The Dynamics of Metropolitan Housing Prices

Article *in* Journal of Real Estate Research · February 2002

Source: RePEc

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Abstract

This article is the winner of the Innovative Thinking ''Thinking Out of the Box'' manuscript prize (sponsored by the Homer Hoyt Advanced Studies Institute) presented at the 2001 American Real Estate Society Annual Meeting.

This study examines the dynamics of real housing price appreciation in 130 metropolitan areas across the United States. The study finds that real housing price appreciation is strongly influenced by the growth of population and real changes in income, construction costs and interest rates. The study also finds that stock market appreciation imparts a strong current and lagged wealth effect on housing prices. Housing appreciation rates also are found to vary across areas because of location-specific fixed-effects; these fixed effects represent the residuals of housing price appreciation attributable to location. The magnitudes of the fixed-effects in particular cities are positively correlated with restrictive growth management policies and limitations on land availability.

Introduction

The factors that influence changes in housing prices are of interest to urban planners, developers, real estate professionals and financial executives as well as most American households. According to a 1998 Federal Reserve survey (Kennickell, Starr-McCluer and Surette, 2000), 66.2% of households in the United States are homeowners, and housing investment amounts to 33% of household net worth. Over the past two decades, stock market appreciation has markedly increased the total wealth of U.S. households, but the linkage between housing prices and stock market wealth has not been explored. A number of studies have examined housing price change by metropolitan area, but few studies have been able to estimate the separate the effects of both demand- and supply-side variables.

This study examines the factors that influence real housing price changes in a sample of 130 metropolitan areas during the 1984 to 1998 period. In comparison to prior research, this research offers a much broader sample of MSAs over a longer time period. The study shows that real housing price appreciation is significantly related to changes in population and real changes in income, construction costs, stock price appreciation and after-tax interest rates. The analysis employs a fixed-effects model to control for MSA-specific factors that may influence appreciation rates in particular areas. The magnitudes of the fixed-effect coefficients are positively correlated with restrictive growth management policies and limitations on land availability.

Past Studies of Housing Price Changes

There have been a number of studies of housing prices and housing price changes. The focus here is on those studies that have examined housing price changes, rather than the level of prices. A review of early work in this area can be found in Bartik (1991, Chapter 5), who introduces a lagged adjustment model and provides additional empirical results. The studies reveal that housing appreciation is directly influenced by population and employment growth, although the estimated impacts of these factors vary widely. A study by Poterba (1991) examines the effects of population and income changes as well as the impacts of construction and after-tax user costs. He finds that income and construction costs are important in explaining housing cost changes, but his results provide no support for the role of demographic factors or after-tax user costs.

Abraham and Hendershott (1996) develop a model of housing price change that allows for a lagged adjustment process. Their model, which is estimated using the quality-adjusted Freddie Mac-Fannie Mae repeat transaction database for thirty metropolitan areas, reveals that that real housing price appreciation is directly related to increases in real construction costs, employment and real income. They find that appreciation rates are negatively related to rises in real interest rates.

The prolonged rise in stock prices over the past two decades has dramatically increased household wealth, and stock holdings have grown as a fraction of total household wealth, rising from 8.5% in 1989 to 22.9% in 1998 (Kennickell, Starr-McCluer and Surette, 2000).[1] Although the effect of wealth on consumption has been much debated (Ludvigson and Steindel, 1999; and Starr-McCluer, 1998), no work was found that focused specifically on the impact of wealth changes on housing expenditures or prices.

A number of economic models have examined the ''wealth effect'' on total consumer spending. Most of these models estimate that a one-dollar increase in stock market wealth raises consumer spending by three to seven cents per year (Starr-McCluer, 1998), but the magnitude of the effect remains a subject of debate and research. For example, a recent paper by Poterba (2000) suggests the wealth effect might be less than three cents per dollar, while work by Ludvigson and Steindel (1999) finds evidence that the effect of wealth on durable goods spending is larger and more long lasting than its effect on total spending.

This study analyzes the determinants of real housing price change using a sample encompassing 130 metro areas from 1984 through 1998. The model introduces a wealth effect on housing prices, and an MSA fixed-effects model is utilized to account for changes in metropolitan-specific cost factors. The model is estimated with a maximum likelihood procedure that allows correction of the time-series, cross-sectional sample for heteroskedasticity and autocorrelation within metropolitan cross sections.

