The Measurement and Determinants of Single-Family House Prices

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Abstract

We assess the conceptual and empirical features of a number of house price series for the United States. We then calculate a measure of the net upgrading of the existing stock of houses that took place during the 1950-1989 period and adjust price indexes for this net increase in quality. Judgments about the trend, volatility, and determinants of house prices are shown to depend crucially on which price series is used. The Freddie Mac upgrade-adjusted house price measure rose 5.7% over the past four decades, falling 7.7% from 1950 through 1970 before rising 14.5% from 1970 through 1989. Real house prices declined in the early 1980s as a result of the increase in real after-tax interest rates and the decline in real materials costs. The recovery of house prices in the late 1980s is attributed to lower unemployment and real after-tax interest rates and particularly to demographic factors associated with the aging of baby boomers.

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The Measurement and Determinants of Single-Family House Prices

Research in real estate has long been hampered by the quality of price data for various categories of real estate. In spite of the long-standing importance of real estate as a household and a business asset and in spite of the wide variety of alternative price series currently available for single-family homes, data limitations persist. Though it is common to hear references to "house prices," none of the currently available series adequately measures what we presume is meant by the term: the national-average, quality-adjusted price of the stock of structures plus lots ("houses").

Below we describe and analyze a number of available house price measures. The timing and magnitude of fluctuations in alternative measures of house prices differ considerably. Estimates of the increase in real house prices over the past two decades, for example, range from a low of about 10% to nearly 90%. The Freddie Mac series, adjusted for the net investment that takes place through expenditures on additions and alterations, rises much less than most other indexes of house prices, increasing only 14% in real terms from 1970 through 1989. Next we estimate models of real house prices that incorporate financing, income, demographic, and cost factors. The real after-tax mortgage rate, construction costs, and demographic factors, especially those associated with the baby boom, can account for much of the postwar movement in real house prices.

House Price Data

House Prices and Quality Change

Because different series embody different concepts of house prices, which series is most useful depends on the purpose at hand. Some series track prices of new houses; some measure the prices of existing houses. Most measure the prices of structures and lot, although the U.S. Bureau of Economic Analysis' implicit deflator for residential investment excludes land value. Some attempt to control for quality change over time; others do not. A house price series that does not adjust for increasing quality over time will produce an upward-biased measure of the increase in the price of a unit of housing services. Yet no currently available house price data series completely adjusts the national-average price of the existing stock of houses (including land value) for quality change over a long time span.

House price measures with and without land may differ substantially. To the extent that both the short-run and the long-run price elasticities of land supply are lower than those of construction labor and materials, an increase in the demand for houses may raise land's share of the value of structure and lot. In fact, differences in land's share account for much of the variation in house prices through time and across regions. According to the National Association of Home Builders' Construction Cost Survey, the cost of the finished lot comprised 11% of the total cost of a typical new house in 1949, 21% by 1969, and 27% by 1988. Thus, house price measures that omit land value are likely to be severely biased downward over the past four decades. For example, the real residential investment deflator rose by 0.8% between 1949 and 1988. This increase coupled with the increase in land's share of total value over this period implies an increase in real house prices of 22.9%.[1]

Two methods of obtaining quality-adjusted price series for existing houses have been employed, the hedonic technique and the repeat-sales approach. For example, Thibodeau [28] has derived quality-adjusted price

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[1]The relationship between the value of structures (VS), land (VL) and houses (VH) is VH = VS + VL. If s represents land's share of total house value, VL = sVH, and VH = VS/(1 - s).

indexes based on hedonic techniques for ten years for a number of cities. Unfortunately, insufficient data exist to produce such an index for house prices nationwide over a long time span. The repeat-sales method compares the prices of individual houses that are resold over time (for example, Abraham and Schauman [2] and Case and Shiller [8]). While this largely controls for quality, provided maintenance, repair, and other expenditures are only just sufficient to offset depreciation, net upgrading of the existing stock of houses can produce upward-biased measures of the increase in the price of constant-quality houses.

When quality change is not explicitly controlled for, non-repeat-sales indexes are biased by the changing composition of transactions. Measures like the average or median sales price reflect the combination of shifts in prices of houses of constant quality, as well as shifts in the average quality of houses sold. An increase in incomes or a decrease in financing costs, for example, would be expected to lead to an increase in the price of houses of a given quality as well as a shift in sales toward houses of higher quality (Hendershott and Thibodeau [17]). The resulting systematic measurement errors in the dependent variable would bias regression estimates of income and interest rate effects on house prices. Measured price increases and regression estimates would also be biased if houses that have appreciated relatively more are sold relatively more frequently. That might occur if house price appreciation itself provided the additional equity to allow homeowners constrained by loan-to-value limits to "trade up" to higher-quality housing.

Biased measures of price increases can also result from non-random sampling of transactions. Truncation bias will result if houses in different price categories appreciate at different rates and the price series excludes observations from some price categories; for example, those financed with above-ceiling mortgages. The conforming loan ceiling imposed on federally sponsored agencies operating in the secondary market and the ceiling on the size of FHA-insured loans may produce such biases over either the short run or the long run. However, to the extent that ceilings move in response to market conditions, this bias is attenuated. If the ceilings move sluggishly but completely in response to changes in general market prices, short-run bias may be considerable but little or no long-run bias will be present.

Data Characteristics

Table 1 lists characteristics of various house price indexes. The data sources are the Federal Housing Administration (FHA), the National Association of Realtors (NAR), the U.S. Bureau of the Census, the Mortgage Interest Rate Survey of the Federal Home Loan Bank Board (now the Office of Thrift Supervision (OTS)), the U.S. Bureau of Economic Analysis (BEA) and the Federal Home Loan Mortgage Corporation (Abraham and Schauman [2]).

Only the FHA series and the BEA's implicit deflator for residential investment series are available before 1963. Because the demand for data may be importantly driven by significant variance and by changes in the general level of (real or nominal) house prices, the lack of data may indicate that neither was large nor of particular concern much before the 1970s.[2]

[2] Indeed, the University of Michigan's Survey Research Center Survey of Consumer Attitudes shows that people judged house prices to be high in the 1970s, but relatively low from the mid 1950s to the mid 1960s and, perhaps surprisingly, in the 1980s. From the late 1960s through the early 1980s, about 25% of respondents claimed it was a bad time to buy because house price levels were high, while only about 5% claimed it was a good time to buy because prices were low. From the mid 1950s until the late 1960s, the percentage responding that house prices were low rose from about 5 to about 20%, while the percent responding that prices were high fell from about 25 to about 15%. In the 1980s,

Table 1

House Price Series

Mnemonic	Source	Available Beginning	All/New/ Existing	Includes Land	Quality Adjustment	Subject to Truncation Bias
FHA	FHA	1936	All	Yes	No	Yes
NAR	NAR	1968	Existing	Yes	No	No
CMEAN	Census	1963	New	Yes	No	No
CQ	Census	1963	New	Yes	Yes	No
MIRSEX	OTS	1963	Existing	Yes	No	Yes
RESDEF	BEA	1929	New	No	Yes	No
FRED	Freddie Mac	1970	All	Yes	Yes	Yes

The FHA calculates the median value of single-family homes purchased each year that are financed with mortgages insured by its Section 203 program. This series is based on appraised values and has been adjusted by subtracting the closing costs that FHA includes in its price series. One advantage of the FHA series is that it is the only series that is available for several decades and also includes the value of land. On the other hand, the FHA series makes no attempt to adjust for quality change over time. Furthermore, because ceilings exist on FHA loan size, this series is subject to truncation bias.[3] However, this bias has been mitigated by the frequent raising of the FHA ceiling in response to house price increases.[4] Indeed, median FHA house prices fell relative to the FHA ceiling throughout much of the period. This may suggest that truncation bias has lessened over time.

The NAR measure of the median sales price of existing single-family houses, available since 1968, is probably the most widely known measure of house prices. The disadvantages of this series are that it reflects changes in the composition and quality of houses sold and that it is not available for a long period of time.

We consider three house price measures from the Housing Sales Survey of the Bureau of the Census and include two in our analysis. This survey contains information on the physical characteristics and sales prices of new,

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about 20% responded that house prices were low, while about 10% referred to them as high.

