales can have a strong effect on price trend estimates (Knickerbocker, 1990).

Hedonic or assessed value methods that use data on all transactions should be considered as an alternative to the repeat sales methodology. If the repeat subsample is used for price index construction, one should be cognizant that the price trend estimates do not represent all transactions over short time periods.

Acknowledgments

The authors are grateful to the Center for Real Estate and Urban Economic Studies, The University of Connecticut, for financial support, research assistance, and secretarial help. Valuable comments on earlier drafts were received from Robert Shiller, Yale University, Susan Woodward, U.S. Department of Housing and Urban Development, an associate editor, and two referees.

Notes

1. Mark and Goldberg (1984) found that cumulative price appreciation for their repeat subsample was about half of the full sample. They conclude that a few neighborhoods with volatile prices dominate the repeat subsample.
2. We did not have enough transactions of properties with more than three sales to examine this category separately.
3. Three or more transactions also cause econometric problems for the repeat-sales methodology. First, the choice about pairing the three sales (there are three possible pairs) is arbitrary (Knickerbocker, 1990; Palmquist, 1982). Second, the presence of three or more transactions creates nonzero covariances in the repeat-sales methodology (Palmquist, 1982).
4. Logarithms are used on sales price and housing characteristics in order to reduce heteroscedasticity and to convert the estimates on the quarterly dummies to a cumulative logarithmic index with base zero at $t = 0$.
5. In this expression, the variance of the log of A is actually the weighted average of the variances in each quarter of the analysis, with the weights being the number of observations in each quarter. This is the maximum bias because the true bias is proportional to $\mathrm{Var}(f/g)/\mathrm{VAR}(\ln A)$; since we do not know $\mathrm{Var}(f)$, we must use the larger variance estimate (the mean squared error) available from the regression equation.
6. We experimented with the random walk heteroscedasticity adjustment of Case and Shiller (1987) but found slight evidence in its favor.
7. The vertical axis is the difference in decimal terms between the two price indices. The horizontal axis is time measured in quarters, with 1 = the fourth quarter of 1981.

8. For example, if one calculates the confidence interval using all the data, it does exclude the price index from the repeat subsamples in a number of quarters.
9. Hartford condominiums are the only exception: repeats (two-only and three-plus combined) typically sell for a few thousand dollars more than all condominiums. However, this is entirely due to the higher average price for condominiums that sell only twice (see table 4).
10. The lemon hypothesis (Akerlof, 1970) typically assumes complete asymmetric information, where low-quality goods sell at the same price as high-quality goods. (Primary and secondary markets are allowed to have different prices.) Asymmetric information cannot be the case here since properties that sell three or more times are clearly perceived by the market as lower quality than those that sell twice.

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