The sample data of housing prices are derived from recently available quality-adjusted housing price indexes reported by the Office of Federal Housing Enterprise Oversight (OFHEO). OHHEO's House Price Indexes are available at the MSA level. They track average house price changes in repeat sales or refinancings on the same single-family properties and are based on analysis of data obtained from over 11.9 million repeat transactions over the past twenty years (OFHEO, 1999).

The Model and Empirical Specification

The demand for housing in any metropolitan market (i) at time (t) is given by:

$$Q^D_{i,t} = D(P_{i,t}, Y_{i,t}, W_{i,t}, I_{i,t}, Pop_{i,t}, u_{i,t}), \tag{1}$$

Where:

$P_{i.t}$ = Real housing price;
$Y_{i.t}$ = Real income;
$W_{i.t}$ = Real wealth;
$I_{i.t}$ = Real after-tax mortgage interest rate;
$Pop_{i.t}$ = Population; and
$u_{i.t}$ = Random error term.

Similarly, market supply is defined as:

$$Q^S_{i,t} = S(P_{i,t}, I_{i,t}, C_{i,t}, M_{i,t}, v_{i,t}), \tag{2}$$

Where:

$P_{i.t}$ = Real housing price;
$I_{i.t}$ = Real after-tax mortgage interest rate;
$C_{i.t}$ = Real construction costs;
$M_{i.t}$ = MSA-specific cost factors; and
$v_{i.t}$ = A random error term.

All variables are defined in logarithms.

In equilibrium:

$$Q^D_{i,t} = Q^S_{i,t}. \tag{3}$$

Substituting Equations (1) and (2) into Equation (3), produces the reduced form equation:

$$P_{i,t} = f(Y_{i,t}, W_{i,t}, I_{i,t}, Pop_{i,t}, C_{i,t}, M_{i,t}, z_{i,t}). \tag{4}$$

All of the variable coefficients are assumed to be positive except for the coefficient on the real mortgage rate, where the sign is indeterminate.[2]

The percentage change in prices during any time period is measured by $\%\Delta P_{i,t}$, or $(P_{i,t} - P_{i,t-1})/P_{i,t-1}$, and, assuming no lags in the adjustment process, is estimated by:

$$\%\Delta P_{i,t} = f(\%\Delta Y_{i,t}, \%\Delta W_{i,t}, \%\Delta I_{i,t}, \%\Delta Pop_{i,t}, \%\Delta M_{i,t}, e_{i,t}). \tag{5}$$

Equation (5) is estimated using a pooled time-series cross-section model with MSA fixed effects.[3] In place of $\%\Delta M_{i,t}$, which represents the percentage change in MSA-specific cost factors, a vector of MSA dummy variables (fixed effects) is utilized to capture the average percentage change in MSA-specific cost factors over the sample period.

All of the variables in Equation (5) reflect changes in real values; thus, in compiling sample date, all monetary values are deflated by a regional index of prices, in order to focus on changes in real values. The regional Consumer Price Indexes (CPI-U), compiled by the Bureau of Labor Statistics (BLS), are used to measure price level changes. Specific aggregate price indexes are available for twenty-four metropolitan areas.[4] For those MSA's where the BLS does not produce a specific CPI-U, the CPI-U for the corresponding urban census region is used.

To test the appropriateness of the price deflation procedure, a restricted sample is formed using only the twenty-four MSAs for which the BLS has a metropolitan specific CPI-U. The model (Equation (5)) is estimated using the restricted sample, and the results are reported in the Appendix in Exhibits A.1–A.3. (The Appendix exhibits correspond with Exhibits 1–3.) Overall, the restricted-sample results accord completely with the findings obtained using the full sample of 130 MSAs. The results from the full sample are discussed in the following sections.

The sample data covers 130 metropolitan markets with annual data for 1984–98. The real price variable ($P_{i,t}$) is the quality-adjusted housing price index for metropolitan markets reported by the OFHEO and deflated by the regional price index. The real income variable ($Y_{i,t}$) is the personal income per capita in real terms for the MSA. The real wealth variable ($W_{i,t}$) is measured by the S&P 500 stock index deflated by the regional cost index. The effects of real cost factors are measured in two ways. First the construction cost component of the producer price index deflated by the CPI-U is used to capture the effects of national changes in real construction costs.[5] Second, factors specific to each MSA, other than real wage increases, are proxied by MSA-specific dummy variables. Increases in real wages are captured by the real income variable ($Y_{i,t}$).