[3]The sample is further limited by excluding cash transactions, as is also the case with the OTS series. Further bias is possible in the price series to the extent that the distribution of cash sales differs from sales that involve credit.

[4]Greenlees' [13] in-depth investigation of this issue concluded that truncation bias in the case of FHA data was likely to be negligible.

single-family houses.[5] Since 1963, a median and an average (CMEAN) sales price series have been calculated for new, single-family houses sold. The most important drawbacks of these two series are that they are limited to new houses and that they make no attempt to hold quality constant. Failure to adjust a new house price series for quality may be more serious than not adjusting a price series for existing houses, because new houses are likely to incorporate changes in quality, for example through technological innovations, more rapidly than the existing housing stock. Because the median and average series move so similarly, we report results only for the average.

The Census Bureau also provides a constant-quality series (CQ) for the 1963-1989 period.[6] Using hedonic regression techniques, prices were adjusted for quality as measured by 10 physical characteristics: floor area, number of stories, number of bathrooms, presence of central air conditioning, type of parking facility, type of foundation, geographic division within region, whether the house is inside a metropolitan statistical area, square footage of land included, and whether there is a fireplace.[7] Because only lot <u>size</u>, and not lot <u>quality</u> per square foot, is taken into account, a downward bias in this index will emerge to the extent that, on average, lower lot quality per

[5]The current annual sample consists of approximately 13,000 new houses sold by speculative builders.

[6]A new version of the quality-adjusted series beginning in 1977 is also available. It uses 1987 as the base year for quality comparisons, while the earlier series was based on typical 1982 houses, a change that could, but in practice does not, make much difference. This series omits <u>any</u> explicit adjustment for changes in lot size or value, which typically is one of the most important determinants of house prices in hedonic models. Because this series is available only since 1977, we have not included it in our analysis.

[7]The latter two characteristics were not included for the 1963-73 period. Construction of these series is explained in more detail in U.S. Bureau of the Census [34].

square foot is used in new construction over time. Such a bias is likely because new construction on average takes place further down the rent gradient.

The Mortgage Interest Rate Survey calculates the average prices of recently sold new and existing single-family houses that are financed by institutions monitored by OTS.[8] These series do not adjust for changing composition over time or for other sources of changing quality of the houses being financed. They have the additional drawback of being subject to truncation bias. Being averages of conventional, conforming first mortgages, they exclude from the sample some mortgages at the low end of the distribution (e.g., FHA mortgages) and all at the high end ("jumbo" loans). Because the two series are so similar, we include only the series for existing houses (MIRSEX) in our analysis.

Annual measures of the implicit price deflator for residential investment expenditures (RESDEF) are available from the Bureau of Economic Analysis' National Income and Product Accounts starting in 1929. While this series has the advantage of being available over a long time span and, in principle, holds constant the quality of the structure being priced, it is limited to new construction, it measures not just the price of single-family homes but the price of residential construction generally, and it does not include the value of land. As indicated above, omitting land value can affect the average growth rate of house prices substantially.

Recently, the Federal Home Loan Mortgage Corporation (Freddie Mac) has

[8]The data are based on a sample taken over the first five days of each month. The change in the sampling procedure in 1973 introduces an inconsistency in the series based on this survey. Nourse [23] reports that the new-procedure observation for the new house price series in February 1973 is 7% lower than that based on the pre-1973 sampling procedure.

used the repeat-sales methodology to construct a house price index (FRED) based on approximately seven million loans that have passed through its portfolio.[9] The main advantages of the repeat sales approach are that it controls for changing composition of house sales and holds constant the location of the house, which is likely to be the primary determinant of lot quality.[10] This series also has the advantage of being based on a large, national sample. It does have the disadvantage that no allowance is made for quality change at a given address. Because this index is based on conventional conforming mortgages, it may also suffer from truncation bias. However, truncation bias stemming from Freddie Mac's mortgage size ceiling may not be a severe problem in practice. Based on simulations, Abraham [1] concludes that counterbalancing biases render the Freddie Mac series representative of the actual price experience in the 1980s. Hendershott [14], on the other hand, conjectures that the increases between 1985 and 1989 are likely to be biased upward because the downward truncation bias was reduced when the conforming loan limits were substantially increased during this period. Thus, we use the Freddie Mac series to construct a price index of the national stock of existing houses. Because the Freddie Mac series does not adjust for changes in structure quality at given locations, we adjust it for net upgrading.

Price Trends and Variability

Table 2 presents summary statistics for real house prices for the 1963-

[9]See Abraham and Schauman [2] for a thorough and balanced introduction to the features of the Freddie Mac Weighted Repeat Sales index, which is aggregated from four Census region series using 1987 NAR weights. Those shares are virtually the same as the shares of the stock of housing units by region.

[10]For an early example of the repeat-sales technique, see Bailey, Muth, and Nourse [4], and more recently, Case and Shiller [8].

Table 2

Measures of Real House Prices[a]: Summary Statistics

1963 to 1989

Series	Percentage Change	Percentage Standard Deviation: Without Regard to Trend[b]	Percentage Standard Deviation: Relative to Own Trend[c]
FHA	20%	11.7%	7.4%
Census Average	98	20.1	6.6
Census Constant Quality	14	9.1	4.6
MIRS Existing	80	17.3	9.1
Residential Investment	13	6.6	3.5

1970 to 1989

Series	Percentage Change	Percentage Standard Deviation: Without Regard to Trend[b]	Percentage Standard Deviation: Relative to Own Trend[c]
FHA	26%	12.4%	5.4%
NAR	34	9.5	4.3
Census Average	86	18.4	5.5
Census Constant Quality	17	8.1	5.2
MIRS Existing	53	17.1	9.7
Residential Investment	12	5.4	4.0
Freddie Mac	31	7.9	5.2

[a]Deflated by the GNP deflator.
[b]As a percentage of the mean of the sample.
[c]As a percentage of the standard deviation of series from its trend.

89 and 1970-89 periods. The percentage changes in real (i.e., deflated by the GNP deflator) house prices are shown.[11] Also shown are two measures of the variability of the price series. Column 2 reports the standard deviation of each series as a percentage of its own sample mean. Column 3 presents the percentage standard deviation of each series from its trend.[12]

A notable feature of these price series is the enormous difference in their long-run growth rates. The real growth rates fall into two distinct groups: the NAR, the FHA, the Census constant quality, the residential investment deflator, and the Freddie Mac series grow relatively slowly; the Mortgage Interest Rate Survey and Census average series grow relatively rapidly. This bifurcation results in part from conceptual differences: the series that attempt to adjust for quality change grow more slowly. The quality-adjusted series also tend to exhibit somewhat less variability, with the percentage standard deviations of the series not adjusted for quality being roughly double those of the quality-adjusted series. Indeed, the quality-adjusted series sometimes have moved relatively little over periods as long as a decade.

Housing demand studies find that more housing quality is demanded as real incomes rise (Mayo [22]). The long-run increase in real incomes then will raise the (quality-unadjusted) average price of purchased houses relative to the price of "constant-quality" houses. While the Census constant-quality

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[11]Throughout, real values are obtained by deflating nominal values by the implicit price deflator for GNP.

[12]For this series, the standard deviations of the residuals were obtained by regressing the logarithm of each real house price series on a constant and a linear time trend. The percentage variation was then calculated as follows: The base of the natural logarithm was raised to the power of the standard deviation of the residuals. One is then subtracted. That difference is then multiplied by 100.

series rises only 14% from 1963 to 1989, the unadjusted average price series rises by 98%. This implies that the quality of new homes has risen by 74% ((1.98/1.14)-1) over the past quarter-century.[13] Thus, according to the Census series, quality change accounts for three-fourths of the increase in these real new house prices over this period. However, this series, discontinued in 1989, may overestimate the increase in quality since the late 1970s. The Census revised hedonic-based model indicates that between 1977 and 1989 prices rose 12 percent more, and quality concomitantly less, than estimated by its previous model.

