An Examination of Systematic Differences in the Appreciation of Individual Housing Units

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Abstract. **House price appreciation should play an important role in households' decisions of when, where, and how 'much' house to buy, and whether to default on their mortgages. Several price indexes are published which could be used as a measure of appreciation, but their focus on aggregate price changes does not facilitate their inclusion in micro-level studies of housing decisions. This paper examines individual housing unit appreciation using owners' valuations. This measure is accurate and is available in several commonly used data sets. Systematic differences in these rates are found between cities, within cities, between different types of units, and between individual owners.**

Introduction

Homeownership has two aspects: consumption that consists of the utility households get from consuming a flow of housing services, and investment that considers the tax benefits from ownership as well as the return a household may get from holding an asset that could appreciate over time. The consumption side of ownership has been carefully considered in both the theoretical and the empirical literature. In recent years the investment aspect has been examined in theoretical papers that have begun to elaborate on holding a house in an investment portfolio.[1] This is a reasonable development, since for most U.S. households their home is the largest asset they hold [20].

Theory tells us that the rate of change in house prices should play an important role through the investment aspect of homeownership in homebuyers' decisions of when, where, and how 'much' to buy. Housing appreciation may also affect the probability that households will default on their mortgages [5]. Therefore, including a measure of housing appreciation in empirical studies of housing decisions of these types is appropriate. A question remains about the appropriate level of aggregation of such a measure. If one believes that a national (or regional) rate of appreciation is appropriate, then any of the national (or regional) price series could be used [17]. However, it has been shown that changes in prices vary across SMSAs [13], and casual observation would indicate that appreciation varies not only between SMSAs but within them as well. Dale-Johnson and Phillips [3] suggest there are differential rates of appreciation between individual housing units in their study of Santa Clara County in 1976–77.

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If such differences exist among housing units then the appropriate level of aggregation for empirical studies would be low, but to this point no measure of housing appreciation on the level of individual housing units is available to researchers. This study examines the approaches that might be taken to obtain estimates of individual appreciation rates, implements one of the approaches on two widely available microdata sets, and checks the estimated rates for accuracy. The estimated rates are then examined for systematic differences between SMSAs, types of houses, and among identifiable demographic groups. The results indicate that appreciation does vary in a predictable way across these stratifications, clearly demonstrating the importance of using individual appreciation rates when modelling individuals' housing decisions.

In addition, a measure of individual appreciation could also be used to examine the distribution of rates within different SMSAs, to study how the distribution of rates differs across SMSAs, and to test whether different types of structures or different demographic groups experience different rates of appreciation. Results from examinations such as these should shed light on the structure of the housing market. They may indicate the size of housing submarkets, the presence of discrimination, or the riskiness of investing in certain types of houses. An understanding of what affects appreciation may lead to an investment strategy in residential real estate. A study of appreciation rates through time may indicate the length of disequilibrium periods in the housing market that could contribute to development of dynamic models of the market.

This paper will evaluate methods which could be used to calculate individual housing appreciation rates, then calculate rates using two readily available data sets. The rates are compared with aggregate measures of appreciation from other sources as a check of accuracy. The individual rates are examined for systematic differences, and alternatives to the classical model are considered which would allow for explainable differences in appreciation rates to exist through time.

Obtaining Individual Appreciation Rates

To calculate individual appreciation rates, it is necessary to know a house's value at two points in time. Conceptually, there are three methods that could be used to obtain such data, each of which has advantages and drawbacks. First, a house could be followed through time and its value reported in each period either by its owner or an appraiser; this requires data from a panel survey of either owners or appraisers/assessors. By following the same set of houses through time and asking the value of the house at each point in time, the current estimated sales prices for a set of houses over time is obtained. Because such a sample contains both houses that sell and those that do not sell, selectivity bias is not a problem; it is not necessary to control for changes in the mix of housing characteristics.[2]

A problem with this technique concerns the accuracy of the owners' or appraisers' evaluations. For most individuals their largest asset is their home and, as such, it might be expected that homeowners would be accurate when asked to estimate their unit's value. Indeed, previous cross-sectional studies have found this to be true on average ([9], [21], [8]).

One way to avoid the problem of accuracy in evaluation is to follow a house through time and record its value each time it sells; this is the second procedure. However, data on repeat sales can be difficult to obtain, and such data sets often do not include other information the researcher might require, such as characteristics of the house, neighborhood, or owner. In addition, it is possible that sample selection bias might occur if homes that sell differ in systematic ways from those that do not.

The third approach employs several cross-sectional samples of homes and utilizes hedonics to estimate a sales value for any home during the periods considered. Hedonic indexes assume that a house can be viewed as a bundling of different characteristics, each of which carries an implicit price. By regressing a house's sales price on characteristics such as number of bedrooms, number of bathrooms, or presence of a garage or pool, the implicit price of each characteristic is obtained as a function of the data and the regression coefficients. The estimated sales price of a house that did not actually sell can then be obtained by pricing each of the characteristics of the house using the sample period's price coefficients.

To calculate individual appreciation rates a hedonic equation must be estimated for each period ([19], [3]) so houses with different characteristics can appreciate at different rates. The ratio of coefficients from the different periods provides an indicator of the rate of appreciation for different housing attributes. For the results using the hedonic method to be accurate, the individual equations must be correctly specified[3] and each cross-sectional data set representative of the desired housing mix.

