The Price and Quantity of Residential Land in the United States*

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Abstract

One can conceptualize a house as a bundle comprising a reproducible tangible structure and a non-reproducible plot of land. When the value of a home is decomposed this way, land capitalizes the market value of a homes location. We develop a formal relationship between the dynamics of house prices, structures costs and land prices, and thereby construct the first constant-quality price and quantity indexes for the aggregate stock of residential land in the United States. In a range of applications we show that these series can shed light on trends, fluctuations and regional variation in the price of housing.

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1 Introduction

We estimate the market value of the housing stock in the United States to be $24.1 trillion at the end of 2005. This figure is 1.42 times the combined capitalizations of the NYSE, Nasdaq and Amex exchanges. Because housing accounts for such a large fraction of national wealth, changes to the price of houses may have important macroeconomic effects.[1] Interest in understanding house price dynamics has been heightened by the recent boom in the housing market: the average price of existing single-family homes in the United States rose by 5.4 percent per year in real terms over the ten year period ending in the second quarter of 2006.

In this paper we argue that one way to advance our understanding of house prices is to think of a house as a bundle of two components: a structure and a plot of land. The structure can be priced explicitly as the replacement cost, after accounting for depreciation, of the physical building. We attach the label "land" to anything that makes a house worth more than the cost of putting up a new structure of similar size and quality on a vacant lot. Thus land is shorthand for the size and attractiveness of the plot and all the amenities associated with a home's location.

We decompose the aggregate value of the housing stock into structures and land components, and show that the growth rate of the price of housing is a weighted average of the growth rate of the price of structures and the price of land. The time-varying weights are given by the relative shares of land and structures in the total market value of the housing stock. This relationship allows us to construct price and quantity series for land given publicly-available (but appropriately adapted) series for house and structure prices, and for the market values of housing and existing

[1] A large empirical literature investigates wealth effects from house price changes on aggregate consumption and saving (see, for example, Davis and Palumbo, 2001, or Carroll, Otsuka, and Slacalek, 2006). Changes in the price of housing also have implications for risk-sharing and asset pricing (see, for example, Davis and Martin, 2006, Lustig and van Nieuwerburgh, 2006, or Piazzesi, Schneider and Tuzel, 2006), as well as distributional effects in heterogeneous-agent economies (Bajari, Benkard and Krainer, 2005).

structures.[2] Our series are the first constant-quality price and quantity indexes for the aggregate stock of residential land in the United States.

Note that we do not directly measure the price of land, but rather infer it from data on house prices and structures costs. With the exception of land sales at the undeveloped fringes of metro areas - where land is relatively cheap - there are very few direct observations of land prices from vacant lot sales, because most desirable residential locations have already been built on. Our indirect approach allows us to circumvent this potentially intractable measurement problem.

2 The Importance of the Land-Structures Distinction

A key message of this paper is that exploring the evolution of land and structures prices separately makes it much easier to understand the dynamics of house prices. The reason is that even though a structure and its associated plot of land are typically traded as a single bundle in the housing market, structures and land are really quite different goods, whose prices should respond differently to shocks.

On the demand side, the physical structure is valued as a capital input in home production and leisure activities, while land capitalizes the market value of local schools and the commuting distance from employment centers. On the supply side, the land-structures distinction is even more stark: structures are easily reproduced, while desirable residential land is not. This supply-side asymmetry between structures and land means that increases in the demand for housing will have very different effects on the prices of these two components, even if there is no change in the relative taste for structures versus land. In particular, the cost of putting up new structures is determined by the productivity of the construction industry relative to other sectors of the economy and the cost of some basic materials. Thus one should not expect changes in demand-side factors such

[2]Our distinction between structures and land is analogous to the tangible versus non-tangible capital distinction in stock market valuation. McGrattan and Prescott (2005) use the discipline of the growth model to estimate the stock of intangible capital in the United States given data on corporate profits and the returns to tangible capital.

as demographics or interest rates to have much impact on the relative price of structures, just as one would not expect such factors to impact the price of cars or any other produced goods.[3] By contrast, because desirable land is largely non-reproducible, changes in the demand for housing will likely have a large effect on the price of land

2.1 Summary of Findings

Between 1975 and 2006, we estimate that land accounts, on average, for 36 percent of the value of the aggregate housing stock. Over the same period, the inflation-adjusted price of residential land nearly quadrupled, while the real price of structures increased cumulatively by only 33 percent. At business cycle frequencies the price of land is more than three times as volatile as the price of structures. Thus both trend growth in house prices and cyclical house price fluctuations are primarily attributable to changes in the price of residential land and not to changes in the price of structures.

As a first step towards a deeper understanding of land-price dynamics we run some simple regressions. We regress house prices, structures prices and land prices on income, interest rates, and other variables thought to be fundamental determinants of house prices. We find strong evidence that land prices are systematically correlated with these variables. However, while the interest rate coefficient in our land price regression is negative and significant, as one might expect, the same coefficient in the house price regression turns out to be close to zero. Our interpretation of this finding is that housing combines both structures and land components whose prices evolve quite differently. Thus studies that correlate composite house prices with supposed fundamentals provide an incomplete picture of how housing markets connect to the broader macroeconomy.

Land's share in home value varies dramatically, both over time and in cross-section. Our land-structures decomposition is a powerful tool that we can use to link this variation in land's share of

[3]Davis and Heathcote (2005) calibrate a multi-sector model in which the price of residential investment (structures) is driven by changes in relative productivity across sectors. This model is very successful in terms of replicating the dynamics of residential investment over the post-war period in the United States.

value to corresponding variation in house price dynamics.

First, land's share in the value of the entire housing stock is much larger than land's share in new homes, where the new-homes ratio is measured as the ratio of raw land purchase costs to home sale prices. This differential in land's share coupled with the fact that land prices have been growing much more rapidly than structures prices can explain why price growth for existing homes has smartly outpaced growth for new homes over the past thirty years.

Second, our findings of dramatic differences between structures and land price dynamics in the aggregate suggests that house price dynamics should be quite different in regions where the value of housing is largely accounted for by the value of land (such as San Francisco and Boston) compared to regions where land's share of house value is relatively small. In particular, changes in demographics, interest rates or the tax treatment of housing might have large effects on house prices in regions where land's share is high, whereas prices should be largely pinned down by construction costs where land is cheap. Thus one might expect regional variation in house price dynamics, even if the demand for land and structures in all regions are driven by a common set of fundamentals.[4] We verify that over both the current land price boom and since 1950, house price gains have typically been largest in regions where house prices (and thus land's share) were relatively high initially, consistent with faster trend growth in land prices than structures prices. Furthermore, regions where house prices are relatively high (indicating higher land values) tend to be the same regions where house prices are more volatile, consistent with our finding that land prices are more volatile than structures prices.

Third, land's share of aggregate home value has been trending upwards since 1950, reflecting growth in land prices at more than twice the rate of per capita income. By mid-year 2006, land accounted for 46 percent of aggregate home value. In the context of our analysis, this suggests that demand side factors impinging on the price of land will continue to play an important role in the

[4]Case and Shiller (2004) point out that income growth rates and interest rate changes, two of the most commonly-cited fundamentals driving house prices, show little cross-regional variation, while there are dramatic regional differences in price dynamics. However, Otrok and Terrones (2005) and Del Negro and Otrok (2005) find evidence of a common factor in the current housing boom.

future evolution of the housing market.