The series that rises least (13%) from 1963 through 1989 is the deflator for residential investment. Its relatively slow growth is not too surprising given that it is quality-adjusted and that it omits the value of land, whose relative price rose markedly over this period. That the residential investment deflator is the least volatile series suggests that much of the short-run movement in house (i.e., structure and lot) prices is attributable to changes in land value.[14]

Quality Change in the Exitsting Housing Stock

The large increase over time in the Census average price series relative to the quality-adjusted price series indicates that new houses have increased in quality. The average quality of existing houses rises through time both because the quality of new houses flowing into the stock rises and because

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[13]The implied 2.1 annual percentage change is virtually the same as that reported by Hendershott and Thibodeau [17].

[14]Its volatility may also be reduced by the BEA procedure of using a three-quarter moving average of the underlying single-family structure price series in constructing the residential deflator.

existing houses are upgraded.

The amount of net upgrading can be obtained from data on the net investment in the existing stock of houses. The U.S. Department of Commerce measure of the net stock of residential structures is based on the assumption of straight-line physical depreciation over 80 years (i.e., 1.25% annually).[15] Offsetting the decline in quality associated with depreciation is the gross flow of expenditures made to maintain and to upgrade the quality of houses (Apgar [3]). The Bureau of the Census [31] reports expenditures, in real terms, on residential property maintenance, repair, and improvements. Typically, over half of such expenditures are classified as "improvements." "Additions and alterations" are generally about 40% of expenditures. Indeed, the Bureau of the Census [29] reports that the following percentages of existing homes underwent these repairs, improvements, or alterations during 1985 and 1986: 5% built additions, 8% remodeled kitchens, 9% remodeled bathrooms, 14% bought and installed storm windows or doors, 9% added insulation, and 19% reported other major work. The Census [31] estimated that over $60 billion was spent to maintain, repair, and upgrade all owner-occupied properties in 1988.

We use the Census data as a starting point in calculating the net percentage increase in the real net stock of residential structures and lots that is due to the net upgrading of the existing stock. Net investment is obtained by subtracting from gross investment the real value of physical depreciation, which is the product of the Commerce Department's physical

[15]See Palmquist [24] and Randolph [26, 27] for estimates of the physical depreciation rate for housing. 1.25% is greater than the average depreciation rate in the studies surveyed by Randolph [26]. Some of those estimates refer to multi-family and other rental housing, which may have different, perhaps lower, depreciation rates than owner-occupied and single-family units.

depreciation rate for residential structures and its estimate of the stock of real net residential structures. This real net investment is then divided by a measure of the real net residential capital stock (including land value) to obtain the real net percentage increase in the quality of the existing residential capital stock.[16] The resulting measure deliberately omits upgrading of the stock due to the inflow of higher quality houses.

This measure underestimates gross and net investment, and thus net upgrading, to the extent that unmeasured labor time is used to repair, renovate, or otherwise maintain or improve the quality of housing at a given location. To make allowance for this widespread phenomenon, we have included an estimate of the value of unmeasured labor time, or "sweat equity." The Census reports separate data for materials purchased by homeowners and for payments to contractors. Because the value of materials is approximately equal to the value of labor in market-based construction generally (Baily and Gordon [5]), we assumed that the value of homeowners' labor time would be about the same as the value of the materials they purchased. The U.S. Bureau of the Census [31] reports that about half of materials used for projects of this type are purchased by homeowners, while the other half are provided through builders. In the late 1980s, the value of materials purchased by homeowners, and thus the estimated value of unmeasured labor time, is about 25% of total expenditures on owner-occupied properties. Since expenditures on owner-occupied properties are about 60% of total outlays, we raised gross measured outlays for materials and labor on all properties by 15% to allow for

[16]The value of land is obtained by using the Commerce Department estimate of the net residential capital stock, which only includes structure value, and the Board of Governors of the Federal Reserve System [6] ratio of the household sector's ownership of residential structures and land.

the estimated value of sweat equity. This adjustment raises the average annual growth rate of quality over the 1948 to 1989 period by one-third, from 0.66% to 0.89%.[17]

This measure of net upgrading is plotted in Figure 1, which shows that the "rehab boom" of the middle and late 1980s substantially raised the growth rate of the average quality of the standing stock of housing. Net investment was also substantial in the period before the mid 1960s. The adjustment to a price series implied by this amount of net upgrading is sizable. In the case of the Freddie Mac series, its real growth rate over the 1970-1989 period is lowered from 31% to 14%.

Figure 2 illustrates that series with similar average growth rates over a given time span may have quite different trajectories within that time span. Three conceptually different house price measures are plotted: the adjusted Freddie Mac series (FRED-ADJ), the FHA series and the residential investment deflator. Though these series rose similarly during the 1970s, in the 1980s their movements bore little resemblance to each other. The residential investment deflator generally trends down through the 1980s, while the FHA series generally rises. The adjusted Freddie Mac series drops sharply in the early 1980s and then rises very rapidly. Thus, in spite of their similar average growth rates over the past two decades, these real house price series are neither highly nor stably correlated with each other. The simple correlations of the adjusted Freddie Mac series with the other two are only 0.30 and 0.43, while the latter two series have a simple correlation

[17]The results reported below are based on the net upgrading series that includes the value of unmeasured homeowner labor. Clearly, including the sweat equity adjustment lowers both the level and the growth rate of real house prices. However, excluding the value of homeowners' labor produces regression results qualitatively similar to those presented in the tables.