Estimation of Individual Appreciation Rates

The inherent difficulties involved in using the last two approaches to calculate individual appreciation rates suggest employing the first approach discussed. The rates are calculated using the Annual [American] Housing Survey (AHS) which follows housing units (rather than people) through time. The survey contains demographic and economic information on the current occupants as well as information about the structure itself.

This panel study utilizes the 1974, 1979 and 1983 waves of the national portion of the survey that consists of approximately 75,000 face-to-face interviews across the United States. One flaw in this data set is its lack of information on the neighborhood in which the unit is located; since the area is not identified in any way other than SMSA and central city location, the observations cannot be linked to data from other sources.

Another survey that could be used is the Michigan Panel Study of Income Dynamics (PSID), but its use raises some problems since it follows individuals instead of housing units. Since it is impossible to observe houses that change hands, there may be selectivity bias. In addition, it does not contain as much information on the housing unit as does the AHS, although it does contain more information on the occupant. Since both the AHS and PSID do contain the appropriate data but each has a slightly different focus, the nature of the study may dictate which survey is utilized.[4] As this paper is interested in housing in particular, it will concentrate on the AHS. Results using the PSID will be included as a check of the procedure's validity.

Only homeowners in the AHS who answered the question, 'What is the current market value of your home?' in 1974 and 1983 are included in this sample. Some houses changed hands during the sample period while others did not; thus sample-selectivity bias should not be a problem.[5] Since the response to the value question was coded in intervals, the midpoint of each interval is employed as the datapoint.[6] This would be problematic if rates were estimated for each year since values may fluctuate within an interval and not be captured by using the midpoint. However, since appreciation rates are calculated over a nine-year span, and the intervals of house values are fairly fine (the ranges vary from $2,500 to $50,000 at the highest end of the value spectrum), this difficulty should not present itself. The formula used to calculate the nominal annual rate of appreciation is:

$$ANNUAL\ RATE = \exp\{[\ln\ (value_t/value_s)]/t{-}s\} - 1 \quad (1)$$

for $t > s$. For example, if t is taken to be 1983 and s is taken to be 1974, then $t{-}s$ equals 9.

Using owners' estimates from the AHS to calculate the rate of appreciation of their housing investment has several advantages. First, the data are easily available and there are large subsamples available for most of the larger SMSAs. Second, it does not require the use of hedonic indexes thereby side-stepping specification problems. Third, by using the AHS data one set of houses can be followed through time so quality mix remains relatively constant; this allows us to get closer to 'pure' value changes. Finally, while we believe that owners are accurate, even if they over- or under-value their homes by a constant percentage, as is suggested in a few of the cross-sectional studies ([11], [4]), that error would drop out during the appreciation rate calculation.

Comparison with Existing Aggregate Measures

One of the key questions that must be raised using this approach is whether the appreciation rates calculated from homeowners' estimates of the value of their homes at different points in time are accurate. Since only aggregate measures of appreciation rates are available, those will be used to check the individual rates estimated above.

The median sales price in each census region is available from the National Association of Realtors' "Existing Home Sales" series [15], and can be used to calculate an annual appreciation rate. Although there are problems with the NAR values, it is commonly believed that because of the many observations used the measure is reliable [1]. The

Exhibit 1
A Comparison of Regional Housing Appreciation Rates

	AHS 1974–83 median	N	NAR 1974–83 median	PSID 1974–82 median	N
West	0.1336	2,170	0.1179	0.1417	126
Midwest	0.0754	2,763	0.0863	0.0870	238
South	0.0866	2,642	0.0883	0.0905	351
Northeast	0.0745	2,246	0.0811	0.0787	181

	Freddie Mac Repeat Sales Index 1975–79	1979–84
West	0.190	0.065
Midwest	0.117	0.015
South	0.086	0.046
Northeast	0.078	0.075

Data is from the Annual Housing Survey and the Panel Study of Income Dynamics. Medians found using SAS statistical package. National Association of Realtors data and Freddie Mac Repeat Sales Index are from publications listed in the bibliography.

NAR-based rate is compared to the median of regionally grouped AHS and PSID rates[7] in Exhibit 1. These three estimates of rates are close in value. Differences between houses and SMSAs are expected to exist, but they tend to be reduced as one aggregates upward.

A more appropriate comparison would be with an index that controlled for changes in the housing mix over time. Exhibit 1 therefore includes regional appreciation rates as calculated by Abraham and Schauman [1] for the years 1975–79 and 1979–1984. They utilize repeat sales data which are weighted by the length of time between sales. Because of the split in years it is difficult to compare their measure to the AHS measure, but they report that until 1985 their index is "similar to other indexes" such as the NAR index [1, page 6].

It would be helpful to compare rates at a less aggregated level. Possibly the best measure of appreciation rates at a SMSA-wide level is that found in the study by Case and Shiller [2]. Their study also utilized weighted repeat sales data and considered four metropolitan areas; Atlanta, Chicago, Dallas and San Francisco. Rates estimated from their index are shown in Exhibit 2 along with AHS rates aggregated to the SMSA level (the PSID subsample was too small to allow further disaggregation).

Again, the values are very similar. To evaluate the statistical closeness of the two estimates, the Case and Shiller figures are assumed to be accurate. This is necessary since they list the standard deviation of their index quarter by quarter and not by groups of quarters. To presume that their rate estimates represent the truth is a very conservative assumption. If the null hypothesis that the two rates are the same is accepted under this assumption, it would be accepted when their estimates are random variables. Using the mean and standard deviation of rates for each of the four SMSAs as obtained from the AHS, a t-statistic can be calculated. The t-values range between -0.13953 and 0.15787. Therefore, the null hypothesis cannot be rejected.