The real after-tax interest rate variable ($I_{i,t}$) is the annual average real after-tax, effective rate on conventional loans closed. The after-tax mortgage rate is computed using the mean tax rate calculated from the personal income series as reported by the Bureau of Economic Analysis.[6] The real rate is computed by subtracting the ex post inflation rate, as measured by the regional CPI-U's, from the after-tax mortgage rate.[7] The real interest rate variable in Equation (5) is the *percentage change* in the real after-tax rate ($\%\Delta I_{i,t}$).

Population ($Pop_{i,t}$) is the estimated total MSA population as reported by the Bureau of Economic Analysis in the personal income series.

In estimating Equation (5), MSA-specific autocorrelation is corrected by estimating separate AR terms for each MSA cross-section, allowing the AR terms to vary among the MSAs.[8] Hereroskedasticity within MSA cross sections is corrected with a generalized least squares procedure for cross-section weighted regression. The White heteroskedasticity consistent covariance correction is also applied to adjust for non-constant variances across cross sections.

The possibility of lags in the housing market adjustment process was examined by including into Equation (5) the lagged values of independent variables. The only variables where significant lags were found were real stock prices and real construction costs. In the reported results, a lag is introduced into the model for the stock prices, allowing the real wealth effect to extend over more than one year. A real construction cost lag also is added to the model to capture the delayed effects of construction costs on existing house prices.[9]

Empirical Results

Exhibit 1 shows the estimates of Equation (5) with lagged changes in stock prices and construction costs. All of the coefficients are statistically significant and have the expected signs. The R^2 is 65% and the overall regression model is statistically significant. The Durbin-Watson statistic indicates most of the effects of autocorrelation have been removed.

Exhibit 1 | Determinants of Housing Price Change

Independent Variable	Coefficient	Std. Error	*t*-value
$\%\Delta Y_{i,t}$	0.1679	0.0261	6.43
$\%\Delta W_{i,t}$	0.0988	0.0047	21.00
$\%\Delta W_{i,t-1}$	0.0628	0.0033	18.93
$\%\Delta I_{i,t}$	0.0239	0.0018	13.01
$\%\Delta Pop_{i,t}$	1.0892	0.0973	11.19
$\%\Delta C_{i,t-1}$	0.1216	0.0101	12.00
R^2	0.65		
F-statistic	9.77		
D.W.	1.80		

Notes: MSA fixed effects are shown in Exhibit 2. $n = 1{,}690$.

The estimated coefficients reveal that a 1% change in real per capita income is associated with a modest, but statistically significant, 0.17% change in real housing prices. A notable feature of the research relates to the effects of real wealth accumulation (or stock prices) on housing values. A 1% change in stock prices is found to produce a 0.16% change in housing values after the full effect of the one-period lag is felt. These results suggest a significant real wealth effect operates in the existing housing market and that the lagged change in real wealth makes an important contribution to the total real wealth effect.[10]

The findings also indicate a 1% change in real, after-tax mortgage interest rates is associated with a 0.024% increase in real prices, and a 1% change in real construction costs raises housing values by 0.12% following a one-period lag.

Real housing values at the MSA level are found to be most responsive to changes in population. A 1% change in the rate of population growth raises community-housing values by 1.09%.

Exhibit 2 shows the MSA fixed effects for 130 MSAs with the coefficients ranked from lowest to highest. The dummy variable coefficients of only seven MSAs are positive, and none of these positive coefficients are statistically significant. This finding suggests that price appreciation in most all MSAs would have been less than the inflation rate, were it not for the influence of changes in population and real changes in income, construction costs, stock market valuation and mortgage interest rates.[11] Among the 130 MSA dummy variable coefficients, sixty are statistically significant at the 5% level or better and forty-seven are significant at the 1% level.[12]