Figure 1

Net Upgrading of Residential Capital Stock

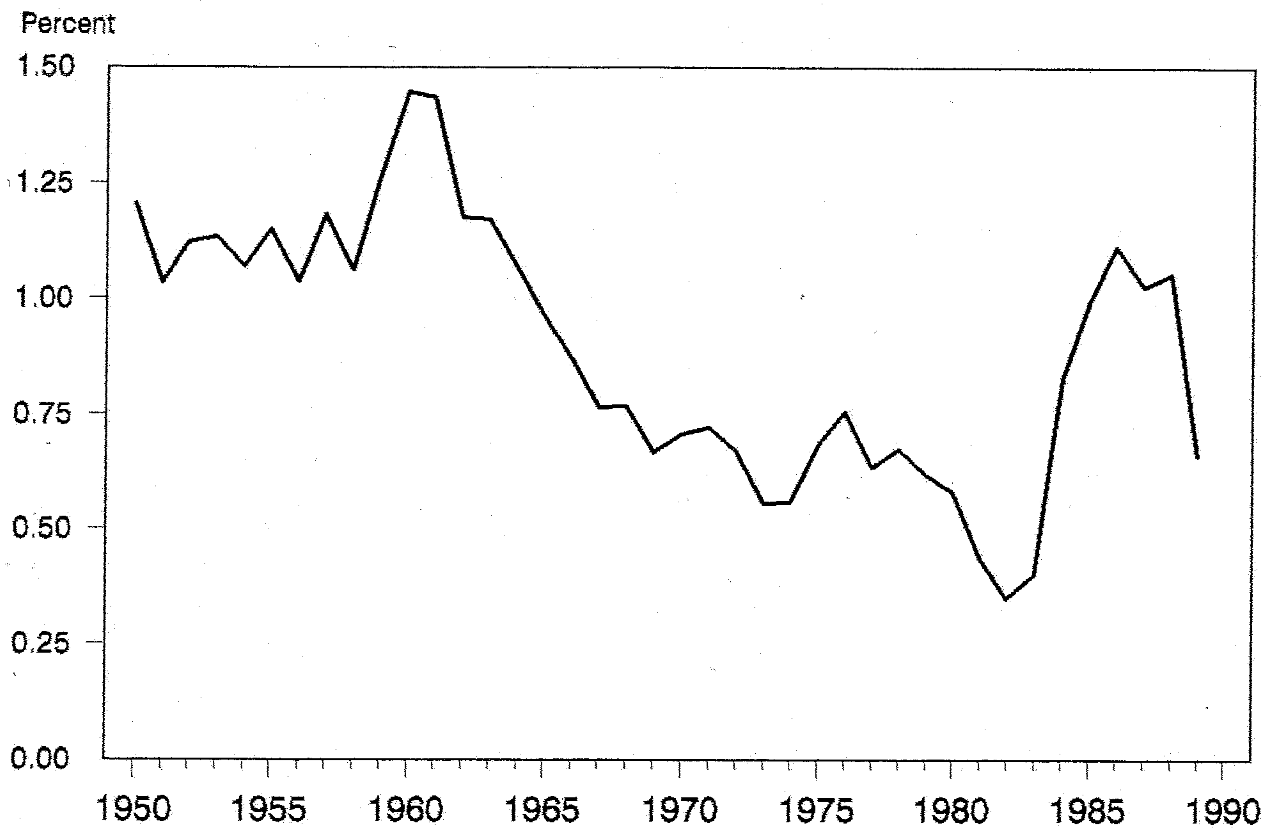
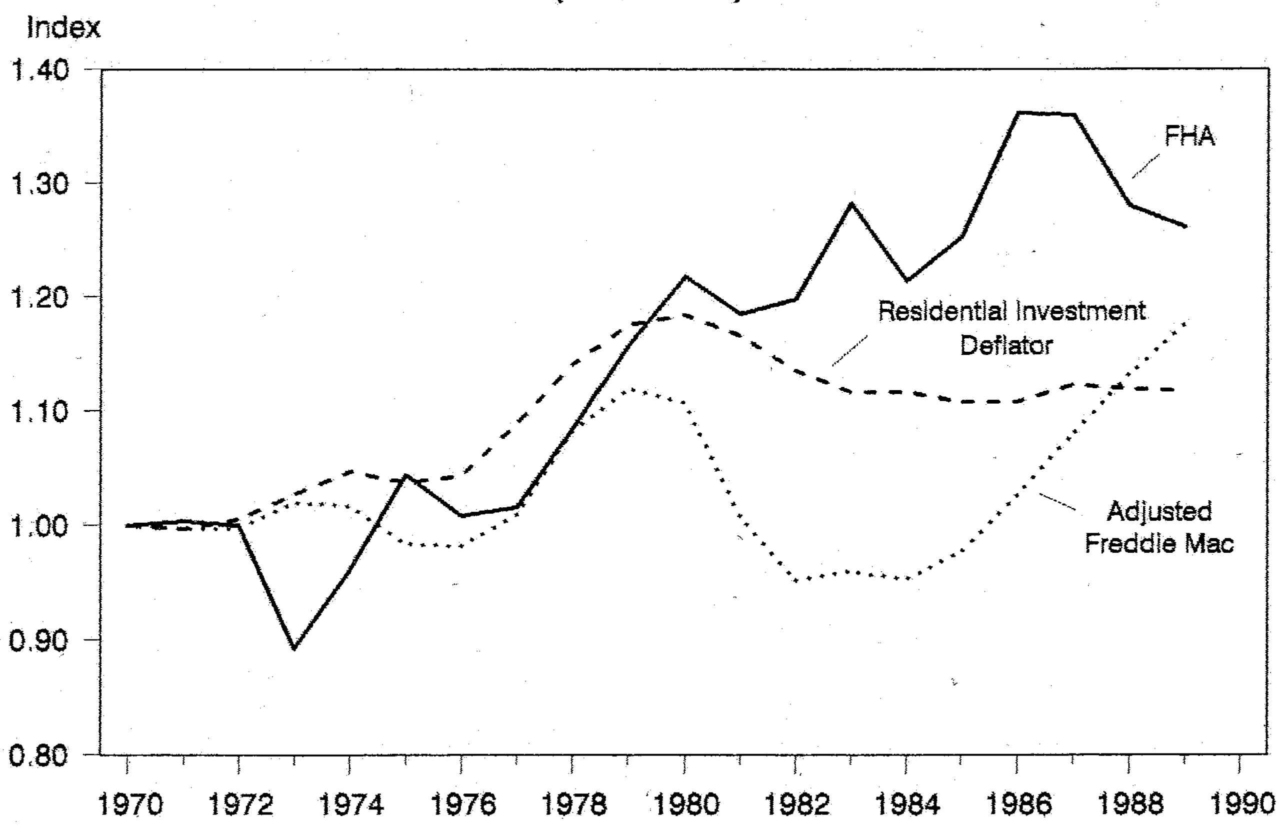


Figure 2

Alternative Measures of Real House Prices

(1970 = 1.00)



coefficient of 0.70. And as we shall see below, these series also respond considerably differently to economic and demographic forces.

Determinants of House Prices

A reduced-form equation for (the log of) real house prices as a function of the unemployment rate, financing costs, demographic factors, and materials costs can be obtained from a model of the aggregate supply of and demand for houses. The stock supply of houses (1) responds positively to real house prices and negatively to the real price of construction materials (RPCON):

$$HS = F(\underset{(+)}{P}, \underset{(-)}{RPCON}) \tag{1}$$

The demand for houses (2) depends positively on the real income per household of a given age (INC) and on the size and age distribution of the population (HH), and negatively on real house prices (P), the cyclical component of the unemployment rate (UGAP), and homeowners' real after-tax borrowing costs (RATMR).[18] The share of household heads aged 20-29 (POP20s) is also included in order to capture the labor market effects of atypically large cohorts entering the labor market. To the extent such cohorts depress the real incomes of their members relative to normal (as captured by INC and HH), the impact of POP20s is expected to be negative.

$$HD = G(\underset{(-)}{P}, \underset{(-)}{UGAP}, \underset{(-)}{RATMR}, \underset{(+)}{INC}, \underset{(+)}{HH}, \underset{(-)}{POP20s}) \tag{2}$$

Equating demand and supply produces the reduced-form equation for real house prices:

$$P = H(UGAP, RATMR, INC, HH, POP20s, RPCON) \tag{3}$$

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[18]Because financing costs can also affect the supply function for housing, the reduced-form coefficient associated with financing costs can be expected to reflect both influences, though the demand effect is likely to dominate.

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Supply Considerations

Shifts of the supply function of land and structures depend upon technological advance in sectors that provide and use them. Above-average advances in construction, materials, or agricultural technology (depending upon the extent to which they are biased in one direction or another), the opening up of previously inaccessible land, and even changes in world weather patterns could produce such shifts. Above-average technological advance in construction, for example, could imply perennial rightward supply shifts that might justify the inclusion of a time trend in the house supply function (1). There seems little reason to expect a priori, however, that relative technological advance will be above average. If anything, the dismal performance of measured construction labor productivity would suggest that technological advance has been slower than average in this sector (Baily and Gordon [5] and Hendershott [15]). Relying on these measures of productivity growth could be misleading, however, because unmeasured change in the quality of residential construction may have been a source of underestimates of construction output, and therefore productivity growth.

The slope of the national residential land supply curve is not obviously either very flat or very steep. Some evidence supports the view that the long-run national land supply curve is not horizontal, thereby allowing demand shifts to change real house prices. The real per acre price of farm land and buildings rose at a compound annual rate of about 0.7% between 1850 and 1950, and the real per acre price of farm land rose 1% annually from 1950 through 1990 (U.S. Bureau of the Census [32]). The supply of land to urban uses holding quality constant, particularly its accessibility, is very likely to be upward sloped. Case and Kopcke [7] show that the real per square foot price of land five to ten miles from the center of Boston rose at a compound annual rate of 1.9 percent between 1850 and 1950; since then it has risen at a faster rate on average. It seems more reasonable to account for the persistent increase in real land prices in part by demand sliding up a positively sloped land supply curve, rather than exclusively by a horizontal supply curve for land shifting upward.

To proxy for shifts in the housing supply function due to changes in the relative price of construction materials, we include RPCON, the log of the real producer price index for intermediate stage materials and components for construction (Council of Economic Advisers [10], p. 366). The real price of construction materials fluctuates considerably through time. Over the decades of the 1950s and 1960s, for example, construction materials prices relative to the GNP deflator fell by about 17%. The relative prices of gypsum, roofing, and lumber fell even more (U.S. Bureau of the Census [32]). The price of plywood actually fell in nominal terms, resulting in a 50% decline in its real cost between 1950 and 1970. During the 1970s and 1980s, however, real construction materials prices rose 5%. Lumber prices rose by 14%, for example, while the real prices of gypsum and plywood fell by 6% and 17%, respectively.