This suggests that homeowners, at least when aggregated to the city-wide level, are accurate in their estimates of the value of their home at any point in time, such that the rate of change is correctly captured. The dynamics (i.e., the aggregate appreciation rates) compare favorably which appears to rule out the possibility of a particularly troubling type of random error which sometimes plagues panel data sets: an individual over- or under-estimates in one period and does the converse in a later period. This results in levels that are correctly estimated but changes that are poorly estimated.

Exhibit 2
A Comparison of City-Wide Housing Appreciation Rates

	Case and Shiller 1974:1–83:4		Annual Housing Survey 1974–83		
	Nominal Rate	N	Median	Mean	N
Atlanta	0.0696	8,745	0.0723	0.0736	145
Chicago	0.0766	15,530	0.0828	0.0840	478
Dallas	0.1212	6,669	0.1099	0.1134	141
San Francisco	0.1403	8,066	0.1473	0.1451	257

Data from Annual Housing Survey. Means and medians found using SAS statistical package.
Case and Shiller data from publication listed in bibliography.

Individual Appreciation Rates and the Classical Model

The models that are usually developed in the context of classical urban economic theory are static, that is, supply and demand automatically adjust to clear the national housing market (see Muth [14]). It is difficult to incorporate differential appreciation rates into this framework. If the differences in appreciation rates are substantial or predictable, then housing market models must be extended to include this fact.

The stochastic version of the classical housing market model yields several implications which can be tested. Since the model requires that mobility of individuals and changes in the supply of housing immediately eradicate any differences in appreciation rates, all homeowners in all SMSAs across the country will experience the same expected rate of housing appreciation. Therefore, conditioning on observable factors should not aid in explaining the differences in appreciation rates. Since the individual appreciation rates calculated above are accurate, they can be used to test for systematic differences in individual rates across SMSAs, types of houses, and among demographic groups. They can also be utilized to determine what factors are associated with micro-level appreciation rates.

The subsample of the AHS used in this portion of the paper includes all homeowners with complete information who had been in the same house since 1974. Although one of the benefits of the AHS is that it follows houses rather than people, the sample was restricted in this way so the hypothesis that the owner's characteristics did not affect the rate of appreciation could be tested. This could lead to selectivity bias if houses that do not change hands or individuals who do not move are systematically different from houses that sell or people who move. However, work using an unrestricted sample led to similar results.

To control for large changes in an individual unit's quality over time, perhaps due to renovation through adding on, houses where the number of rooms reported differed between several years were also excluded. The ten largest SMSAs were then selected as the focus of the study. The SMSAs in order of size are: Los Angeles, Philadelphia, Detroit, Pittsburgh, St. Louis, Boston, Baltimore, Cleveland, Washington, D.C., and Atlanta. The sample sizes range from 267 complete observations to 67 complete observations. Appreciation rates are calculated in the method that was proposed above.

The means, medians, and standard deviations of the SMSA-wide appreciation rates in each of the ten metropolitan areas are shown in Exhibit 3. To test whether SMSAs,

Exhibit 3
Summary Statistics of SMSA Appreciation Rates

	Mean	Median	S.D.	N
Atlanta	0.0716	0.0732	0.0493	67
Baltimore	0.0961	0.0955	0.0524	107
Boston	0.0882	0.0860	0.0392	112
Cleveland	0.0701	0.0723	0.0513	103
Detroit	0.0557	0.0624	0.0445	214
Los Angeles	0.1538	0.1553	0.0368	267
Philadelphia	0.0675	0.0654	0.0432	266
Pittsburgh	0.0911	0.0866	0.0471	143
St. Louis	0.0943	0.0932	0.0455	131
Washington, D.C.	0.1009	0.0932	0.0436	77

Data from the Annual Housing Survey. Statistics from SAS statistical package.

structures, or individuals experience different rates of appreciation, similarity of means can be examined using Analysis of Variance (ANOVA). The null hypothesis of equality of means for the ten SMSAs is rejected at the 0.01 significance level. However, ANOVA is sensitive to outliers and nonnormality. A test was undertaken, and seven of the ten SMSAs rejected the null hypothesis of a normal distribution.[8] Therefore, the medians were examined for equality using the median test that has a chi-squared distribution with 9 degrees of freedom.[9] The test-statistic takes a value of 408.89; the null hypothesis that every SMSA has the same median appreciation rate is rejected for this data since the 0.01 critical value for a chi-squared random variable with 9 degrees of freedom is 21.7. This result indicates that any model that considers the housing market to be a national market and thus allows appreciation rates to exist only on the national level, is inappropriate.