Exhibit 2 | MSA Fixed Effects

Fips Code	Metropolitan Area	State	Coefficient	Std. Error	*t*-value
74120	Las Vegas*	NV-AZ	−8.813	1.024	−8.609
75960	Orlando*	FL	−6.205	1.222	−5.078
78960	West Palm Beach-Boca Raton*	FL	−6.198	0.875	−7.081
72020	Daytona Beach*	FL	−5.840	0.700	−8.338
72800	Fort Worth-Arlington*	TX	−5.628	0.769	−7.320
71920	Dallas*	TX	−5.559	0.526	−10.576
74900	Melbourne-Titusville-Palm Bay*	FL	−5.489	1.316	−4.169
76200	Phoenix-Mesa*	AZ	−5.348	1.991	−2.685
76640	Raleigh-Durham-Chapel Hill*	NC	−5.238	1.213	−4.318
70520	Atlanta*	GA	−5.138	0.634	−8.110
76720	Reno*	NV	−5.132	1.223	−4.196
78520	Tucson*	AZ	−4.900	1.191	−4.113
73360	Houston*	TX	−4.479	0.729	−6.144
75720	Norfolk-Virginia Beach*	VA-NC	−4.425	0.519	−8.529
78280	Tampa-St. Petersburg-Clearwater*	FL	−4.399	0.513	−8.581
72840	Fresno*	CA	−4.352	1.551	−2.807
70680	Bakersfield*	CA	−4.350	1.752	−2.482
72680	Fort Lauderdale*	FL	−4.341	0.731	−5.941
77510	Sarasota-Bradenton*	FL	−4.306	0.691	−6.227
78780	Visalia-Tulare-Porterville*	CA	−4.208	1.719	−2.447
77240	San Antonio*	TX	−4.001	0.895	−4.470
71880	Corpus Christi*	TX	−3.970	0.778	−5.102
70200	Albuquerque	NM	−3.943	2.817	−1.400
79160	Wilmington-Newark	DE-MD	−3.943	2.903	−1.358
76780	Riverside-San Bernardino*	CA	−3.894	1.718	−2.267
70640	Austin-San Marcos*	TX	−3.888	1.666	−2.334
76760	Richmond-Petersburg*	VA	−3.805	0.284	−13.407
79040	Wichita*	KS	−3.801	1.520	−2.500
71520	Charlotte-Gastonia-Rock Hill*	NC-SC	−3.779	0.670	−5.639
75015	Middlesex-Somerset-Hunterdon	NJ	−3.742	4.257	−0.879
73120	Greensboro/Winston-Salem*	NC	−3.713	0.394	−9.414
74280	Lexington*	KY	−3.694	1.252	−2.950
72120	Des Moines*	IA	−3.673	1.631	−2.252
74920	Memphis*	TN-AR-MS	−3.625	0.560	−6.478
78440	Topeka*	KS	−3.620	0.867	−4.173

Exhibit 2 | (continued)
MSA Fixed Effects

Fips Code	Metropolitan Area	State	Coefficient	Std. Error	*t*-value
74680	Macon*	GA	−3.595	0.593	−6.058
73200	Hamilton-Middletown*	OH	−3.587	0.387	−9.266
72760	Fort Wayne*	IN	−3.511	0.717	−4.895
73760	Kansas City*	MO-KS	−3.508	1.018	−3.446
77490	Santa Fe	NM	−3.471	1.986	−1.748
75360	Nashville	TN	−3.425	2.130	−1.608
78560	Tulsa*	OK	−3.398	0.958	−3.546
76690	Redding	CA	−3.350	1.961	−1.708
71150	Bremerton	WA	−3.228	2.613	−1.235
76680	Reading*	PA	−3.224	1.187	−2.716
74940	Merced	CA	−3.203	1.676	−1.911
75170	Modesto*	CA	−3.167	1.554	−2.038
78840	Washington	DC-MD-VA-WV	−3.154	2.488	−1.268
77040	St. Louis*	MO-IL	−3.095	0.677	−4.574
71123	Boston-Worcester-Lowell	MA-NH	−3.093	2.245	−1.378
70875	Bergen-Passaic	NJ	−3.057	4.006	−0.763
75120	Minneapolis-St. Paul*	MN-WI	−3.015	0.680	−4.436
74400	Little Rock-North Little Rock	AR	−3.010	2.375	−1.267
74000	Lancaster*	PA	−2.961	0.896	−3.307
78160	Syracuse*	NY	−2.948	1.384	−2.130
75800	Odessa-Midland*	TX	−2.881	0.980	−2.939
73480	Indianapolis*	IN	−2.867	0.284	−10.111
71720	Colorado Springs	CO	−2.866	2.056	−1.394
72670	Fort Collins-Loveland	CO	−2.860	2.844	−1.006
73160	Greenville-Spartanburg-Anderson*	SC	−2.824	0.859	−3.289
74360	Lincoln*	NE	−2.767	1.183	−2.340
73240	Harrisburg-Lebanon-Carlisle*	PA	−2.746	0.235	−11.710
70840	Beaumont-Port Arthur*	TX	−2.723	0.621	−4.382
76880	Rockford*	IL	−2.708	0.806	−3.360
75640	Newark	NJ	−2.623	4.134	−0.634
78120	Stockton-Lodi	CA	−2.602	1.613	−1.612
78720	Vallejo-Fairfield-Napa	CA	−2.590	1.359	−1.906
72080	Denver	CO	−2.549	1.451	−1.757
70760	Baton Rouge*	LA	−2.502	0.902	−2.774