The relative price of construction materials is taken to be predetermined. To the extent that, instead, causality runs from changes in the demand for houses to the relative price of construction materials, OLS estimates of the reduced-form equation for real house prices (3) will be affected by simultaneity bias. To assess whether shifts in the demand for houses are likely to have been an important source of changes in RPCON over the 1950-89 period, RPCON was regressed on the other, presumably predetermined determinants of demand (UGAP, RATMR, INC, HH, and POP20s, as described more fully below). One signal of the endogeneity of the relative price of construction materials with respect to house prices would be its significant positive reaction to increases in the determinants of the demand for houses. However, over the 1950-89 period, little evidence of such a reaction is found. Real after-tax interest rates and the demographic variable POP20s are each statistically insignificant, and, while the unemployment rate and the household and income variables are statistically significant, increases in the demand for houses emanating from these sources are estimated to reduce the relative price of materials.

Unemployment and Interest Rate Effects

The cyclical component of the unemployment rate, UGAP, is included to allow for the possibility that income constraints, uncertainty, and other factors associated with the transitory departures of real income from its underlying trend affect the demand for houses. UGAP is calculated as the difference between the actual unemployment rate and the natural, or equilibrium, rate.[19]

The nominal after-tax mortgage interest rate has been calculated as the secondary-market yield on FHA mortgages times one minus the DRI series for the average marginal federal income tax rate.[20] In the absence of a data series for the expected long-term inflation rate, the expected real rate was obtained

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[19]Values for the natural rate of unemployment for 1950 - 1988 are taken from the Congressional Budget Office [9]. The 1989 value is set equal to the 1988 value. The Congressional Budget Office [9] uses the values from Gordon [12] for its estimates for 1950 - 1980.

[20]See Poterba [25] for illustrations of the substantial changes in after-tax housing costs during the 1980s.

by subtracting the Livingston survey inflation rate expectation for the upcoming year. In order to assess whether our results were sensitive to this particular formulation, other specifications were also tested. To match the interest rate and expected inflation rate maturities (at one year), one measure (RATS) subtracted the Livingston expected inflation rate from the after-tax Treasury bill rate measured on a bond-equivalent basis. Another measure (RATTB) substituted the 10-year Treasury bond rate for the mortgage rate. This measure effectively removed the time-varying call premium present in prepayable FHA mortgage rates that is not present in non-callable Treasury bonds. The last measure (RATTP) subtracted the spread between 10-year and one-year Treasuries from RATMR.

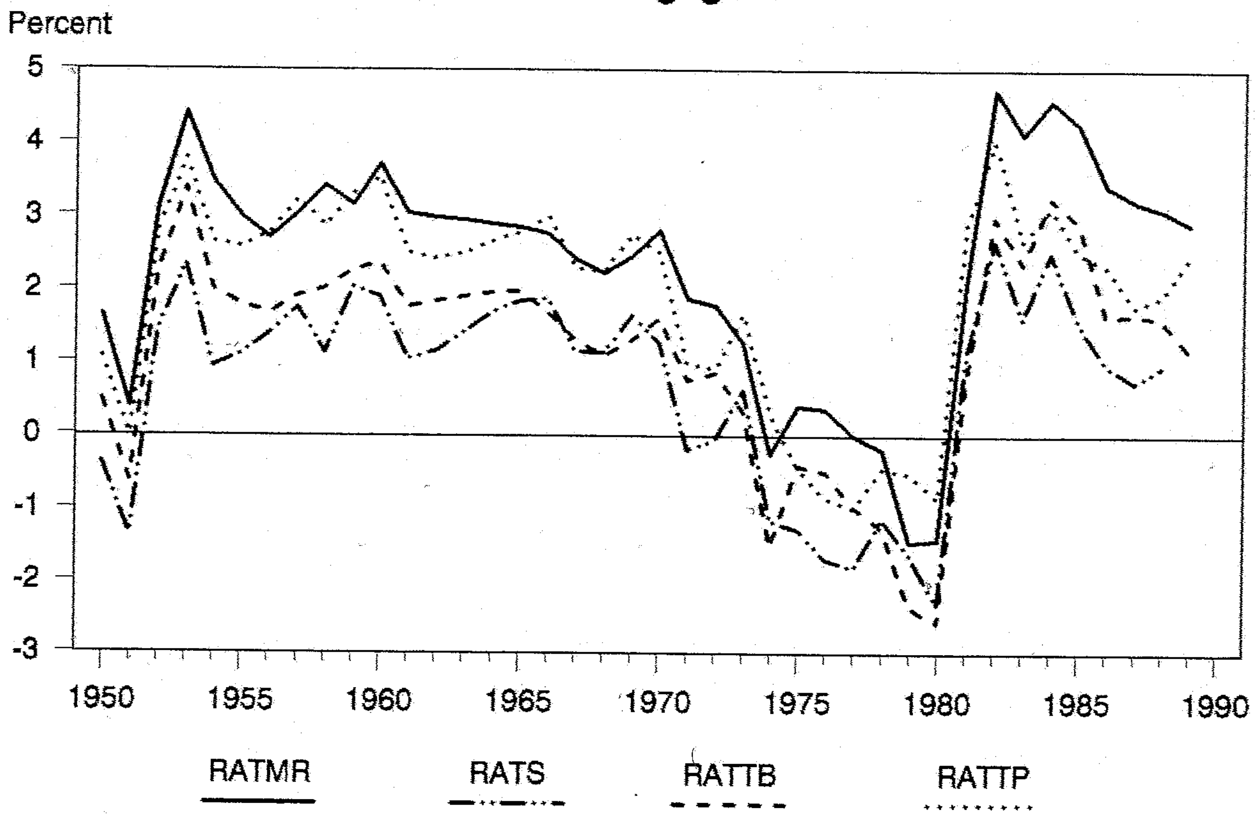
The four financing cost specifications are shown in Figure 3. Though these measures differ somewhat over short time spans, they closely track each other over the full sample: their simple correlations were each above 0.9 for the 1950-1989 period. Noteworthy are their long, accelerating slides from the early 1950s until 1980 and their abrupt increases early in the 1980s. The average values in the 1980s are not much above those experienced during the 1950s and 1960s. Apparently, the factors that have moved these rates over the past four decades have predominantly affected the general level of interest rates rather than the spreads between them. As a result, none of these specifications led to appreciably different results from those reported below for RATMR.

Income and Demographic Effects

INC, HH, and POP20s are intended to capture the effects of income (apart from the effects associated with transitory movements of the unemployment rate), demographic factors, and their interaction on the demand for houses.

Figure 3

Alternative Measures of Real, Expected After-Tax Mortgage Costs



It is widely accepted that the demand for houses rises fairly steeply with real income per household (Hendershott [15]). INC is the logarithm of real income per constant-age-household. INC is designed to capture the effects of changes in real income per household over time, apart from those arising from changes in the age-earnings profile. The effect of changing age structure on the age-earnings profile will be described below and proxied by the variable POP20s. INC deliberately avoids incorporating changing age-earnings profile effects by using the income of a family headed by someone likely to be less affected by the entrance of baby boomers into the labor market. The income measure used to calculate INC is the real median annual income of a family with a head of household between 45 and 54 years of age (U.S. Bureau of the Census [30]). Measures of average real income per hour, worker, or family, on the other hand, would not suffice because they are affected by the demographic composition of the labor force.

Similarly, the greater the number of households, the greater the demand for houses. HH is the logarithm of the number of households weighted by the average tendency of various categories of households to be homeowners. Homeownership rates by age reflect (1) the progression along the typical upward slope of the age-earnings profile and (2) the greater desire of older households to own their own homes (Hendershott [15]). The combination of these two factors produces a demand for houses that is a fairly steeply rising function of age. The demand for houses is also greater for married couples, <u>ceteris paribus</u>. To reflect these three effects on the demand for houses, HH weights the number of households in each age and marital status category by the long-run average homeownership rate of that category.[21] By basing HH on the long-run average homeownership rates, rather than those observed year by year, it reflects the typical age-earnings profile that each age and marital status group has faced.