Some models allow appreciation rates to differ across SMSAs but assume that rates are the same for people and houses within a SMSA (for example, [13]). To test this, a regression is run of individual appreciation rates from 1974–1983 on the characteristics of the houses and the individuals who own them (see Exhibit 4, column 1) using pooled data from the ten SMSAs. The regression that is run is:

$$Y_i = \beta_0 + X_{1i}\beta_1 + X_{2i}\beta_2 + \varepsilon_i \qquad (2)$$

where Y_i is the individual appreciation rate, X_1 is a row vector of housing characteristics, X_2 is a row vector of owner characteristics, and i takes on values 1 to N. If the rates are the same, then any variation in rates that might be observed could not be explained by the independent variables in this regression. The characteristics of the houses include the number of rooms, the age of the house, the age of the house squared, the number of people per room in the unit (a measure of physical depreciation), the value of the house in 1974, the value squared, and whether the house was located in the central city of the SMSA. Individuals' characteristics include age, race, sex, and educational level. The test is whether the estimated coefficients of these variables jointly equal zero ($\beta_1 = \beta_2 = 0$); this is an F-test. The value the F-statistic takes on in this regression is 11.447 and so the null hypothesis that rates are the same for people and houses cannot be accepted as the 0.01 critical value is 2.32.

A similar technique can be employed to test if rates are the same for each house, after controlling for the SMSA in which it is located, and the characteristics of its owner. Again, a regression is run of appreciation rates on the characteristics of the units and their owners, as well as a row vector (X_3) of dummy variables for the SMSAs being considered (see Exhibit 4, column 2).

$$Y_i = \beta_0 + X_{1i}\beta_1 + X_{2i}\beta_2 + X_{3i}\beta_3 + \varepsilon_i \qquad (3)$$

The appropriate test is whether the coefficients on the houses' characteristics jointly equal zero ($\beta_1 = 0$).[10] The F-value for this test is 46.463 and since the critical value at the 0.01 level is 2.64 the null hypothesis that rates are the same across houses is rejected.

The regression coefficients suggest that larger houses experience higher rates of appreciation, while those located in the SMSAs' central city area experience lower rates. This former result is consistent with Dale-Johnson and Phillips [3]. It also appears that lower priced and higher priced homes (in 1974 values) experience higher rates, while homes in the middle range appreciated less rapidly. Therefore, it does seem that demand for certain housing characteristics increases faster than the supply of homes with those characteristics.

Exhibit 4
Regression Results

	Dependent Variable is individual annual rate in:			
	1974–83		1974–79	1979–83
Intercept	0.0736	0.0995	0.1320	0.0734
	(3.687)**	(6.185)**	(4.083)**	(1.851)*
Rooms83	0.0015	0.0065	0.0105	0.0018
	(1.222)	(6.618)**	(5.313)**	(0.740)
House Age	0.0025	0.00058	0.0002	0.0005
	(2.70)**	(0.817)	(0.161)	(0.304)
House Age Sq.	−0.000045	−0.00002	−0.00002	−0.00001
	(2.978)**	(1.465)	(0.664)	(0.356)
Person per room	−0.0002	−0.0007	−0.0028	−0.0022
	(0.195)	(0.736)	(1.519)	(0.966)
Central City	−0.0053	−0.0114	−0.0131	−0.0080
(=1 if in CC)	(1.501)	(4.081)**	(2.319)**	(1.154)
Value74	−0.000005	−0.000006	−0.00001	−0.000003
	(9.899)**	(15.665)**	(12.653)**	(2.594)**
Value74 Sq.	5.85E−11	6.61E−11	1.10E−10	2.63E−11
	(9.068)**	(12.943)**	(10.719)**	(2.092)**
Age83	0.0003	0.00013	−0.00014	0.0007
	(1.919)*	(1.269)	(0.689)	(2.622)**
Race83	0.0087	0.0175	0.0421	−0.0142
(=1 if white)	(1.835)*	(4.737)**	(5.671)**	(1.561)
Sex83	−0.001	0.0027	0.0095	−0.0060
(=1 if male)	(0.371)	(1.045)	(1.851)*	(0.954)
Grade83	0.0029	0.00189	0.0027	0.0010
	(5.520)	(4.686)**	(3.318)**	(1.020)
Los Angeles		0.0925	0.1540	0.0223
		(16.555)**	(13.713)**	(1.619)
Philadelphia		−0.0058	0.0082	−0.0250
		(1.045)	(0.735)	(1.817)*
Detroit		−0.0128	0.0254	−0.0558
		(2.257)**	(2.225)**	(3.987)**
St. Louis		0.0096	0.0410	−0.0293
		(1.559)	(3.311)**	(1.930)*
Pittsburgh		0.0022	0.0574	−0.0638
		(0.360)	(4.669)**	(4.234)**
Baltimore		0.0192	0.0555	−0.0228
		(3.053)**	(4.381)**	(1.468)
Boston		0.0219	0.0303	0.0108
		(3.442)**	(2.366)**	(0.691)
Cleveland		0.0034	0.0538	−0.0577
		(0.543)	(4.219)**	(3.692)**
Washington, D.C.		0.0267	0.0550	−0.0111
		(3.906)**	(3.994)**	(0.656)
R^2	0.0787	0.4695	0.3203	0.0908
Adjusted R^2	0.0718	0.4622	0.3110	0.0784
F-value	11.447	64.860	34.542	7.319

Parentheses contain t-statistics. Sample size for all four regressions is 1487. * indicates that the t-statistic is significant at the 10% level, ** indicates significance at the 5% level.
Data from the Annual Housing Survey. Regressions were run using the SAS statistical package.

This would indicate that housing submarkets do exist and the correct level of aggregation that is appropriate in housing-decision models appears to be very low.