Exhibit 2 | (continued)
MSA Fixed Effects

Fips Code	Metropolitan Area	State	Coefficient	Std. Error	*t*-value
75000	Miami*	FL	−2.404	0.557	−4.317
70720	Baltimore	MD	−2.400	1.560	−1.539
75190	Monmouth-Ocean	NJ	−2.347	4.278	−0.549
74720	Madison	WI	−2.313	1.226	−1.887
78480	Trenton	NJ	−2.306	3.946	−0.584
76920	Sacramento	CA	−2.297	1.869	−1.229
75380	Nassau-Suffolk	NY	−2.260	4.102	−0.551
73000	Grand Rapids-Muskegon-Holland*	MI	−2.197	0.543	−4.043
75920	Omaha	NE-IA	−2.192	2.419	−0.906
71000	Birmingham*	AL	−2.147	0.640	−3.352
75880	Oklahoma City*	OK	−2.136	0.926	−2.307
77840	Spokane	WA	−2.131	2.369	−0.900
77320	San Diego	CA	−2.113	1.749	−1.208
70860	Bellingham	WA	−2.091	3.287	−0.636
71640	Cincinnati*	OH-KY-IN	−2.049	0.250	−8.194
76160	Philadelphia	PA-NJ	−2.010	3.205	−0.627
71125	Boulder-Longmont	CO	−2.009	2.663	−0.754
77500	Santa Rosa	CA	−1.915	2.957	−0.648
70240	Allentown-Bethlehem-Easton	PA	−1.859	3.433	−0.541
77600	Seattle-Bellevue-Everett	WA	−1.859	2.018	−0.921
76483	Providence-Warwick-Pawtucket	RI	−1.846	4.967	−0.372
78200	Tacoma	WA	−1.738	2.304	−0.755
74040	Lansing-East Lansing*	MI	−1.735	0.751	−2.310
77120	Salinas	CA	−1.627	2.154	−0.755
75560	New Orleans	LA	−1.590	1.261	−1.261
75600	New York	NY	−1.574	5.092	−0.309
71600	Chicago	IL	−1.544	1.612	−0.958
72000	Dayton-Springfield*	OH	−1.354	0.303	−4.466
75775	Oakland	CA	−1.299	2.207	−0.588
76740	Richland-Kennewick-Pasco	WA	−1.276	2.188	−0.583
71280	Buffalo-Niagara Falls	NY	−1.251	1.482	−0.844
74520	Louisville*	KY-IN	−1.201	0.486	−2.470
70380	Anchorage	AK	−1.187	1.182	−1.004
70440	Ann Arbor	MI	−1.157	0.661	−1.750