3 Methods and Data

3.1 Method Used to Create the Land Series

We start by defining the nominal market value of residential land at date t, $p_t^l l_t$, as the difference of the market value of the housing stock, $p_t^h h_t$, and the replacement cost of the stock of residential structures, $p_t^s s_t$:

$$p_t^l l_t = p_t^h h_t - p_t^s s_t. \tag{1}$$

In this equation, p_t^h, p_t^s, and p_t^l are quality-adjusted prices per unit of houses, structures and land, and h_t, s_t, and l_t are the corresponding quality-adjusted quantities. Thus we attach the label "land" to anything that makes a house more valuable than the replacement cost, adjusted for depreciation, of the physical structure.

Consider applying the decomposition in equation (1) to a set of houses observed in two successive periods, t and $t+1$. Assuming that houses in the set do not change between dates, so that the quantities of structures and land are constant, one can express the growth rate of house prices as

$$\begin{aligned} \frac{p_{t+1}^h h_t}{p_t^h h_t} &= \frac{p_{t+1}^s s_t + p_{t+1}^l l_t}{p_t^h h_t} = \frac{p_t^s s_t \frac{p_{t+1}^s}{p_t^s} + p_t^l l_t \frac{p_{t+1}^l}{p_t^l}}{p_t^h h_t} \\ &= (1 - w_t^l)\frac{p_{t+1}^s}{p_t^s} + w_t^l \frac{p_{t+1}^l}{p_t^l}, \end{aligned} \tag{2}$$

where w_t^l is the fraction of the market value of the set of houses accounted for by land:

$$w_t^l = \frac{p_t^l l_t}{p_t^h h_t} = 1 - \frac{p_t^s s_t}{p_t^h h_t}. \tag{3}$$

Thus the growth rate of house prices is a simple weighted average of the growth rates of the prices of housing's two components, land and structures, where the time-varying weights are given by the fractions of the value of housing accounted for by the two pieces.

Re-arranging equation 2, the growth rate of the price of land is

$$\frac{p_{t+1}^l}{p_t^l} = \frac{1}{w_t^l}\left[\frac{p_{t+1}^h}{p_t^h} - (1 - w_t^l)\frac{p_{t+1}^s}{p_t^s}\right]. \tag{4}$$

Our goal in this paper is to apply equation (4) to the entire stock of housing in the United States in order to produce an aggregate price index for residential land.

In the first application of the methodology, detailed below, we derive a quarterly price index for land for the period 1975:1-2006:2. For this period, high quality quarterly series are available for two of the variables in equation (4), p_t^h and p_t^s. We develop a new methodology, described in detail below, to construct a quarterly series for land's share, w_t^l.

In the second application, we explore long run trends in land prices for the period 1930-2000. Prior to 1975 there does not exist a continuous high quality index for house prices, but we can still learn about trend growth in land prices by exploiting the connection between land price growth and time variation in land's share of home value, w_t^l. This second application is helpful in determining whether the trends we uncover in the price of land in the 1975-2006 period are historically anomalous, or are a continuation of earlier patterns.

3.2 Quarterly Data, 1975-2006

We now describe the data sources we use to operationalize equation (4) for land price growth. A detailed appendix explaining our data and methods in more detail is available for download at http://www.marginalq.com/morris/landdata.html.

Structure and House Price Indexes

For structures prices, p_t^s, we use the price index for gross investment in new residential structures produced by the Bureau of Economic Analysis (BEA) within the National Income and Product Accounts (NIPA). The NIPA definition of new residential structures includes gross investment in newly-built housing units as well as improvements to existing units. It excludes expenditures on brokers' commissions.

For house prices, p_t^h, we use the the repeat-sales-based index produced by the Office of Federal Housing Enterprise Oversight (OFHEO). The OFHEO index uses data on sales prices or appraisal values for homes with conforming mortgages issued by the Government-Sponsored Enterprises known as Fannie Mae and Freddie Mac. From 1991:1 we use the OFHEO's purchase-only index, which excludes appraisals. From 1975:1 to 1991:1 we use the OFHEO index which includes appraisals associated with mortgage refinancing, since this is the only series available over that period.

The OFHEO price index attempts to hold quality constant by using sales prices of houses that transact multiple times within a period to gauge price growth over the period. By looking at the same houses, the hope is that the structure and land attributes are held constant, and thus that the index identifies changes in house prices rather than changes in quantities, exactly in the spirit of equation (2).

In a recent article, McCarthy and Peach (2004) have argued that the OFHEO price index is biased upwards since it does not explicitly control for improvements in any given housing unit.By similar reasoning, the OFHEO index could be biased downwards because it does not control for depreciation of structures. There is evidence these biases largely offset in aggregate data. The National Income and Product Accounts contain estimates of gross investment in structures that are improvements based on data collected by the Census Bureau. The average annual nominal value of these expenditures as a fraction of our estimate of the market value of housing (land plus structures) was 0.77 percent over the period 1975 to 2006. This is very similar to our estimate of nominal annual depreciation, 0.93 percent of the market value of housing.[5] This evidence supports the OFHEO's implicit assumption that by measuring price growth using repeat sales of the same homes one can effectively hold constant the quality of structures over time.

One may also worry that the OFHEO index under-represents expensive homes, because Freddie Mac and Fannie Mae can only purchase and securitize mortgages that are less than a certain size called the "conforming loan limit." This restriction is potentially problematic if prices of expensive homes exhibit different dynamics than prices of cheaper homes. However, large numbers of expensive home purchases are financed with combinations of conforming loans, secondary liens,

[5]Spending on improvements as a share of home value does not vary much in our sample: it ranges from 0.67 percent (1982:4) to 0.88 percent (1986:3). It is not systematically correlated with the rate of house price growth, and has been slightly below its long run average over the 10 year period to 2006:2, the end of our sample. Thus none of the recent boom in house prices can be attributed to unusually rapid improvements in structure quality. See the appendix for more details.

and cash, and there is little evidence that expensive homes are significantly under-represented. Consider California, the state with the most expensive housing in the nation after Hawaii. The OFHEO reports that in 2002, the median sales price of homes in California financed (at least in part) with a conforming mortgage was approximately $300,700, which was also the conforming loan limit for that year.[6] This is close to the median California-wide sales price in 2002 for existing detached single-family homes, $316,130.[7]

A final concern is whether some of the fluctuations in the OFHEO index reflect measurement error rather than actual changes in house prices. Any measurement error in the growth rate of house prices or structures costs will contaminate our estimate of the growth rate of land prices. To explore this possibility we estimated (via the Kalman filter) a specific model for measurement error incorporating measurement error in the OFHEO house price series that is independently and identically distributed over time, and a random walk process for the growth rate of the true but unobserved real house price index.[8] We found that the dynamics of the land price series derived by applying the accounting system described above to the Kalman-filtered OFHEO house-price index are quantitatively similar to those derived using the unfiltered series, both at business cycle and lower frequencies. For example, the percentage standard deviation of filtered land prices derived assuming no measurement error in house prices is 3.9 compared to 3.7 after removing measurement error from the house price series.[9] We therefore focus on the unfiltered OFHEO index.[10]

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[6]Source: OFHEO Press Release, available at http://www.ofheo.gov/media/pdf/2q05hpi.pdf

[7]Source: California Association of Realtors, available at http://www.car.org/index.php?id=MzMzNzI. The corresponding figure for the United States was $156,200.

[8]This is the state-space representation of the Hodrick-Prescott filter, as documented by King and Rebelo (1993).

[9]Both these statistics refer to the standard deviation of the residuals from applying the Hodrick-Prescott filter to the logged real price series, using a smoothing parameter of 1,600.

[10]More details are in the appendix. In an earlier version of the paper we used the Conforming

Land's Share of Home Value

We now describe how we construct the last input required, which is a series for land's share of home value, w_t^l. First, we use the Bureau of Economic Analysis (BEA's) published series for the replacement cost of residential structures as the basis for our estimate for the value of structures, $p_t^s s_t$. We strip the accumulated value of commissions from existing home sales from this value, which the BEA considers part of residential investment, but which does not increase the stock of structures in place. This correction reduces the BEA's published estimate of the replacement cost of structures by about 8.5 percent. We also use quarterly investment data and a perpetual inventory accounting system to convert the annual BEA stock estimates into a quarterly series.