To test whether appreciation rates are the same for owners of similar houses in an SMSA, the same regression is used. The test is whether the coefficients on the individuals' characteristics jointly equal zero ($\beta_2=0$). The F-statistic in this case is 11.8661 and the 0.01 critical level is 3.32, so the null hypothesis cannot be accepted. It appears that white homeowners experience a higher rate of appreciation than nonwhites, even after controlling for the quality of the house and the SMSA in which it is located. This could indicate some type of market failure and may help explain lower rates of homeownership observed among nonwhites. It is also possible that the difference in appreciation is due to incomes of white and non-white homeowners changing at different rates during the period under consideration. Census data shows this did occur. The median real income of whites decreased by 0.9% while black median real income fell by 1.2% during the period. Another possible explanation is that an individual's characteristics act as proxies for certain neighborhood characteristics that cannot be controlled for using the AHS data.

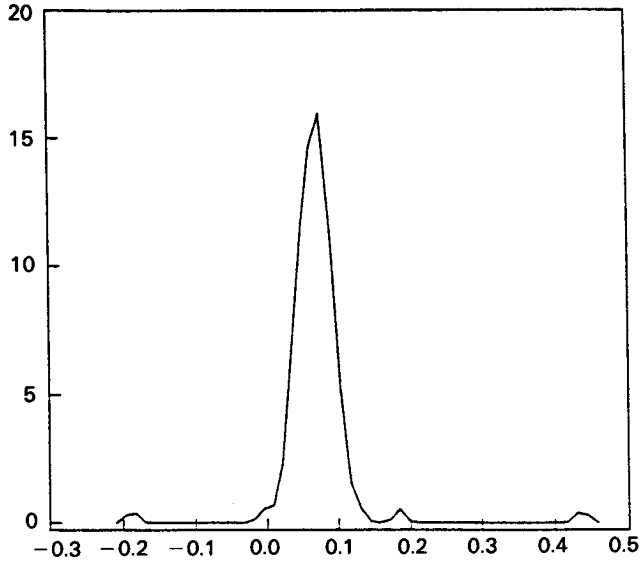
When testing whether rates are the same for all SMSAs, after controlling for the characteristics of the houses and their owners, the coefficients on the SMSA dummy variables are examined to see if they jointly equal zero ($\beta_3=0$). Here, the F-statistic is 119.9849, the 0.01 critical value is 2.41, and the null hypothesis cannot be accepted. Los Angeles, St. Louis, Baltimore, Boston and Washington, D.C. experienced higher than average rates of appreciation. This could be due to the rapid growth these SMSAs experienced during the period under consideration and if so, confirms Manning's result that faster growing SMSAs are more likely to experience faster home price appreciation. It is possible that demand for housing of all types in these SMSAs increased faster than supply. Philadelphia and Detroit underwent periods of lower than average appreciation, possibly because of the outmigration both SMSAs experienced during the 1970s. Therefore regional effects do impact on appreciation rates, but they are only part of the story.[11]

Alternative Models—Houses as Financial Assets

Since substantial and predictable variation in individual appreciation rates has been found, it is necessary to consider alternatives to the classical model. One option is a model based on finance theory where units with high appreciation are more risky. Another option is a model that allows for disequilibrium so supply and demand change slowly enough to allow differences in rates to exist through time. A third possibility is that the relevant housing market is not nationwide but rather is much smaller so even a SMSA consists of several housing markets. Rates can then differ within a SMSA as well.

To examine the investment aspect of ownership, the risk involved in purchasing a home in various SMSAs must be considered. As a first step it is necessary to look at the distribution of appreciation rates across and within the SMSAs.[12] Plots of the density of appreciation rates for non-movers in four of the SMSAs were made using Wegman's [26] nonparametric density estimator[13] (see Exhibit 5a–d). The density plots indicate substantial variation of rates around the mean. The coefficients of variation, the standard deviations divided by the means, range from 0.2392 to 0.7989 with a mean of 0.5518, which is larger than typically seen for price data or asset return data.

Exhibit 5a
Annual Appreciation Rates, Cleveland, 1974–1983
(sample size = 103 non-movers)



Plots in Exhibits 5a–d use data from the Annual Housing Survey and the "S" statistical and graphics package.

Exhibit 5b
Annual Appreciation Rates, Detroit, 1974–1983
(sample size = 214 non-movers)

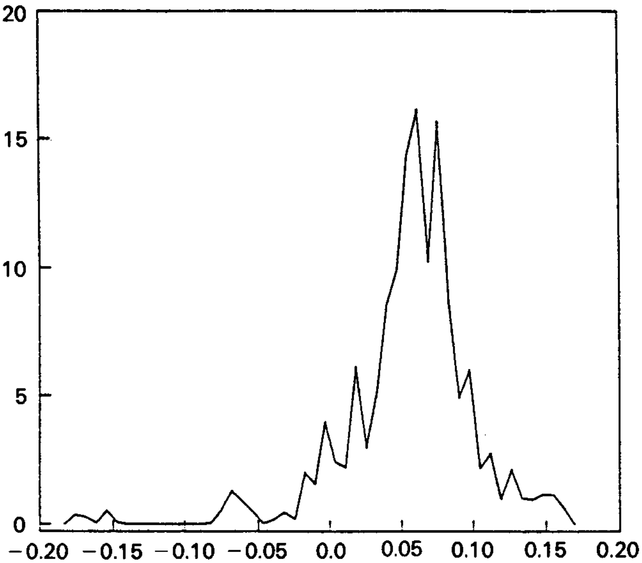


Exhibit 5c
Annual Appreciation Rates, Los Angeles, 1974–1983
(sample size = 267 non-movers)