Exhibit 2 | (continued)
MSA Fixed Effects

Fips Code	Metropolitan Area	State	Coefficient	Std. Error	*t*-value
78400	Toledo	OH	−1.131	0.614	−1.842
75080	Milwaukee-Waukesha	WI	−1.098	0.729	−1.507
72960	Gary	IN	−1.013	1.164	−0.870
76280	Pittsburgh	PA	−1.000	0.527	−1.897
76120	Peoria-Pekin	IL	−0.975	0.895	−1.090
77080	Salem	OR	−0.925	2.143	−0.432
70080	Akron*	OH	−0.803	0.317	−2.529
75483	New Haven-Bridgprt	CT	−0.781	4.616	−0.169
77460	San Luis Obispo-Paso Robles	CA	−0.718	2.997	−0.239
76440	Portland-Vancouver	OR-WA	−0.675	1.811	−0.373
73283	Hartford	CT	−0.626	3.462	−0.181
73720	Kalamazoo-Battle Creek	MI	−0.610	0.903	−0.676
71680	Cleveland-Lorain-Elyria	OH	−0.595	0.436	−1.363
77480	Santa Barbara-Santa Maria-Lompoc	CA	−0.586	1.831	−0.320
75945	Orange County	CA	−0.546	2.480	−0.220
77160	Salt Lake City-Ogden	UT	−0.541	4.322	−0.125
71320	Canton-Massillon	OH	−0.451	1.199	−0.376
78735	Ventura	CA	−0.430	2.375	−0.181
76960	Saginaw-Bay City-Midland	MI	−0.332	0.992	−0.334
72640	Flint	MI	−0.043	1.217	−0.035
72160	Detroit	MI	0.285	0.787	0.362
77485	Santa Cruz-Watsonville	CA	0.597	3.014	0.198
72400	Eugene-Springfield	OR	0.631	0.978	0.645
77400	San Jose	CA	0.799	2.870	0.279
73320	Honolulu	HI	0.825	4.425	0.186
74480	Los Angeles-Long Beach	CA	1.290	2.591	0.498
77360	San Francisco	CA	1.704	3.822	0.446

Note: *MSA with statistically significant coefficients with a *t*-value of 2.0 or larger.

The model appears to be well specified with changes in real income, population, real wealth, real construction costs and real interest rates accounting for most of the variation in real price changes among MSAs, leaving comparatively little variation to be explained by the dummy variables (MSA-specific growth factors). Over a fourteen-year time period, it is reassuring that real price changes in most MSAs can be explained by changes in the real income, population, real interest rates, real wealth and real cost variables. Nonetheless, for the sixty-nine MSAs with statistically significant dummy variables, local factors also contribute to an understanding of real price changes. This issue is examined in detail in the following section.

The coefficients in Exhibit 2 show the average annual percentage increase in real existing housing values attributable to location, after controlling for real changes in income, population, wealth, construction costs, and interest rates. For example, holding the effects of all other independent variables constant, real housing prices in San Francisco are estimated to have risen 1.7% annually, while prices in Las Vegas are estimated to have declined 8.8%. A perusal of Exhibit 2 indicates that cities with the largest coefficients are located on the West coast and Hawaii and in the North and East. The lowest rates of price appreciation appear in cities in the South and Southwest where land availability is high and growth restrictions appear to be low.

Comparisons with Prior Studies

Four prior studies (Segal and Srinivasan, 1985; Rose, 1989; Linneman, Summers, Brooks and Buist, 1990; and Malpezzi, 1996) have constructed growth restriction indexes. The indexes developed by Segal and Srinivasan, Linneman, et al. and Malpezzi were concerned with local regulatory restrictions on growth. Rose focused on land availability.

Exhibit 3 shows the correlations between the estimated MSA fixed effects (Exhibit 2) and the indexes developed in other studies. Two sets of correlations are shown. The first row of Exhibit 3 presents the unadjusted correlations. The second row lists the correlations obtained using the standard errors of the estimated MSA fixed effects as weights in calculating the correlation coefficients.

Since the data used in past studies were collected at different time periods and the time periods do not correspond completely with the dates of the data used in this study, perfect correlations cannot be expected. Nevertheless, Exhibit 3 indicates that the estimated MSA fixed effects are significantly correlated with growth restriction indexes developed in prior studies. The negative correlation with Rose's (1989) index indicates that the fixed-effects measure is negatively related to land availability. The positive correlations with the other three indexes suggest that local regulatory restrictions impede housing growth, causing a larger appreciation in local housing prices. The same pattern of correlation is found using

Exhibit 3 | Correlations with Prior Studies of Growth Restrictions

	Linneman, Summers, Brooks and Buist	Malpezzi	Rose	Segal and Srinivasan
Unadjusted correlation	0.340**	0.118	−0.307*	0.248*
Adjusted correlation	0.482***	0.367***	−0.390**	0.271*
N	48	113	37	47

*Significant at the .10 level or better.
**Significant at the .05 level or better.
***Significant at the .01 level or better.

the results of the restricted sample of twenty-four MSAs, which is shown in Exhibit A.3.