Second, we create quarterly estimates of the market value of housing, $p_t^h h_t$. We begin by using a benchmark estimate for the market value of housing in 2000:2 derived from micro data in the 2000 Decennial Census of Housing (DCH) and the 2001 Residential Finance Survey (RFS). For owner-occupiers, the owner's self-assessed market value of the housing unit is always reported in the Census of Housing. However, we make an adjustment for houses with assessed values exceeding \$1 million, which are top-coded.[11] For vacant and rental units, for which values are not reported in the DCH, we assign values based on the 2001 RFS, adjusting for house price growth of 7.46 percent between 2000:2 and 2001:2. We find that the total market value of owner-occupied housing units in 2000 was \$10,615 billion, while the total market values of rental and vacant units were, respectively, \$2,491 and \$664 billion.

Third, given the benchmark value for all housing (owned, rented or vacant) in 2000:2, we

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Mortgage House Price Index (CMHPI) produced by Freddie Mac, which starts in 1970. Prior to 1975, when the CMHPI sample is small, growth rates in house prices exhibit significant negative auto-correlation. Estimates from our model for measurement error strengthen our prior that measurement error accounts for a large fraction of house price fluctuations over this period. This is another reason to focus on the OFHEO index, which starts in 1975.

[11] Based on confidential information from the 2001 Survey of Consumer Finances, we assume the market-value of any top-coded unit is \$1.86 million.

construct a quarterly time series for $p_t^h h_t$ using a perpetual inventory system.[12] In this system, we set the nominal market value of housing at $t+1$ as the sum of two components: (i) market value at t revalued to account for price growth between t and $t+1$, and (ii) nominal net new additions to the stock of housing:

$$p_{t+1}^h h_{t+1} = \frac{p_{t+1}^h}{p_t^h} p_t^h h_t + p_{t+1}^h \Delta h_{t+1}. \tag{5}$$

We use the OFHEO house price index to measure growth in house prices, p_{t+1}^h / p_t^h. The value of increments to the housing stock, $p_{t+1}^h \Delta h_{t+1}$ is not reported directly, but can be computed as the sum of net residential investment in structures plus the value of the increment to the stock of residential land associated with the construction of new homes

$$p_{t+1}^h \Delta h_{t+1} = p_{t+1}^s \Delta s_{t+1} + p_{t+1}^l \Delta l_{t+1}. \tag{6}$$

We identify net residential investment, $p_{t+1}^s \Delta s_{t+1}$, with NIPA nominal net investment in residential structures (gross investment less depreciation), excluding commissions. We can infer a value for the increment to the stock of land, $p_{t+1}^l \Delta l_{t+1}$, by inverting the procedure the Census Bureau uses to estimate the value of new residential structures put in place. The Census Bureau does not observe the latter directly, but rather imputes a value given data on the prices at which new homes sell, and an estimate of the fraction of the aggregate value of sales that is attributable to the cost of raw land and other non-structures costs (landscaping, appliances, realtor fees, marketing and financing costs). For homes built for sale the Census Bureau estimates the value of structures put in place to be 84.2 percent of the average sales price, while raw land accounts for 10.6 percent.[13] Thus we assume that additions to residential land account for 10.6/84.2 = 12.6 percent of NIPA

[12] In principle a time-series for the market value of the housing stock is contained in the Flow of Funds Accounts (FFA) published by the Federal Reserve Board. We do not use the FFA because the data sources used to derive aggregate home value in the FFA change from time to time, and at the dates of these changes the capital gains implicit in the FFA value series are not always consistent with the OFHEO index. The FFA estimates are currently under review in light of this problem. See the appendix for more details.

[13] The Census Bureau estimates are based on an unpublished study in 1999 that is summarized in a

gross investment in new residential structures. Since these percentages are actually used to estimate NIPA residential investment given basic data from the Census Bureau on the sales prices of new homes, this procedure should deliver reliable estimates for increments to the nominal value of the housing stock. Formally, in assuming that land accounts for a constant fraction of the value of new home sales, the Census Bureau is implicitly assuming a unitary elasticity of substitution between structures and land in the production of new homes. This assumption is consistent with Thorsnes (1997).

To summarize the procedure used to compute w_t^l, we first construct a quarterly time series for $p_t^s s_t$, and then apply equations (5) and (6) to construct a quarterly series for $p_t^h h_t$ that is benchmarked to our estimate of $13.9 trillion for the value of the housing stock in 2000:2. Combining (5) and (6) and substituting in the expression for house price growth from equation (2) gives

$$\begin{aligned} p_{t+1}^h h_{t+1} &= \frac{p_{t+1}^h}{p_t^h} p_t^h h_t + p_{t+1}^s \Delta s_{t+1} + p_{t+1}^l \Delta l_{t+1} \\ &= \left((1 - w_t^l) \frac{p_{t+1}^s}{p_t^s} + w_t^l \frac{p_{t+1}^l}{p_t^l} \right) p_t^h h_t + p_{t+1}^s \Delta s_{t+1} + p_{t+1}^l \Delta l_{t+1} \\ &= p_{t+1}^s s_{t+1} + p_{t+1}^l s_{t+1}. \end{aligned}$$

Thus equations (5) and (6) are consistent in the sense that they preserve across time the decomposition defined in equation (1) of home value into structures and land components.

We now compare the predicted values for aggregate home value in 1980 and 1990, calculated using the system described above and benchmarked exclusively to the year 2000, to independent estimates derived from micro data collected within the 1980 and 1990 Decennial Censuses of Housing, and the 1981 and 1991 Residential Finance Surveys. These estimates are reported in Table 1, and are discussed in more detail in the next section. In 1990 we under-predict market value relative to the micro-data-based estimates by 2.4 percent. In 1980 we over-predict market value by 7.0 percent. We view a 7 percent discrepancy over a twenty-year period as broadly vindicating the quality of our data and methodology.

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memorandum from Dennis Duke to Paul Hsen entitled, "Summary of the One-Family Construction Cost Study" dated August 1, 2000.

3.3 Annual Data, 1930-2000

The NIPA price index for new residential structures p_t^s is available on an annual basis going back to 1929, but a consistent constant-quality time series for the price of housing p_t^h does not exist prior to 1975.[14] Thus to gauge earlier trends in land prices we follow a slightly different approach.

We first use evidence from the Decennial Census of Housing (DCH), the Residential Finance Survey (RFS), and other sources on the values of owned and rented units to construct estimates for the aggregate value of the housing stock $p_t^h h_t$ at ten year intervals between 1930 and 2000.[15] When combined with data from the BEA on the replacement cost of structures, $p_t^s s_t$, estimates of land's share of value w_t^l in ten year intervals from 1930-2000 are also produced. These estimates of $p_t^s s_t$, $p_t^h h_t$, and w_t^l are displayed in Table 1. We use these estimates, in conjunction with equations (5)

[14]Shiller (2005) has made an impressive attempt to construct such a series by splicing together several existing series that cover various sub-periods, and filling in a gap between 1934 and 1953 using a five city average of median city-level home prices computed from newspaper advertisements. Between 1953 and 1975 Shiller uses the home purchase component of the U.S. Consumer Price Index (CPI). Shiller cites a paper by Greenlees (1982) who finds significant downward bias in this series. In section 4.7 we provide evidence that suggests growth in Shiller's series is biased downwards in the 1970s by around two percentage points per year.