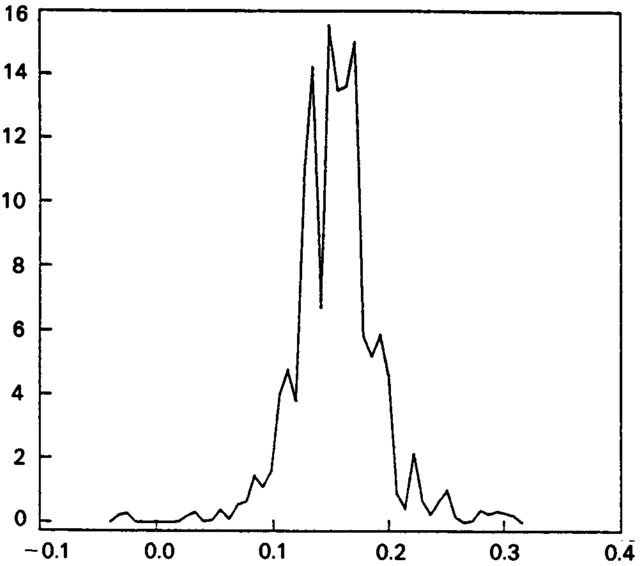
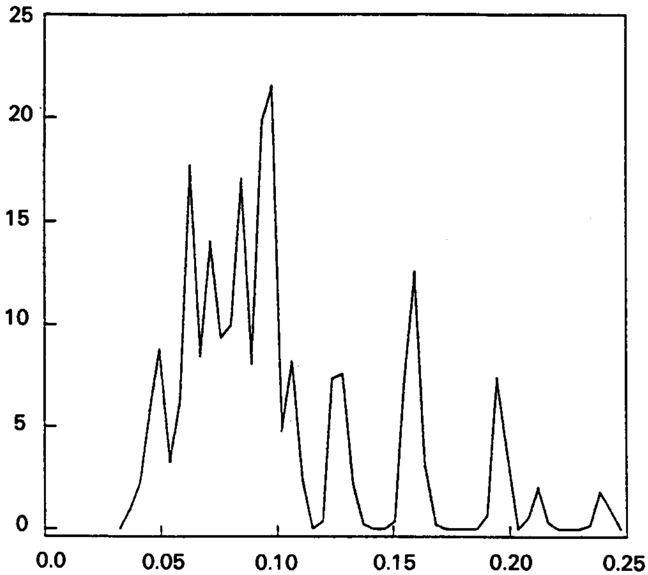


Exhibit 5d
Annual Appreciation Rates, Washington, D.C. 1974–1983
(sample size = 77 non-movers)



The distributions look different across SMSAs. It may be more risky to buy a home in Detroit than in Los Angeles; the distribution of rates in Detroit has a larger left tail while the density in Los Angeles is more skewed to the right. A person could buy a home at random in Cleveland and feel fairly confident in predicting its rate of appreciation; the density is concentrated heavily at one point. An investor would have to be more careful buying at random in Washington, D.C.—the density has many spikes that might appeal to more risk-loving investors. The spikes could be due to urban homesteading where an individual buys a house in a less desirable neighborhood, fixes it up, and hopes that others nearby do the same. Whether others do so may have a large effect on the appreciation rates of such dwellings.

To compare the ten SMSAs to see if they have the same distribution, the Kruskal-Wallis *k*-level test is used.[14] The statistic is distributed as a chi-squared random variable with 9 degrees of freedom. The statistic takes on a value of 567.11 where the 0.01 critical level is 21.7. The null hypothesis that all the SMSAs have the same distribution of appreciation rates is not accepted, confirming what was suspected from observing the figures above. Therefore rates across SMSAs have more than different means; they also have different distributions. Researchers need to recognize the differences in variance of aggregated appreciation rates if they choose to utilize such rates in their models of housing decisions.

To test whether the distributions varied in any systematic way across SMSAs, it is necessary to control for the other factors. A regression of the individual appreciation rates controlling for housing and owner characteristics was run and the residuals from this regression were saved and grouped into the ten SMSA categories. The Kruskal-Wallis test was then run and was found to have a value of 587.76 compared to the 0.01 critical value of 21.7. The null hypothesis that SMSA-wide appreciation rates have the same distribution, after controlling for the types of houses and residents, is rejected. There must be unique SMSA characteristics, perhaps growth rates, that affect the distribution of appreciation rates.

Similar tests were run to see if distributions are the same across types of structures when controlling for the SMSA and the owner's characteristics, and to determine if distributions are the same across people after controlling for the SMSA and the type of structure. If evidence of this is found, it would indicate that a clever buyer could increase the chance of experiencing higher appreciation rates by buying a house with certain characteristics.

Whether or not groups of houses have the same distribution, holding constant the SMSA they are located in and the characteristics of the owner, was tested. Residuals from regressions of rates on SMSA and residents were grouped into eight categories: whether the house was located in the central city, if the house was thirty years old or younger, and if its value in 1983 was above or below $60,000. The Kruskal-Wallis statistic has a value of 68.66 versus the critical value of 20.01, so the null hypothesis that the groups of houses listed above have the same distribution, is rejected. This information indicates that an investment strategy could be developed that would allow an investor to reap higher returns by careful purchase of housing units.