Over the past four decades, INC and HH have been dominated by their upward trends, making the correlation between them extremely high. Because of that collinearity and the likelihood that the elasticities of the demand for houses with respect to income per household and the number of weighted households are quite similar, INC and HH were summed to form INCHH. T-tests did not reject the hypothesis that the elasticities of INC and HH were the same.

Another demographically based effect operates through the ratio of households headed by a person aged 20 to 29 to those whose head is aged 30 to 54 (POP20s), which captures the change in the age-earnings profile brought on by changes in the age structure of the labor force.[22] As a demographic bulge like the baby boom flows into the labor force, the ratio of the number of young to older workers rises. As a result, the real incomes of individual baby boomers are temporarily depressed, thereby steepening their age-earnings profiles (Freeman [11], Welch [35]). POP20s, plotted in Figure 4, began to rise as the first baby boomers entered their twenties in the late 1960s. The

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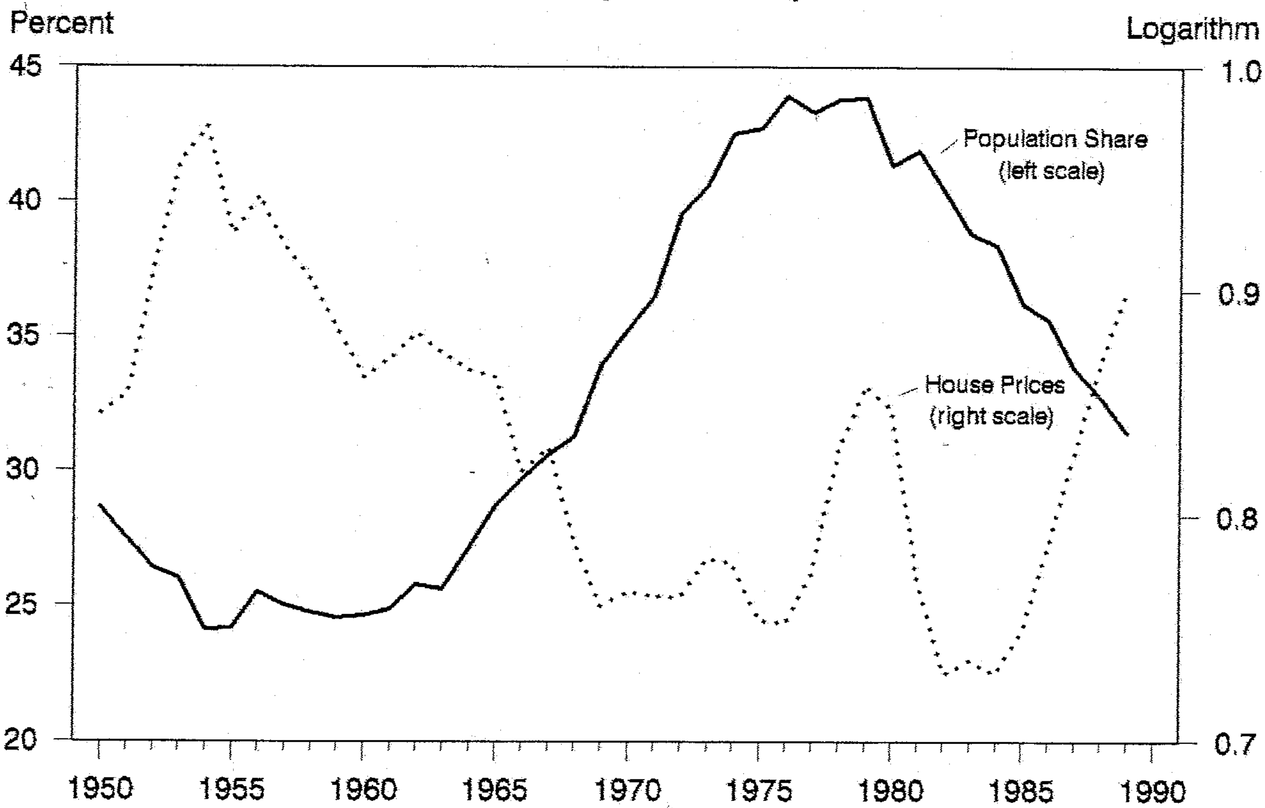
[21]The "long-run" average homeownership rates by age and marital status are averages of the rates calculated from the 1960, 1970, and 1980 decennial Censuses of Housing and Housing Vacancy Survey, taken from Hendershott [16]. The data for the number of households by age and marital status are taken from U.S. Bureau of the Census [33].

[22]For a more detailed discussion of demographic effects on income and the demand for houses, see Lapkoff, Peek and Wilcox [18]. The ratio of young to older households is highly correlated (0.98) with the ratio of young to older population.

Figure 4

Adjusted Real Freddie Mac House Prices and Share of Population Aged 20-29



peak years for POP20s are from the early 1970s through the middle of the 1980s. Then, as the baby boomers age further, POP20s recedes as boomers swell the ranks of the 30- to 54-year-old group.

Individual baby boomers' incomes can be expected to rise faster than the historical average age-earnings profile would indicate because, as they age, they become closer substitutes for other, older workers. This atypically rapid income growth, combined with lenders' practices that impose payment-to-income ceilings without regard to age, unleashes baby boomers' "pent-up" demand for houses. The easing of borrowing constraints implies greater demand for houses than would be predicted by specifications that ignore the "catch-up" of baby boomer real incomes.

Empirical Evidence

Table 3 presents the results for the 1970-89 period of regressing the log of various real house price measures on a constant term, the level of the unemployment rate gap (UGAP), the level of the real after-tax mortgage interest rate (RATMR), the sum of the logs of real income per constant-age household and of the number of weighted households (INCHH), the ratio of household heads aged 20 to 29 to those aged 30 to 54 (POP20s), and the log of real construction materials prices (RPCON). The bottom two rows contain the unadjusted (FRED) and the upgrade-adjusted (FRED-ADJ) versions of the Freddie Mac house price series.

Judgments about both the size and the statistical significance of some of the determinants of house prices are sensitive to the choice of house price series. The effects of cyclically higher unemployment, for example, are significantly positive in one case (FHA), significantly negative in one case

Table 3

House Price Equations, 1970 - 1989
(dependent variable: log of real house prices)
(t-statistics in parentheses)

House Price Series	Coefficient on: Const	UGAP	RATMR	INCHH	POP20s	RPCON	R^2	S.E.E.	D.W.
1. FHA	3.16 (1.69)	3.48 (2.38)	-0.457 (-0.32)	0.428 (2.83)	-1.80 (-2.17)	0.729 (1.11)	0.883	0.050	1.09
2. NAR	-5.63 (-5.39)	0.101 (0.12)	-0.081 (-0.10)	0.480 (5.68)	-0.557 (-1.20)	0.981 (2.67)	0.941	0.028	0.84
3. Census Average	-4.58 (-4.51)	-0.931 (-1.17)	-0.490 (-0.64)	1.043 (12.71)	-0.707 (-1.57)	0.916 (2.57)	0.984	0.027	1.97
4. Census Constant Quality	2.69 (1.82)	0.148 (0.13)	1.451 (1.30)	0.289 (2.42)	-0.138 (-0.21)	1.148 (2.22)	0.833	0.039	0.70
5. MIRS Existing	3.67 (2.28)	-0.030 (-0.02)	-2.917 (-2.41)	0.648 (4.99)	-2.780 (-3.89)	0.278 (0.49)	0.947	0.043	1.68
6. Residential Investment Deflator	-6.53 (-7.71)	-0.393 (-0.59)	0.800 (1.25)	0.142 (2.08)	-0.342 (-0.91)	1.084 (3.65)	0.873	0.023	0.84
7. Freddie Mac	-1.42 (-2.14)	-0.938 (-1.80)	-1.738 (-3.46)	0.340 (6.31)	-1.158 (-3.92)	0.513 (2.20)	0.960	0.018	1.61
8. Freddie Mac Adjusted	-2.05 (-3.18)	-1.147 (-2.28)	-1.745 (-3.60)	0.116 (2.23)	-1.007 (-3.52)	0.422 (1.87)	0.911	0.017	1.51

(FRED-ADJ), and statistically insignificant otherwise. In no case is the coefficient's t-statistic larger than 2.4. The lack of compelling evidence that transitory unemployment affects the prices of long-term assets is not particularly surprising. On the other hand, because we take FRED-ADJ (bottom row of table 3) to be the most appropriate of these house price series, we place relatively more weight on the finding that cyclically higher unemployment rates lower house prices.