[15]The appendix describes in fine detail precisely how the housing stock estimate was computed for each year ending in zero. In particular we describe the details of how we deal with top-coded home values in the DCH, non-synchronicity between the DCH owner-occupied data (years ending in zero) and RFS renter and vacant data (years ending in one), and occasional missing values for particular properties in the DCH micro data. We also discuss the assumptions we make when no micro data for certain types of housing are available. In particular, there are no IPUMS details for (1) all 2+ owner-occupied units in 1970, (2) the number and value of vacant units in 1930, 1940 and 1960, (3) owner-occupied house values in 1950, (4) rents or values for rented units in 1950, and (5) values for rented units in 1930 and 1940 (though micro data on rent paid is available for these years).

and (2) to estimate trend changes in house and land price growth, given a time series for nominal net additions to the housing stock.

In particular, let $\widehat{p}_t^h$ denote the real price of housing at date t, defined as the nominal price index for housing p_t^h divided by a consumer price index, p_t^c. Equation (5) can be rewritten as

$$p_{t+1}^h h_{t+1} = \frac{\widehat{p}_{t+1}^h}{\widehat{p}_t^h} \frac{p_{t+1}^c}{p_t^c} p_t^h h_t + p_{t+1}^h \Delta h_{t+1}. \tag{7}$$

An annual series for additions to the housing stock $p_{t+1}^h \Delta h_{t+1}$ beginning in 1930 can be constructed using the same methods as for the 1975-2006 quarterly data. The value of the housing stock $p_t^h h_t$ at Census dates must be consistent with iterating the perpetual inventory equation (7) forward through time. We use the discipline of this consistency requirement to gauge trends in the real house price $\widehat{p}_t^h$. In particular, we assume that the true series for $\widehat{p}_t^h$ can be well approximated in between Census dates by a cubic spline.[16] The coefficients for this spline are uniquely determined by the requirement that the implied series for nominal home value passes through the Census values for 1930 and each Census year between 1950 and 2000.[17]

This produces (a) an annual time series for house prices $p_t^h = \widehat{p}_t^h p_t^c$ and (b) annual series for the market value of housing $p_t^h h_t$ and (given $p_t^s s_t$) land's share w_t^l. With these series in hand, we can use equation (4) to compute an annual series for land prices, p_t^l.

Any trends in land's share identified by this methodology will be suspect if there is systematic bias in either the growth rate of structures values (according to the BEA) or in the growth rate of home value (according to our Census-based estimates). There are no obvious reasons to suspect systematic bias in our series for home value. Moreover, this series is broadly consistent with other

[16] We also experimented with assuming the the true price series is piecewise linear between Census dates. The implied average annualized growth rates between Census dates are different in this case, but the differences are extremely small.

[17] In particular, we assume that $\widehat{p}_t^h$ is piecewise cubic between Census dates, and continuous up to the second derivative across Census dates. We impose the not-a-knot endpoint conditions. These restrictions, plus the requirement that the nominal series generated by equation (7) pass through the Census values of Table 1 are sufficient to determine a unique sequence for $\widehat{p}_t^h$.

independently-derived estimates.[18] One important caveat is that the Census-based estimate for 1940 is almost certainly too low. There is widespread consensus that owner estimates of home value in the 1940 DCH were biased downwards in the wake of the Great Depression (see, for example, Grebler, Blank and Winnick, 1956).[19]

The BEA series for the replacement cost of structures is constructed using a perpetual inventory system according to which the existing stock of structures is augmented by new investment and diminished by depreciation. The BEA assumes depreciation rates have remained constant over the entire sample period, an assumption which will bias the measured growth rate of the structures stock if there is really a trend in the average depreciation rate.[20] This concern provides a motivation to compare our land's share estimates to a variety of estimates in the literature based on alternative methodologies.

The Federal Housing Administration (FHA) has collected annual data on the home and site

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[18]Estimates for the $1930-1950$ period may be compared to those in Grebler, Blank and Winnick (1956, Table D-3). In the appendix we note that our estimates are similar to the ones they report, and discuss the source of specific differences. From 1950 onwards, we can compare our estimates to those reported by the Federal Reserve Board with the Flow of Funds Accounts (FFA). Once again differences are generally quite small. The largest discrepancy is between 1970 and 1980, over which period our nominal value series increases by a factor of 3.7, while the FFA series increases by a factor of 3.2 (see Table 1 in the appendix).

[19] One compelling piece of evidence in this direction is that the average self-reported value for owner-occupied housing in the 1940 DCH was $\$3,472$, while the average value for existing single-family homes assessed by the Federal Housing Administration (FHA) was much larger at $\$5,170$. By contrast, the average value of existing FHA homes was less than the average DCH value in 1950 and subsequent Census years.

[20]One reason to entertain such a possibility is that this period was characterized by a switch from renting to owning as the dominant form of housing tenure, and there is some evidence that owner-occupied homes depreciate more slowly than rental housing.

value of the properties for which it issues mortgages. This data provides consistently-produced estimates for land's share of home value over the period 1935 to 1979. The FHA evidence suggests that land's share remained relatively low between the Depression and the early 1950s, a conclusion consistent with Winnick (1953) who argued for a downward trend in land's share between 1890 and 1953.[21] In 1950, 1960 and 1970 our Census-based estimates for the value of the entire housing stock are remarkably similar to the FHA estimates for existing single-family homes: 0.104 and 0.124 in 1950, 0.180 and 0.177 in 1960, and 0.199 and 0.216 in 1970.

Manvel (1968) produced a widely-cited estimate of land's share using a special Census tabulation with separate land and improvement estimates for individual pieces of taxable realty in 12 large assessing areas. Manvel's resulting estimate for the aggregate share of land in non-farm residential real estate was 0.259 for 1966, slightly higher than our estimates for 1960 and 1970.

We are not aware of more recent attempts to estimate land's share. However, for a subset of U.S. states and for certain years, there is information on land's share in all taxable realty in the Taxable Property Values volume of the Census of Governments. We focus on the 1982 and 1992 Censuses (containing information for 1981 and 1991) since this is the period over which the estimates in Table 1 indicate the largest increase in land's share. This data is not ideal for our purposes because residential realty is not separated from other types of taxable realty. However, there is large cross-state variation in the ratio of the gross assessed value of residential property relative to the gross assessed value of all property, and the states which are especially reliant on non-farm residential realty for local tax revenue typically exhibit an increase in land's share of market value between 1981 and 1991. For example, comparing the 15 states for which land shares

[21]Early estimates from Kuznets (1946) and Keller (1939) suggest a land's share in excess of 0.5 over the period 1880 to 1922, though their estimates apply to a broader class of real estate than simply residential property. Winnick (1953) also argued that land's share was high in this period, providing evidence for a range of different cities. Goldsmith (1955), by contrast, assumed a land's share of 0.2 for 1-4 unit structures for the period 1900 to 1939, following Wickens (1941). Land's share declined dramatically during the Great Depression, as documented in great detail by Hoyt (1933) for the city of Chicago.

are reported in both 1981 and 1991, New Jersey had the highest share of residential real estate in total taxable property in 1981 (69.9%) and also exhibited a large increase in land's share between 1981 and 1991, from 0.325 to 0.397. Thus the Census of Governments evidence is consistent with our finding of an increase in land's share of residential real estate during the 1980s.[22]

We conclude that, with the exception of 1940, the housing value and land share estimates reported in Table 1 are consistent with the available independent evidence. Thus we can safely characterize trends in house and land prices over the entire 1930-2000 period, even though we cannot accurately estimate quarter-to-quarter or year-to-year changes prior to 1975.