To test whether individuals have the same distribution of appreciation rates, residuals from a regression of rates on the SMSA and the housing characteristics were grouped into sixteen categories: whether the resident was white, female or male, fifty years old or younger, and had a college education or not. The Kruskal-Wallis statistic has a value of 40.94 where the 0.01 critical value is 30.6. The null hypothesis that individuals in the above categories have the same distribution of appreciation rates, even after controlling for the SMSA and type of house they inhabit, is rejected.

To test the notion of an investment strategy further, it is interesting to see if individuals can use past information on appreciation to develop better forecasts of future appreciation. Several forecast strategies were developed which were then compared to the difference between the actual rate of appreciation each unit experienced from 1979 until 1983 and the mean national rate of appreciation from 1979–83. Four forecasted values were considered. Each required only data available to the individual in 1979. The simplest prediction would be the mean national rate from the previous five years. The mean square error of the forecast is calculated as:

$$\sum_{i=1}^{N} [(App7983_i - \text{Mean7983}) - \text{Mean7479}]^2/N \tag{4}$$

and it is 0.0257. A slightly more sophisticated forecast would use the mean rate experienced in the SMSA during the past five years:

$$\sum_{i=1}^{N} [(App7983_i - \text{Mean7983}) - (SMSA7479_i - \text{Mean7479})]^2/N \tag{5}$$

where *SMSA*7479 is the mean rate from that period for the SMSA the unit is located in. The mean square error is 0.0114. A third measure bases predictions on a model of appreciation rates from 1974–79:

$$\sum_{i=1}^{N} [(App7983_i - \text{Mean7983}) - (Pred7983_i - \text{Mean7479})]^2/N \tag{6}$$

where *Pred*7983 is estimated using the model of appreciation rates from 1974–79 (see Exhibit 4, column 3). This takes on a value of 0.012. The final measure bases predictions on a model of appreciation that considers only the characteristics of the house and the SMSA in which it is located:

$$\sum_{i=1}^{N} [(App7983_i - \text{Mean7983}) - (HPred7983_i - \text{Mean7479})]^2/N \tag{7}$$

It takes on a value of 0.0117. Thus, an individual making a prediction using only the national average from the previous five years would do much worse than someone using additional information. The best prediction (from these four possibilities) is made by assuming that the SMSA average from the first period will continue into the second period.

Appreciation Rates in the Short and Long Run

Another alternative to the classical theory suggests that predictable individual appreciation rates can exist if short-run disequilibrium in the market is allowed. In the long run, however, the market must move into equilibrium where all houses experience the same rate of appreciation. In this paper, appreciation rates are examined over nine years under the assumption that such a period could be considered the long run. Differences in individual appreciation rates do exist over this nine-year period which may indicate that the period cannot be considered the long run.

One way to test whether housing markets are in short-run disequilibrium is to test whether rates are moving towards each other during the sample period. A simple technique is used that examines the rates in two subsamples of time; 1974 to 1979 and 1979 to 1983. Regressions are run on both rates (see Exhibit 4, columns 3 and 4).[15] Then average rates can be calculated for different groups of people and different types of structures in different SMSAs by plugging in mean values of variables, and the rates can be compared across time. If average rates do move toward each other, it would be expected that groups who experienced lower rates in the first period would experience relatively higher rates in the second period.

In looking at the effects of the owners' characteristics, an otherwise average nonwhite individual in Los Angeles in the first period experienced an annual rate of 0.08105, while a white individual who is the same in all other respects saw a rate of 0.12305. The ratio of these two rates is 0.6587. The ratio of rates experienced by the same two people in the second period is 1.134; nonwhites who 'lost' in the first period 'gained' in the second. Similar results can be obtained for other groups. This suggests that these gainers and losers may trade places over time, so on average, none of these groups consistently do better.

In looking at rates of appreciation based on structural differences, an average house owned by the average individual not in the central city area of Detroit gained (or, more precisely lost less) relative to the same house in the central city in both periods. A house with eight rooms gained more (or lost less) than the same house with four rooms in St. Louis in both periods. Thus, it appears that with this data there are structural characteristics which may gain relatively more over both periods. Demand for these characteristics may exceed supply for long periods if supply is relatively inelastic over the nine-year period studied.

These preliminary results indicate that the gap in individual appreciation rates due to demographic differences was reduced during the period studied. This is to be expected, since individuals are mobile. Differences due to structural variations are more persistent. The types of houses available will not change quickly through time since the stock of housing is relatively constant. This suggests that persistent disequilibrium may exist in housing markets.

Conclusion

The individual housing appreciation rates calculated in this paper suggest that homeowners do well when asked to estimate the value of their house at one point in time, such that the change in value over time is captured correctly. This is to be expected given the importance of the home in most individual's investment portfolios. The ability to calculate individual appreciation rates directly from two existing data sets (AHS or PSID) should allow researchers to test various hypotheses about consumer behavior with respect to housing decisions.

The results from an examination of individual rates indicate that it is difficult to consider individual appreciation rates in the classical housing model framework. The stochastic version of the classical model yields the strong hypothesis that it should not be possible to condition on any a priori observable variables and improve the prediction of a house's appreciation rate. Test statistics, however, show that significant explanatory power is gained by conditioning on SMSA location, other physical characteristics of the house, and even the demographic characteristics of the owners. In particular, larger homes, those not located in the center city of SMSAs, those situated in faster growing SMSAs, and those owned by households headed by white males, experienced higher than average rates of appreciation over the period studied. This suggests that the use of aggregated rates of appreciation in housing decision models may be inappropriate.