The correlation results shown in Exhibit 3 (Exhibit A.3) indicate that the fixed effect coefficients reported in Exhibit 2 (Exhibit A.2) may be interpreted properly as measures of the magnitude of restrictions on housing growth attributable to specific metropolitan areas. Thus, the empirical model employed in this study provides a useful approach for measuring the effects of restrictive growth management policies and limited land availability.

Conclusion

This study examines housing price growth dynamics in metropolitan areas across the U.S. Real housing price appreciation is found to be strongly influenced by the real growth of population, income, construction costs and interest rates. The real stock market appreciation is also found to impart a strong current and lagged wealth effect on the growth of real housing prices. Lastly, appreciation rates are found to vary across areas because of location-specific fixed-effects, although most of the variation in appreciation stems from differences in the rates of growth of real income and population.

The MSA fixed effects in this study represent the residuals of housing price appreciation attributable to location. The magnitudes of the fixed effects in particular cities are positively correlated with restrictive growth management policies and limitations on land availability. Therefore, the empirical model in this study provides a useful method of identifying the effects of restrictive growth policies and limited land availability on the pace of housing price changes in specific MSAs.

Appendix

Exhibit A.1 | Restricted-Sample Results

Independent Variable	Coefficient	Std. Error	*t*-value
$\%\Delta Y_{i,t}$	0.2053	0.0686	2.99
$\%\Delta W_{i,t}$	0.1161	0.0111	10.50
$\%\Delta W_{i,t-1}$	0.0743	0.0082	9.07
$\%\Delta I_{i,t}$	0.0196	0.0037	5.25
$\%\Delta Pop_{i,t}$	0.9411	0.2901	3.24
$\%\Delta C_{i,t-1}$	0.1398	0.0240	5.83
R^2	0.67		
F-statistic	9.81		
D.W.			

Notes: MSA fixed effects are shown in Exhibit A.2. $n = 318$.

Exhibit A.2 | Restricted Sample: MSA Fixed Effects

Fips Code	Metropolitan Area	ST	Coefficient	Std. Error	*t*-value
71920	Dallas*	TX	−5.775	0.855	−6.755
70520	Atlanta*	GA	−5.273	1.077	−4.896
73360	Houston*	TX	−4.812	0.873	−5.509
73760	Kansas City*	MO-KS	−3.869	1.139	−3.398
77040	St. Louis*	MO-IL	−3.595	0.784	−4.584
71123	Boston-Worcester-Lowell	MA-NH	−3.472	2.224	−1.561
75120	Minneapolis-St. Paul*	MN-WI	−3.334	0.828	−4.027
72080	Denver	CO	−2.826	1.830	−1.544
75000	Miami*	FL	−2.682	0.757	−3.542
76160	Philadelphia	PA-NJ	−2.483	3.147	−0.789
71640	Cincinnati*	OH-KY-IN	−2.462	0.460	−5.356
77320	San Diego	CA	−2.270	1.893	−1.200
77600	Seattle-Bellevue-Everett	WA	−2.065	2.229	−0.927
75600	New York	NY	−2.023	4.929	−0.410
71600	Chicago	IL	−1.946	1.483	−1.312
76280	Pittsburgh*	PA	−1.585	0.635	−2.494
70380	Anchorage	AK	−1.557	1.145	−1.360
75080	Milwaukee-Waukesha	WI	−1.544	0.969	−1.593
71680	Cleveland-Lorain-Elyria	OH	−1.120	0.588	−1.905
76440	Portland-Vancouver	OR-WA	−0.719	2.229	−0.323
72160	Detroit	MI	−0.241	0.714	−0.338
73320	Honolulu	HI	0.473	4.479	0.106
74480	Los Angeles-Long Beach	CA	0.931	2.595	0.359
77360	San Francisco	CA	1.175	3.685	0.319

Note: *MSA with statistically significant coefficients with a *t*-value of 2.0 or larger.

Exhibit A.3 | Restricted Sample: Correlations with Prior Studies of Growth Restrictions

	Linneman, Summers, Brooks and Buist	Malpezzi	Rose	Segal and Srinivasan
Unadjusted correlation	0.509**	0.577***	−0.489**	0.532**
Adjusted correlation	0.611***	0.691***	−0.475**	0.498**
N	21	22	21	20

*Significant at the .10 level or better.
**Significant at the .05 level or better.
***Significant at the .01 level or better.