4 Characterizing Land Prices

We now explore the series for land price and quantities derived from the methodology outlined above. We begin in section 4.1 by characterizing broad trends in house, land and structures prices over the 1975 to 2006 period, the period over which high quality quarterly house price data is available. In section 4.2 we use the land-structures decomposition to interpret differences between prices for new versus existing homes. Then in section 4.3 we explore the cyclical properties of land prices. In section 4.4 we explore the relationship of house, land and structures prices to various fundamentals that may help explain price dynamics. In section 4.5 we compare our series for the price of residential land to an existing price series for farmland. Section 4.6 explores whether key properties of the aggregate data also apply at the regional (MSA) level, and offers some insight into variation in house price growth across cities during the recent housing boom. Finally, section 4.7 extends our basic methodology to cover the entire 1930 to 2000 period, and discusses trends since 1975 in a broader historical context.

[22]Interestingly, however, land's share in all taxable realty was stable over this period. In part this reflects the fact that farm land prices were declining sharply (see Figure 4). Thus, North Dakota, the state least reliant on residential property and most reliant on farm acreage in 1981, saw a decline in land's share over the same period from 0.617 to 0.546.

4.1 Trends in the Price and Quantity of Land

The approach outlined above delivers a current dollar price index for residential land.[23] In the data analysis that follows, we deflate this nominal series using the BEA price index for core personal consumption expenditure.[24] Figures 1, 2 and 3 show our resulting price and quantity series for residential land, as well as our estimates of land's share of home value. From these figures, we draw four main conclusions about the evolution of the price and quantity of residential land in the United States.

First, the price of land and the price of structures are, by and large, unrelated. In Figure 1 we plot real price indexes for residential land, existing homes, and the replacement cost of structures. Real land prices have increased by a factor of 3.7 from 1975 to mid-2006, while real home and structures prices have increased by 96 percent and 33 percent respectively. In addition to having different trend growth rates, land and structures prices also exhibit different patterns within the sample. Between 1979 and 1982, the real price of land declined by 24 percent, whereas real replacement costs increased by 1 percent. By contrast, from 1983 through the end of 1995, land prices rose by 44 percent (mostly between 1983 and 1989), while structures prices fell by 7.5 percent. From 1996 to mid-2006 (the end of our sample), real house prices increased by 70 percent, while

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[23] All of our data and a detailed appendix are available for download at http://www.marginalq.com/morris/landdata.html. On this site we report current dollar price indexes for houses, land and structures, as well as series for the nominal values of the stocks of houses, land and structures. Note that the values and percentages reported in this section are different from those of earlier versions of this paper. In the Federal Reserve working paper of July 2004, we report the value of residential land under 1-4 unit structures. In this paper we report the value of residential land under all structures, including structures in 1-4 unit buildings and 5+ buildings.

[24] This price index is available in NIPA table 2.3.4, "Price Indexes for Personal Consumption Expenditures by Major Type of Product," line 23. Users of our data may of course deflate our nominal price series using their favorite index for the general price level.

replacement costs increased by only 29 percent. Thus, rising land prices account for most of this house-price boom; the cumulative appreciation in the real price of land implied by our methodology is almost 160 percent.

Second, the value of land has increased faster than the value of structures, and thus land has become an increasingly important component of aggregate wealth. Averaging over our sample period, residential land accounts for 36 percent of the value of the housing stock. There is evidence of an upward long-run trend in the share of the market value of housing accounted for by land (see Figure 2) and since the mid 1990s the value of land has been rising quickly. By the second quarter of 2006, residential land was valued at $11.6 trillion, accounting for 46 percent of the value of the housing stock and 88 percent of GDP, records for our sample.

Third, the real stock of land has increased quite slowly, and changes to the quantity of the real stock of housing have been accomplished primarily through the addition of structures. The average annual growth rate of the real housing stock is 1.80 percent per year, compared to a 1.57 percent growth rate in the number of households.[25] The constant-quality stock of residential land has grown at a pretty stable annualized rate of 0.67 percent since the first quarter of 1975 (see Figure 3).[26] The growth rate of the real stock of residential structures is much faster, 2.41 percent per year on average, but also more volatile.

Fourth, Figure 3 indicates that growth in the real stocks of land, structures and housing during the boom that began in the mid 1990s was comparable to growth in the rest of the post 1975 period. We conclude that increased demand must play an important role in accounting for the run-up in prices over this period.

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[25]The household-size data are from Table HH-4, "Households by Size: 1960 to Present," of the Current Population Survey (CPS) Reports, and are available at http://www.census.gov/population/www/socdemo/hh-fam.html.

[26]The fact that the real quantity of residential land has risen so slowly and smoothly over time means that fluctuations in the value of the stock of land are almost entirely attributable to fluctuations in land prices.

4.2 New versus Existing Homes

The land data also allows us to better understand intrinsic differences in the price dynamics of new versus existing homes. Our analysis of land's share of home value provides evidence that typical newly-built homes and existing homes (on average) are quite different goods. First, while land now accounts for almost half of the value of the existing aggregate housing stock, the cost of purchasing raw land for newly-built houses is only around 11 percent of these houses' market value. Put differently, our estimates suggest that in 2006 home-buyers are paying about 40 percent more on average for existing homes relative to newly-built structures of similar size and quality. The implication is that a large fraction of the market value of land under existing houses reflects the value placed by home-buyers on these older homes' locations, and that the locations of newly-built houses, on average, are considered much less desirable.

Because existing and new homes comprise different mixes of land and structure there is no compelling reason to expect that they should exhibit similar price dynamics. Since land's share is small in new homes, we should expect their price to be largely determined by construction costs. In the market for new homes, a surge in housing demand will likely translate into new construction rather than rising prices. Existing homes in desirable locations, by contrast, have a large land component, which reflects a scarce supply of desirable locations. Since desirable locations cannot easily be reproduced, in the market for existing homes an increase in demand will likely translate into higher land and house prices.[27]

The National Income and Product Accounts (NIPA) price index for the replacement cost of structures is derived from the Census price index for new one-family houses under construction. Thus differences in trend price growth between new and existing homes can be gauged by comparing

[27]In reality, of course, the housing stock cannot be cleanly divided into two types of housing, new and old. Rather the fraction of home value attributable to land varies widely. Our point is simply that on average newer and older homes represent different bundles of land and structures that are not perfect substitutes on the demand side and that exhibit different price elasticities on the supply side.

the price indexes for structures and houses in Figure 1. The fact that these two series exhibit quite different dynamics indicates that on average home buyers view new homes as rather poor substitutes for existing homes: home buyers have been willing to pay ever larger amounts to enjoy the non-structure attributes of existing homes rather than substitute towards relatively cheaper but structure-intensive new homes.

4.3 The Cyclical Nature of Price Dynamics

Table 2 documents some statistical properties of our price index for residential land at business-cycle frequencies. First, note that land prices are volatile: The real price series for land is 2.8 times as volatile as real GDP, 2.2 times as volatile as real home prices, and 3.3 times as volatile as real structures prices. This last finding, coupled with the fact that on average in our sample land accounts for 36 percent of the total value of housing stock, suggests that fluctuations in house prices are primarily attributable to fluctuations in land prices rather than fluctuations in structures prices. Indeed, the contemporaneous correlation between detrended real land and home prices is 0.92, while the correlation between land and structures prices is only 0.47. Interestingly, Table 2 documents that investment in residential structures leads the price of residential land. This suggests that changes to the demand for housing, which should show up immediately in land prices, may not be the primary factor driving changes in residential investment.

4.4 Prices and Fundamentals

There is a large literature that attempts to use regression analysis to link house prices to variables thought to be fundamental determinants of house prices: see Mankiw and Weil (1989), Poterba (1991), Malpezzi (1999), Gallin (2003), and Case and Shiller (2004) for five examples. The fundamentals in these papers include per-capita income, interest rates, population, and, in the case of Mankiw and Weil (1989), demographic variables.