One possible explanation for these results is that houses that have higher mean appreciation are more risky. This possibility is considered by examining the distributions of appreciation rates within cities and across types of housing units. Although not tested rigorously, it can be noted that a city such as L.A. that has a high mean and median appreciation level also has a low standard deviation. Thus, it would appear that this alternative is not likely. However, further research is required.

Another possible explanation for the results is that nine years is still the short run for housing markets so the market may be in disequilibrium over the period studied. Splitting the data into two shorter periods provides some support for this explanation, as there is a tendency for a demographic variable that predicted a higher than average appreciation rate in the first period to predict a lower than average appreciation rate in the second period. This is not true for structural variables. If this leads to substantial disequilibrium over a nine-year period, the general equilibrium notion that drives the classical housing market model may be of little practical importance. Perhaps future studies should focus on disequilibrium in the housing market and on the path of adjustment, since equilibrium takes some time to reach.

Notes

[1]See for example, [6] and [25] for empirical work on portfolios that include commercial real estate, and [23] for a theoretical model of an individual's investment portfolio that includes owner-occupied housing.

[2]If certain variables are included in the data, it would be possible to correct for depreciation using the technique proposed by Malpezzi, Ozanne and Thibodeau [12]. This study controls for changes in the quality of individual houses through differential levels of depreciation by including measures of the age of the housing unit and the number of residents in the regressions which attempt to explain appreciation.

[3]A paper by Ozanne and Malpezzi [18] considers the effect of incomplete specification (especially concerning dwelling age and location) and finds that not including relevant variables can change estimated coefficients by a standard error or more.

[4]For example, if one is interested in the mover/stayer problem, the PSID sample may be suitable since it is accumulated appreciation that is likely to be an influential factor. If one is examining different rates of appreciation experienced by older homes versus newer homes, use of the AHS sample would be more appropriate.

[5]Individual appreciation rates were also estimated using only non-movers, and the results were similar to those reported in this paper. The subsample of non-movers is used in later sections.

[6]Ihlanfeldt and Martinez-Vazquez [7] test whether using the midpoint of each AHS home-value interval introduces a nonrandom error and find that it does not.

[7]The PSID subsample used here consists of households where the head of the household was the same from 1968 through 1982 and who had not moved since 1968. This was done so the same house was being followed through time.

[8]Normality can be tested for using the Kolomogorov-Smirnov D-statistic. The D-statistic is:

$$D = \sup(Fn(x) - F(x))$$

where $Fn(x)$ is the empirical cumulative distribution function and $F(x)$ is the exact normal distribution function. The data are tested against a normal distribution with mean and variance equal to the sample mean and variance. The formula

$$[N - 0.01 + (0.85/(N^{0.5}D))]^{0.5}$$

where N is the number of observations, is used to linearly interpolate within the range of simulated critical values. The data from each SMSA was tested. Atlanta accepted the null of normality at the 0.015 level, Baltimore accepted at the 0.109 level, and Pittsburgh accepted at the 0.15 level. The other SMSAs rejected the null hypothesis.

[9]Pairwise comparisons of medians can be made using the median test [16, page 161]. If a comparison of the medians of k-samples is required, the median test can be extended [22, page 844].

[10]The F-test considers the null hypothesis that a subset of regression coefficients jointly equals zero. It is calculated by running a regression with all the variables (unrestricted) and a regression which forces the coefficients under consideration to be zero (restricted). The F-statistic is then:

$$F_{q,N-k} = \frac{(R^2_{ur} - R^2_r)/q}{(1 - R^2_{ur})/(N-k)}$$

where ur represents the unrestricted model, r the restricted, q the number of restrictions, N the number of observations, and k the number of coefficients in the unrestricted model.

[11]A regression was also run that interacted each of the dummy variables with each of the explanatory variables to see if the slope as well as the intercept of the equation differed by SMSA. An F-test of the restricted versus unrestricted regressions yields a value of 1.565, so the null hypothesis that the slope coefficients are the same for all SMSAs is not rejected at the 0.01 level. Using only SMSA dummy variables may therefore be appropriate. Thus, the contribution to appreciation of any particular housing or owner characteristic is not dependent on the SMSA the unit is located in.

[12]To evaluate risk, rates of returns would need to be calculated which requires knowledge of the cost of ownership, holding periods, and tax structure. However, since value appreciation is a large part of the rate of return, examining appreciation is a logical first step.

[13]The nonparametric kernel density estimator is similar to a histogram. Calculating a histogram requires specification of an origin and a bandwidth. One then sums the observations within the bandwidth. The kernel estimator requires specification of a kernel that determines the shape of a 'bump' that is placed at each observation. A window width or smoothing parameter must also be specified that determines the width of the 'bump'. The estimator then sums the 'bumps' [24, page 15]. Wegman's estimator uses a normally distributed kernel and an optimal bandwidth [26].

[14]In the Kruskal-Wallis k-level test observations are replaced by their ranks. The sum of the ranks for each class or level is calculated. A test-statistic can then be calculated and will be distributed as a chi-square random variable with $k-1$ degrees of freedom [22, page 848).

[15]Notice the low R^2 for the fourth column compared to that of the third column. This indicates that the differences in appreciation rates were more predictable in the first period than in second.

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