Six out of eight price series respond negatively to real after-tax interest rates. The series that deliver positive interest rate effects are two of the most widely used series, the Census constant-quality series and the residential investment deflator. Based on the FRED-ADJ results, however, higher real after-tax mortgage interest rates lower real house prices. This effect is statistically significant and substantial: a 1 percentage point increase in this interest rate reduces house prices by 1 3/4%.

In contrast to the unemployment and interest rate coefficient estimates, the other coefficients are uniformly signed across price series. The coefficients on INCHH are always significant, though they span a wide range: from about 0.1 to about 1.0. The estimated POP20s coefficients are always negative, and significantly so for four of the price series. Higher materials costs raise every measure of house prices, significantly in five out of eight cases. In the preferred FRED-ADJ specification, the estimated coefficient on RPCON of 0.422 is reassuringly close to materials' share (about one-half) of total construction costs.

Table 4 contains results for the longer, 1950-1989 sample period. RESDEF and FHA are both available for this entire sample period. FHA-ADJ has been constructed by making the same adjustment to FHA for net upgrading as was

Table 4

House Price Equations, 1950 to 1989
(dependent variable: log of real house prices)
(t-statistics in parentheses)

House Price Series	Coefficient on Const	UGAP	RATMR	INCHH	POP20s	RPCON	AR(1)	MA(1)	R^2	S.E.E	D.W.
1. Freddie Mac Adjusted	-2.92 (-4.24)	-0.863 (-2.14)	-1.080 (-2.34)	0.100 (4.20)	-1.047 (-6.91)	0.652 (5.97)	--	--	0.849	0.028	1.33
2. Freddie Mac Adjusted	-2.87 (-5.18)	-0.742 (-2.22)	-0.918 (-2.36)	0.097 (4.90)	-1.032 (-8.47)	0.648 (7.51)	-0.198 (-0.72)	0.755 (2.59)	0.892	0.025	2.06
3. FHA Adjusted	4.52 (4.32)	0.614 (1.00)	1.558 (2.22)	0.170 (4.70)	-0.952 (-4.13)	0.942 (5.66)	--	--	0.736	0.043	1.11
4. FHA Adjusted	4.25 (4.86)	0.720 (1.33)	1.316 (2.27)	0.182 (5.88)	-1.011 (-5.54)	0.974 (7.21)	-0.096 (-0.37)	0.860 (2.91)	0.834	0.036	1.95
5. Residential Investment Deflator	-7.23 (-9.16)	-0.748 (-1.62)	1.470 (2.78)	0.125 (4.59)	0.215 (1.24)	1.230 (9.79)	--	--	0.763	0.033	0.63
6. Residential Investment Deflator	-4.07 (-3.45)	0.049 (0.20)	-0.008 (-0.02)	0.170 (1.87)	0.000 (0.00)	0.448 (2.94)	0.905 (12.43)	0.266 (1.35)	0.957	0.014	1.96

applied to FRED to obtain FRED-ADJ. Because there are no Freddie Mac data before 1970, we splice the 1950-70 values for FHA-ADJ onto FRED-ADJ. Thus, FRED-ADJ in Table 4 is a hybrid series whose reliability is presumably greater for the post-1970 period. This series is plotted in Figure 4. Values of the variables used in Table 4 are listed in the Appendix.

Rows 1, 3, and 5 in Table 4 present OLS results. The top row shows the FRED-ADJ results, which do not differ greatly from those in Table 3. The coefficient estimates for INCHH and POP20s of about 0.1 and -1.0 are nearly identical across the different sample periods used for Tables 3 and 4. Not surprisingly then, an F-test does not reject the hypothesis of coefficient stability over a mid-sample split.

The OLS results for FHA-ADJ differ appreciably from those for FRED-ADJ. In row 3, the UGAP coefficient is insignificantly positive and the estimated effect of higher real after-tax mortgage interest rates is to drive real house prices up! On the other hand, the estimated impacts of INCHH, POP20s, and RPCON are similar to their effects on FRED-ADJ. The OLS estimates based on RESDEF (row 5) also differ from the FRED-ADJ results. Again, higher real after-tax mortgage rates are estimated to raise house prices, and POP20s is insignificant, but positive. Thus, judgment about the strength, reliability, and direction of various variables' effects on house prices depends crucially on which measure of house prices is judged most appropriate.

The low Durbin-Watson statistics in Tables 3 and 4 suggest misspecification and also call into question the validity of the calculated t-statistics. Rows 2, 4 and 6 of Table 4 present regression estimates that allow for nonrandom residuals. An ARMA(1,1) process for the residuals was chosen *a priori* to allow the data latitude to reveal evidence that might suggest equation misspecification. In the case of FRED-ADJ, the magnitudes and statistical significance of the coefficients are little affected by allowing for ARMA(1,1) terms.[23] The FHA-ADJ results are likewise little affected. The results for the residential investment deflator, however, change dramatically, with only RPCON retaining a calculated t-statistic greater than two.

The results in row 6 are consistent with the arguments presented above, that effects on house prices of changes in the aggregate demand for houses operate primarily through changes in the price of land. The residential investment deflator, the series that omits land value, responds significantly only to RPCON, the proxy for supply curve shifts. Contrary to Mankiw and Weil [21], we are unable to detect demand effects on the residential investment deflator. Neither after-tax real interest rates, long-run or short-run movements in income, nor demographic factors had any statistically significant effect on this particular measure of house prices, although each of these factors did affect the quality-adjusted Freddie Mac series with statistically significant coefficients of the predicted sign.

We also investigated the extent to which financial forces other than those operating through RATMR and the steepening of the age-earnings profile have affected house prices. The high and variable nominal interest rates in the 1970s and 1980s are sometimes suggested as important determinants of household spending (Manchester [20], Linneman and Wachter [19] and Wilcox [36]). In particular, we looked to see if the demand for housing has been

[23]A Dickey-Fuller test of the OLS residuals produced a t-statistic of -4.27, allowing us to reject their being non-stationary. On that basis, we accepted the formulation in the top row of table 4 as a co-integrated relation. Estimation of an error-correction formulation based on that co-integrated relation produced a significantly (t=-3.23) negative error-correction term coefficient (-0.55).

restrained by borrowing constraints associated with nominal interest rates. In general, given the inclusion of real after-tax rates, nominal (before-tax) interest rate coefficients were found to be insignificant, so we have not reported them here.[24]

Decomposition of House Price Movements

Table 5 uses the coefficient estimates from the top row of Table 4 to obtain the percentage change in real house prices over various subperiods attributable to each of the explanatory variables. The difference between the actual and the explained movement over each of the subperiods is the residual. The top row in Table 5 shows that, after rising a little in the 1950s, real house prices fell by more than 9% during the 1960s. That decline can be accounted for by the decline in real construction materials costs. In the 1970s, real house prices rose by nearly as much as they fell in the 1960s. The combination of higher real materials costs and the decline in real after-tax interest rates in the 1970s more than offset the depressing effect of higher unemployment and the reduction in the average age of the labor force.

Between 1980 and 1984 real house prices fell about 11%. Over half of that decline is attributed to the enormous increase in real after-tax interest rates (Figure 3). Further downward pressure on house prices emanated from the decline in the cost of construction materials. Some of this downward pressure was offset by demographic factors. In the late 1980s, real house prices rose

[24]One interesting pattern did emerge in this regard, however, when we split the sample approximately in half. Estimates based on the sample containing data before 1970 indicated that nominal interest rates had significant negative effects on house prices, while real rates did not; in the second half of the sample, the opposite pattern held. It is surprising that nominal interest rates were found to be insignificant here, given their significance in equations explaining consumer spending (Wilcox [36]).