We now explore whether our land price series can shed light on the nature of the empirical relationship between house prices and these other variables. Our innovation is to run three sets of regressions for three different dependent variables: house prices, structures prices, and land prices.

Using a cointegration framework we first regress the real log price (separately for houses, structures and land) on a small set of fundamentals: log real per-capita personal disposable income, the nominal 3-month T-Bill rate, and the inflation rate. These are the variables typically included in the literature. We then consider a second specification with a larger set of fundamentals that include log population, the percent of the population aged 35-54, and the spread of the 30-year fixed rate mortgage over the 3-month T-Bill rate. We include the second demographic variable to capture the fraction of the population at the stage of the life-cycle where housing demand peaks, in the spirit of Mankiw and Weil. The term spread variable is included in light of the traditional role of the 30-year fixed rate loan in U.S. mortgage markets. The point of this exercise is not to test a specific model of the housing market, but rather to show that failing to strip out the structures component of housing when regressing house prices on fundamentals can lead to misleading inference. The coefficient estimates and corrected standard errors from this exercise are reported in Table 3.

Consider first the land price regressions in the rows (3) and (6) of the table. In both specifications, we find that real land prices are (i) increasing in real per-capita income, (ii) decreasing in nominal interest rates, and (iii) increasing in inflation. Our estimates are significant and large in economic terms. Focusing on the estimates from row (3), a one percent increase in real per-capita income is associated with an increase in the real price of land of 2.6 percent; a one percentage point increase in the 3-month T-bill is associated with a 3.9 percent decrease in the real price of land; and, a one percentage point increase in the inflation rate is associated with a 12.4 percent increase in the real price of land. A comparison of the rows (3) and (6) indicates that the sign, magnitude and significance of these estimates are largely insensitive to the inclusion of additional variables. The results in row (6) indicate that neither changes in the aggregate population nor the percentage of the population aged 35-54 significantly impact land prices, while a one percentage point increase in the spread of the thirty-year fixed rate mortgage over the 3-month Treasury depresses real land prices by 2.6 percent. These findings are broadly consistent with our prior that land prices should be strongly influenced by the factors traditionally associated with housing demand.

In contrast to the land price regression, the structures price regressions in rows (2) and (5) indicate little evidence of a statistically sound relationship between real structures prices on the one hand and real per-capita income, nominal interest rates, or inflation on the other.[28] This is consistent with our prior that real structures prices, like the prices of any produced goods, should be largely driven by supply-side factors, such as productivity in the construction sector relative to the rest of the economy.

Now focus on rows (1) and (4) of Table 3, the house price regressions. Recall that house prices are a weighted average of land prices and structures costs. In each case, the coefficients on variables in the house-price regressions appear to be a weighted average of the coefficients from the structures regression and the land regression. For example, the near-zero coefficient estimate on interest rates in the house price regression is a mix of the insignificant positive estimate from the structures price regressions (rows 2 and 5) and the significant negative estimate from the land price regressions (rows 3 and 6). However, since the connection between fundamentals and structures prices is not grounded in theory, and appears statistically questionable in practice, one should be cautious in interpreting the near-zero interest rate coefficient in the house price regression as evidence that nominal interest rates do not impact house prices. Rather we conclude that it is difficult to properly assess the impact of fundamentals like income, interest rates, and inflation on the housing market if one fails to disentangle their impact on land and structures prices separately.

4.5 Farm Land versus Residential Land

Figure 4 compares our land-price series to the price-per-acre of farm land for the aggregate United States.[29] This is the only other published aggregate price series for land in the United States of

[28]We performed the Augmented Dickey-Fuller and Phillips-Perron tests for a unit root on the residuals from all six regressions. The hypothesis of a unit root is rejected in all cases but one: the Augmented Dickey-Fuller test for the residual of the structures regression in row (2). This suggests that the structures regression may be mis-specified.

[29]The annual farm price-per-acre series is available from the United States Department of Agriculture web site, http://www.ers.usda.gov/Briefing/LandUse/aglandvaluechapter.htm. We linearly interpolate the annual data to generate a quarterly price-per-acre series.

which we are aware. First, we note that the market value of residential land dwarfs the value of farmland. In 2002 there were 938.3 million acres of farmland in the United States (2002 Census of Agriculture, USDA). The average price per acre was $1,210 for a total farmland value of $1,135 billion. Our estimate for the value of residential land in 2002:2 is more than five times larger, $6,550 billion.[30]

Second, Figure 4 indicates that farm land prices and our measure of the price of residential land have little in common. One might expect to see a connection between farm prices and residential land prices, especially at the urban-rural fringe where agriculture and residential development are competing for land. Recall, however, that fluctuations in aggregate residential land value primarily reflect changes to the value of land under existing homes, both because the quantity of new development is small relative to the existing stock of housing, and because land accounts for a smaller fraction of the price of new homes. We conclude that at the aggregate level, farm land and residential land are essentially different goods, whose prices are determined by different factors.

There is, however, evidence that demand for housing is an important determinant of farm land prices. In particular, farm land prices tend to be highest in regions where future non-agricultural development is most likely. In January 2006, the average price per acre of farmland exceeded $10,000 in five states: Connecticut, Delaware, Massachusetts, New Jersey, and Rhode Island.[31] These same states are also at the top of the rankings for house prices: According to data from the 2000 Census, among the 48 states for which farmland price data is available, average prices for

[30] There is little data on the value of corporate land. Following IRS estimates, McGrattan and Prescott (2005) assume an average value for corporate land relative to GDP of 3.3 percent between 1990 and 1999. Our corresponding value for residential land is 48.5 percent. If these numbers are both correct, the fraction of market value accounted for by land in non-residential real estate is much lower than in housing. Further research on the value of corporate land is needed.

[31] Source: "Land Values and Cash Rents: 2006 Summary" August 2006, available at http://usda.mannlib.cornell.edu/usda/current/AgriLandVa/AgriLandVa-08-04-2006.txt. The average price per acre of farmland in the lower 48 US states in 2006 was $1,900, while the average for the Northeast region was $4,550.

single-family homes in Massachusetts, New Jersey and Connecticut exceed all other states except California.

4.6 Regional House Price Dynamics

To this point we have shown that existing houses have a large non-structure component, and that the price of this component (i) evolves largely independently of the price of structures, (ii) accounts for most of the volatility in house prices, and (iii) is systematically related to fundamentals. We will show that there are big differences in land's share of home value across regions. Thus it is natural to ask whether the key features of aggregate data also apply to prices at the regional Metropolitan Statistical Area (MSA) level. In particular, if regional land prices have a strong common component, reflecting the impact of economy-wide shocks such as changes to interest rates, then we should anticipate two patterns in cross-regional data. First, regions in which land's share of home value is relatively high should exhibit more dramatic house price appreciation in periods when aggregate land prices are rising faster than construction costs. Second, the volatility of house prices at the regional level should also be increasing in the region's land share, since land prices are more volatile than structures costs.

Table 4 contains MSA-level statistics that we use to test these predictions. In column (1), we list the average price of a single-family owner-occupied detached house for various MSAs in 1998, sorted from most expensive to least expensive. These average house prices were calculated using micro data from the 1996 and 1998 Metropolitan American Housing Surveys (AHS-M).[32]

[32]The cities listed in this table are the complete set of MSAs sampled in the AHS-M in either 1996 or 1998. For the 1998 sample, the listed average house prices are calculated directly from the AHS-M micro data. For cities in the 1996 sample, we calculate a 1998 estimate by multiplying our estimated average value from the 1996 AHS-M micro data by growth in the city-specific OFHEO from 1996 to 1998. In both years, the AHS-M top codes the top 3 percent of reported house values in each city; we correct for the top code by multiplying each top coded value by 1.5. Our work with the 2000 Decennial Census of Housing and proprietary 2001 Survey of Consumer Finances data leads us to believe that this is an accurate adjustment.