Endnotes

1 Ludvigson and Steindel (1999) report that a one-point move in the Dow Jones Industrial average changes household wealth by $1 billion to $2 billion.

2 The sign on the real mortgage interest rate variable is indeterminant because when interest rates rise, the housing supply curve shifts upward to the left, while the housing demand curve shifts downward to the left. The net impact on housing prices and the real interest rate coefficient depends on the relative shifts of the demand and supply curves. Although it would be possible to try variations of current and lagged interest rates, theory does not provide a model for choosing a particular interest rate specification. The efficient markets literature suggests, however, that historical interest rate changes should not be related to current and future interest rate changes. Also, the expected impact of interest rate changes on housing prices is expected to be minimal compared with other variables such as population and real income changes.

3 The variables for real wealth, real after-tax mortgage rate, and real construction costs are estimated for MSAs using national data. The use of national data permits the variation in real housing prices because of local growth restrictions to be captured by the MSA-specific dummy variables.

4 The twenty-four areas are: Anchorage, Atlanta, Boston, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, Honolulu, Houston, Kansas City, Los Angeles, Miami, Milwaukee, Minneapolis, New York, Philadelphia, Pittsburgh, Portland, St. Louis, San Diego, San Francisco and Seattle.

5 Producer Price Index series number WPUSOP1220.

6 The tax rates are calculated using personal income and personal disposable income; however, the personal disposable income series is not available for specific MSAs. Although the impact of using a national tax rate is likely to be small, there could be a shift in some MSA dummy variables.

7 Ideally, the ex ante rather than the ex post inflation rate might be subtracted to calculate the real interest rate, but ex ante inflation rates are only available nationally rather than regionally. Also, because this study encompasses a fifteen-year time period, the differences between ex anti and ex post rates should not be large, since over long time periods ex ante and ex post inflation rates should be the same.

[8] Estimations were undertaken using the Eviews 3.1 software package from Quantitative Micro Software.

[9] The results for the construction cost variable indicate that only the lagged construction cost variable is statistically significant, while the current construction cost variable is not. This result is not surprising based on the time delay in construction and the expectation that cost impacts to the existing home markets would rise only after new home prices adjust to higher construction costs. Also, contracts often ''lock in'' new house prices during construction, with higher costs being absorbed by the contractors thereby reducing their profits. Only the lagged construction cost variable coefficient is reported.

[10] It is likely that the local impact of stock prices may vary by metropolitan area, because of differences in stock holdings and the distribution of wealth. To test for this possibility, a separate slopes model was constructed with an interaction effect of the MSA dummy variables and the real wealth variable, that is, adding 130 slope coefficients to the model. At that point, the national real wealth variable is removed from the model to avoid a singular data matrix. A separate slopes model for the lagged real wealth variable was not possible because the model becomes singular, so the lagged national real wealth variable is retained in the model together with the separate slopes (MSA wealth specific) variables. A Chow test is conducted by comparing this specification with the regression shown in Exhibits 1 and 2. The *F*-value of 1.5 is statistically significant, but the R^2 increases only about 1%. The coefficients on the stock-market variables shown in Exhibit 1 reflect an average real wealth effect calculated across all 130 areas. When the MSA dummy variables shown in Exhibit 2 were compared with the set obtained using the separate slopes model, the correlation was found to be quite close. The Spearman rank coefficient is 0.86. This result suggests that while there is some change in the rankings of MSA price growth as measured by the dummy variables, most MSAs rank very similarly under either model. The same procedure was repeated with the twenty-four MSAs shown in Exhibits A1–A3, the Spearman rank correlation is 0.775, largely the same as with the 130 MSA sample.

[11] From 1985 through 1998, the average real growth in residential housing prices was only 0.9% annually, not controlling for other influences including changes in income, population, stock market wealth, construction costs and interest rates.

[12] An *F*-test of the joint significance of the MSA coefficients revealed a calculated *F*-value of 1.10, which is not statistically significant at the 5% level. The test involves a comparison of the error sum of squares between the ''restricted'' and ''unrestricted'' regressions. Pindyck and Rubinfeld (1981: 124) detail the statistical test.

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The authors thank the Joseph M. Bryan School of Business and Economics for a research grant funding this study. The authors are indebted to Stephen Malpezzi for generously sharing his metropolitan area database.

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