Table 5

Determinants of Changes in Real House Prices

Percentage Change	1950-60	1960-70	1970-80	1980-84	1984-89
Real House Prices	1.6	-9.1	8.5	-11.1	18.6
Attributable to:					
UGAP	-0.1	0.8	-1.6	-0.4	1.9
RATMR	-2.2	1.0	4.7	-6.3	1.8
INCHH	5.1	4.8	2.6	0.8	2.1
POP20s	4.3	-10.5	-6.2	3.2	7.6
RPCON	-2.3	-9.2	10.7	-5.3	-1.4
Residual	-3.2	4.0	-1.7	-3.1	6.6

appreciably, even though the relative price of construction materials fell. Lower unemployment rates and lower real after-tax interest rates each accounted for an increase in real house prices of nearly 2%. The demand for houses was also stimulated by the aging of the baby boom. INCHH and POP20s together accounted for half of the nearly 19% rise in real house prices.[25]

Conclusion

This paper seeks to measure and explain house prices over the past four decades. Accurate measures of house prices are required to reliably assess the determinants of house prices, housing affordability, and the investment characteristics of residential real estate and the securities it collateralizes. We have adjusted house price indexes by allowing for the net upgrading of the standing stock of houses. In real terms, the adjusted Freddie Mac series rose by 5.7% over the 1950-1989 period. It rose 14.5% from 1970 to 1989, after having fallen by 7.7% from 1950 to 1970.

Real house prices are estimated to decline with increases in real after-tax interest rates, and rise with both cyclical and more permanent income increases and increases in the relative cost of materials. Demographic factors such as the size and age distribution of the population are also significant determinants of house prices.

The future course of house prices is of interest to current and prospective homeowners, homebuilders, lenders, mortgage insurers, and policymakers. Forecasting house prices far into the future is inherently

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[25]The large unexplained increase in house prices may have resulted from the sharp rise in the conforming loan limit in the late 1980s. Similarly, the unexplained decline in the early 1980s may have been related to the failure of the loan limit to keep pace with housing market conditions.

difficult. Baby boomers will continue to age, however, and as they do, their demand for houses and, hence, house prices are likely to increase, for two reasons. First, baby boomers' propensity for homeownership is likely to increase as they age, even apart from real income increases. In this regard, baby boomers may differ little from the generations that preceded them, and on this count, the demand for houses is likely to rise for at least the next two decades. Second, the sheer size of the baby boom cohort appears to have significantly depressed the individual incomes of its members. A tapering-off of this cohort effect as they age would lead to boomers' real incomes growing at atypically rapid rates in coming years. To the extent the demand for houses is effectively constrained by borrowing limits that are specified in terms of current income, these income gains will stimulate the demand for houses. On the basis of the estimates presented here, that combination of increased desire and ability to own homes could be expected to raise real house prices by about 10% during the 1990s.

DATA APPENDIX

A. Data Underlying Calculation of FRED-ADJ

Year	FHA/ Freddie Mac	Adjusted FHA/ Freddie Mac	GNP Deflator
1950	1.000	1.000	0.239
1951	1.070	1.059	0.251
1952	1.164	1.139	0.255
1953	1.254	1.213	0.259
1954	1.306	1.250	0.263
1955	1.303	1.233	0.272
1956	1.382	1.295	0.281
1957	1.416	1.311	0.291
1958	1.439	1.318	0.297
1959	1.460	1.321	0.304
1960	1.473	1.314	0.309
1961	1.522	1.339	0.312
1962	1.591	1.383	0.319
1963	1.621	1.393	0.324
1964	1.651	1.403	0.329
1965	1.708	1.438	0.338
1966	1.709	1.426	0.350
1967	1.785	1.478	0.359
1968	1.813	1.490	0.377
1969	1.872	1.528	0.398
1970	2.002	1.623	0.420
1971	2.127	1.712	0.444
1972	2.242	1.793	0.465
1973	2.441	1.941	0.495
1974	2.673	2.114	0.540
1975	2.882	2.263	0.593
1976	3.085	2.405	0.631
1977	3.383	2.620	0.673
1978	3.862	2.971	0.722
1979	4.355	3.330	0.786
1980	4.726	3.593	0.857
1981	4.828	3.654	0.940
1982	4.940	3.726	1.000
1983	5.184	3.894	1.039
1984	5.388	4.014	1.077
1985	5.709	4.212	1.109
1986	6.150	4.487	1.138
1987	6.682	4.826	1.174
1988	7.262	5.190	1.213
1989	7.867	5.586	1.263

Note: Nominal house price series indexed to equal 1.0 in 1950.

B. Series Used in Table 4 Regressions

Year	FRED-ADJ	FHA-ADJ	RESDEF	UGAP	RATMR	INCHH	POP20s	RPCON
1950	0.846	10.474	-0.008	0.002	0.017	10.293	0.286	4.697
1951	0.854	10.482	0.012	-0.017	0.004	10.366	0.275	4.739
1952	0.911	10.540	0.023	-0.020	0.031	10.441	0.264	4.716
1953	0.959	10.587	0.015	-0.022	0.044	10.565	0.260	4.718
1954	0.974	10.602	0.004	0.005	0.035	10.543	0.241	4.706
1955	0.926	10.555	-0.007	-0.007	0.030	10.583	0.242	4.713
1956	0.943	10.571	-0.007	-0.010	0.027	10.632	0.255	4.729
1957	0.920	10.548	-0.039	-0.008	0.030	10.644	0.250	4.700
1958	0.905	10.533	-0.059	0.018	0.034	10.668	0.248	4.680
1959	0.884	10.512	-0.082	0.003	0.032	10.729	0.246	4.684
1960	0.862	10.491	-0.091	0.003	0.037	10.792	0.247	4.662
1961	0.871	10.499	-0.101	0.015	0.030	10.829	0.249	4.637
1962	0.881	10.510	-0.120	0.003	0.030	10.877	0.258	4.611
1963	0.873	10.501	-0.139	0.002	0.030	10.925	0.256	4.599
1964	0.865	10.493	-0.144	-0.003	0.029	10.966	0.272	4.593
1965	0.862	10.491	-0.153	-0.011	0.028	11.015	0.287	4.575
1966	0.819	10.448	-0.157	-0.018	0.028	11.065	0.297	4.564
1967	0.830	10.458	-0.150	-0.018	0.024	11.139	0.306	4.551
1968	0.789	10.417	-0.148	-0.020	0.022	11.189	0.313	4.551
1969	0.760	10.389	-0.112	-0.021	0.024	11.256	0.339	4.551
1970	0.766	10.395	-0.127	-0.006	0.028	11.260	0.353	4.513
1971	0.764	10.392	-0.130	0.002	0.019	11.282	0.365	4.521
1972	0.764	10.381	-0.121	-0.002	0.018	11.347	0.396	4.527
1973	0.781	10.262	-0.100	-0.009	0.013	11.381	0.407	4.543
1974	0.779	10.329	-0.081	-0.003	-0.003	11.392	0.426	4.624
1975	0.754	10.406	-0.090	0.025	0.004	11.371	0.428	4.619
1976	0.752	10.363	-0.084	0.017	0.003	11.409	0.439	4.621
1977	0.774	10.365	-0.041	0.011	-0.000	11.446	0.433	4.634
1978	0.829	10.423	0.006	0.002	-0.002	11.474	0.438	4.663
1979	0.858	10.483	0.035	-0.001	-0.015	11.516	0.439	4.674
1980	0.848	10.527	0.042	0.013	-0.014	11.520	0.414	4.668
1981	0.772	10.496	0.027	0.016	0.021	11.532	0.419	4.646
1982	0.730	10.503	0.000	0.038	0.047	11.537	0.404	4.605
1983	0.736	10.567	-0.016	0.037	0.041	11.567	0.388	4.595
1984	0.730	10.504	-0.016	0.017	0.046	11.603	0.384	4.585
1985	0.749	10.526	-0.024	0.014	0.043	11.650	0.362	4.572
1986	0.786	10.598	-0.024	0.012	0.034	11.700	0.356	4.554
1987	0.828	10.587	-0.010	0.005	0.032	11.748	0.338	4.538
1988	0.868	10.516	-0.013	-0.002	0.031	11.750	0.328	4.561
1989	0.901	10.494	-0.014	-0.004	0.029	11.816	0.314	4.564

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