Column (2) reports direct evidence of land's share of house value for these MSAs from a recent paper by Davis and Palumbo (2006).[33] The simple correlation of the values listed in columns (1) and (2) is 0.89.[34] This implies that regional differences in the replacement cost of structures are small relative to regional differences in land prices, and thus that differences in house prices are primarily attributable to regional differences land's share of home value. Column (3) of Table 4 lists the cumulative nominal percentage growth to house prices from as measured by the MSA-specific OFHEO index. Finally, column (4) lists the standard deviation of quarterly percent growth (at a quarterly rate) in the MSA-specific OFHEO index from 1990:2 to 2006:2.[35]

Casual inspection suggests that the MSAs with the highest home values and the highest land shares experienced both the fastest house price appreciation and highest price volatility. This is consistent with our estimates of relative appreciation and relative volatility for land prices versus structures costs in the aggregate United States. The top-five MSAs in this table, ranked by average house value in 1998, averaged 154 percent cumulative growth in nominal house prices over the 8 year period 1998:2 to 2006:2, and a standard deviation of quarterly price growth (quarterly rate) over the 1990:2 to 2006:2 period of 2.2 percent. The corresponding figures for the bottom five MSAs are 46 percent and 0.7 percent. For all the MSAs in Table 4, the Spearman rank-correlation

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[33]Davis and Palumbo (2006) combine MSA-level data on house prices and construction costs to produce quarterly time-series data on house prices, land prices, and land shares for 46 cities from 1984 to 2004. Davis and Palumbo expand on the insights of this paper and more systematically compare the level and growth of land prices across major MSAs. See Gyourko and Saiz (2004) for more evidence on regional variation in construction costs.

[34]The Spearman rank-correlation coefficient for columns (1) and (2) is 0.87 and is statistically significant.

[35]We chose 1998 as a starting point for looking at growth since it is the approximate starting point of the most recent boom and it corresponds to an AHS-M interview year. Standard deviations are calculated going back to 1990 so that the 1998 rankings of house values reflect the middle of the sample period, 1990-2006.

coefficients between 1998 price levels and subsequent appreciation, and between price levels and price volatility, are, respectively, 0.65 and 0.70. Formal testing of the Spearman rank-correlation coefficients allows us to reject the hypotheses that the rank of the MSA-level average house price in 1998 is (i) uncorrelated with the rank of the subsequent growth in home prices and (ii) uncorrelated with the rank of the standard deviation of quarterly growth in home prices.

To investigate the extent to which these results are consistent with longer-run trends, and not simply a quirk of the most recent housing boom, we selected the MSAs for which house price data is available in either the 1979 or the 1980 Metropolitan Annual Housing Surveys (the predecessor to the American Housing Survey) and correlate average house prices in the second quarter of 1980 with cumulative house price growth between 1980 and 2005.[36] The associated Spearman rank-correlation coefficient is positive (0.60) and statistically significant, as expected.

4.7 Historical Evidence

The analysis up to this point covers the period 1975 to 2006. We now provide an historical context to the trends that are discernible over this period, following the extension of our basic methodology outlined in Section 3.3. We address two specific questions. First, does the upward trend in land's share of aggregate home value apparent in the past thirty years have an earlier origin, suggesting a secular upward trend for the importance of land? Second, is the boom in house and land prices in the past decade anomalous as Shiller (2005) and others have argued, or can we identify previous periods of comparable appreciation?

To address the first question, we return to Table 1, which reports aggregate estimates for the values of housing and residential structures and the implied values for land's share over the period $1930 - 2000$. There is a general upward trend in land's share over the last half century, with rapid growth between 1970 and 1990 when land's share doubled from 20 to 40 percent of aggregate home value. Relative to the increase over this period, the increase in land's share from 34 to 46 percent between 1996 and 2006 documented in section 4.1 is not especially large. The longer perspective offered here suggests that economic forces in the direction of mean-reversion in land's share are

[36]Note this is not the same set of cities reported in Table 4.

weak. Thus demand-side factors that impact the price of land are likely to continue to play a major role in house price dynamics.

To address the second question, Table 5 reports our estimates of the annualized growth rates for real structures costs, land prices, and house prices for each decade since 1930. In all decades since 1950, our estimates suggest that the real price of land has increased. There are two periods of rapid growth in house prices: the 1970s and, according to our quarterly data, the more recent boom beginning in the mid 1990s. Land prices grew rapidly in both of these housing booms. In addition, however, real land prices also grew at rapid rates - in excess of 5 percent per year - during the 1950s and the 1980s, even though these were not periods of notable house price appreciation. Conversely, between 1930 and 1950 there was a significant cumulative increase of 41 percent in the real price of housing notwithstanding a cumulative decline of 49 percent in the real price of land.

Comparisons to Other Series

In the rest of this section, we compare our decade-by-decade estimates of real house price growth to two alternative real price series. The first is Shiller's (2005) constant-quality series for house prices, column (4) of Table 5. The second, in column (5), is the average value for owner-occupied housing units, adjusted for consumer price inflation.[37]

In columns (6) and (7), we report two sets of estimates for decade-by-decade changes in the quality of the housing stock. These are computed as the growth rate of the average value of owner occupied homes (column 5) less either our estimate of growth in constant quality house prices (column 3) or the growth in Shiller's series (column 4). According to our house price data, in all decades except the $1930-1950$ period, quality gains to housing were positive but modest - less than one percentage point per year. Over the $1930-1950$ period, housing quality on average was deteriorating by about one percentage point per year. A decline in quality over this period is consistent with evidence from Grebler, Blank and Winnick (1956) who report a large decline in the average inflation-adjusted value of dwelling units (excluding land). One factor they emphasize

[37]Shiller kindly provided his source data, so we were able to apply the same CPI deflator (consumer price inflation less food and energy prices) as for the other series in this table. We derived the average value for owner-occupied units from the Decennial Censuses of Housing IPUMS files.

in accounting for this decline is the large number of conversions of existing structures during the Great Depression and the War and post-War housing shortages: They report 3.1 million additional housing units created by sub-dividing existing structures between 1930 and 1950, compared to 8.0 million additional units from new construction.[38]

Our estimates for the real growth rate of constant-quality house prices are very similar to Shiller's prior to 1960. After 1960, our series increases at a much faster rate, especially during the 1970s when our calculations suggest prices were growing at 4.3 percent per year, while Shiller's series suggests only a 1.8 percent growth rate. Shiller's series implies that the quality of existing homes was increasing at 2.9 percent per year over this period (to account for the 4.7 percent growth rate in average home prices), while our series implies much more modest quality growth of only 0.3 percent per year, a rate that is more in line with earlier and later decades. If house price growth was really as anemic as Shiller's series suggests, then mechanically equation (7) implies that either (i) the nominal value of housing in previous decades was much higher than our Census-based estimates suggest, or (ii) the cumulative increments to the value of the housing stock over the years have been much larger than is suggested by NIPA data on residential investment.[39] We see no evidence to suggest that either possibility is quantitatively relevant. The more likely scenario is simply that Shiller's series underestimates true house price growth, especially during the 1970s.

The differences between our price series and Shiller's are important because they lead to different views of the recent run-up in house prices. Shiller (2005) concludes (p. 2) that the recent experience is "unique in history." By contrast, our price series indicate that the house price boom the began in the mid-1990s is broadly comparable to an earlier boom in the 1970s.

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[38]See Tables 15, 21 and A-1 of Grebler, Blank and Winnick (1956).

[39]For example, if Shiller's series for p^h_{t+1} and our series for increments to the housing stock $p^h_{t+1}\Delta h_{t+1}$ are both taken seriously, then equation (7) implies that the nominal value of the housing stock in 1950 was 3 times as large as annual GDP, while the 1950 Decennial Census of Housing suggests a ratio of 1.

5 Conclusions

In this paper, we have derived an internally consistent accounting and measurement system to estimate price and quantity indexes for residential land, the first such indexes of their kind for the United States. We showed that the price of land is (i) volatile, (ii) has increased enormously in real terms over the past half century, (iii) evolves largely independently of the cost of residential structures, and (iv) accounts for the lion's share of house price fluctuations at low and business cycle frequencies. We then used our new land price and quantity series to shed light on various issues, including differences in price dynamics for new and existing homes and regional variation in house price dynamics. We also showed that "fundamentals" such as per-capita income and interest rates systematically correlate with house prices only through their connection to the price of residential land.

Recently there has been a resurgence of interest in the interaction between housing and financial markets (see, for example, Davis and Martin, 2006, Lustig and van Nieuwerburgh, 2006, or Piazzesi, Schneider and Tuzel, 2006). Our finding that house price fluctuations are primarily driven by changes in the price of land suggests that land price dynamics play a key role in connecting housing to issues of risk-sharing, portfolio choice, or asset pricing puzzles. For example, the regional results we report suggest that in cities where homes are expensive (reflecting pricier land), house prices have historically been more volatile, but have also appreciated more rapidly on average. To the extent that individuals cannot diversify their housing portfolio, this gives an incentive to people in high price areas to buy more low-risk bonds and fewer risky stocks. Further, over time, as land's share of home value has increased, housing in the aggregate may have become a riskier financial asset.

Throughout the paper we have remained largely agnostic about precisely what are the key non-structure attributes of housing that account for the large share of land in aggregate home value. Clearly, land is something that home-buyers are willing to pay handsomely for, and that developers cannot cheaply incorporate in new homes. This scarcity requirement suggests that attributes such as good local schools, low crime, or a pleasant climate are by themselves insufficient to generate high long-term land values, because as long as developers can keep building new homes in low-crime, good-school, sunny-weather neighborhoods, house prices will not rise far above construction costs. There are two ways scarcity can arise. First, land-use restrictions may prevent developers from building enough new homes to align prices with construction costs.[40] Second, scarcity can arise naturally. Suppose that part of the iconic middle-class lifestyle to which many Americans aspire is to own a detached house with a yard for the children and a short commute to work. In many cities developers cannot increase the supply of these homes for the simple reason that all the relatively central land has already been developed; Rossi-Hansberg and Wright (2005) expand on this insight in their model of urban development. In this paper we have documented stable growth over time in the US housing stock, suggesting a role for demand factors in the recent boom in house and land prices, but more work is required to properly assess the impact of supply-side regulation.

Although the goal of this paper is primarily to organize facts rather than to explain them, we have in mind a simple story than can perhaps account both for the decline in land prices between 1930 and 1950 and the upward trend since then. The interpretation of the decline is not new. As the cost of automobiles fell over the first half of the twentieth century car ownership surged, such that by 1950 there were almost as many cars as housing units in the United States: 40.3 million versus 46.1 million.[41] As new roads were built, the quantity of land within reasonable commuting distance of city centers expanded rapidly. This increase in the supply of potential residential land has been put forward as a likely explanation for the decline in land prices over this period (see, for example, Grebler, Blank and Winnick, 1956, p.364). Since the widespread adoption of the automobile there have been no further significant technological innovations in passenger transportation. Over time, more and more cities have either developed most of the land within reasonable commuting distance of the city center, or in a few cases have implemented policies to slow further development. Thus growth in the supply of desirable residential land has not been sufficient to accommodate growth in demand for housing, and land and house prices have risen. This explanation for the u-shape in

[40]See, for example, Glaeser, Gyourko and Saks (2005), Quiqley and Raphael (2005), or Ortalo-Magne and Pratt (2006).

[41]Census of Population and Housing (Table CPH-2) and Federal Highway Administration (Table MV-200).

the value of land over the past century awaits a more formal evaluation in the context of an explicit quantitative theoretical model.

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Table 1: Market Value and Replacement Cost Statistics, All Nonfarm Housing Units

Year	Replacement Cost, Structures ($billions)	Total Market Value ($billions)	Land Share (Percent)
	(1)	(2)	(3) = 100*[(2)-(1)]/(2)
1930	96.4	113.8	15.3
1940	100.7	90.4	-11.4
1950	267.5	298.7	10.4
1960	466.7	569.33	18.0
1970	847.3	1058.14	19.9
1980	2836.4	3887.93	27.0
1990	5090.3	8483.38	40.0
2000	8763.5	13770.04	36.4

Table 2: Business Cycle Properties of Land Prices, 1975:1 - 2006:2

	SD	Corr $\left(X_s, p_t^l\right)$		
X	(%)	$s=t-4$	$s=t$	$s=t+4$
p_t^l	3.90	0.51	1.00	0.51
p_t^s	1.18	0.15	0.47	0.61
p_t^h	1.80	0.41	0.92	0.64
GDP_t	1.38	0.53	0.56	0.14
RES_t	9.09	0.62	0.38	-0.29

p_t^l is the real price index for constant-quality residential land; GDP = real chain-weighted GDP (\$2000); RES = real chain-weighted investment in residential structures (\$2000); p_t^h is the real constant-quality price index for housing; and p_t^s is the real price index for the replacement cost of structures. All variables have been logged and HP-Filtered with smoothing parameter $\lambda = 1600$.

Table 3: Regressions of House, Structures, and Land Prices on Fundamentals

		*Coefficients and T-Statistics (in parentheses)**					
		Log per-capita real disp. pers. inc.	Nominal 3-month T-Bill rate**	Inflation rate**	Log pop.	Percent pop. age 35-54	Spread, 30-yr. FRM over 3-mo. TBill**
(1)	Log real	1.315	-0.009	0.073			
	house prices	(4.61)	(-0.69)	(2.93)			
(2)	Log real	0.719	0.005	0.047			
	structures prices	(3.35)	(0.49)	(2.26)			
(3)	Log real	2.562	-0.039	0.124			
	land prices	(9.31)	(-3.33)	(4.98)			
(4)	Log real	0.526	-0.010	0.047	2.421	-0.043	-0.009
	house prices	(3.04)	(-4.29)	(6.00)	(5.80)	(-5.28)	(-2.89)
(5)	Log real	-0.195	0.006	0.009	2.442	-0.046	-0.002
	structures prices	(-1.74)	(3.97)	(1.95)	(9.07)	(-8.75)	(-1.00)
(6)	Log real	2.406	-0.040	0.102	0.819	-0.026	-0.026
	land prices	(6.61)	(-9.23)	(6.30)	(0.98)	(-1.65)	(-4.23)

* Coefficients are estimated using Stock-Watson procedure with two leads and two lags of the growth rates of all variables, quarterly data, sample period 1975:4 to 2005:4; t-Statistics are calculated according to Hamilton (1994), p. 611.

** The 3-month T-Bill rate, the inflation rate, and the spread of the 30-year fixed rate mortgage above the 3-month T-Bill rate are the average annualized rates during the quarter.

Note: To estimate the coefficient and t-statistic of the spread variable, we use the following procedure: First, we determine the predicted price of land, structures, or housing, using only the coefficients for real per-capita income, the 3-month T-bill rate, the inflation rate, log population, and the percent of the population age 55-64. Then, the difference of the predicted price and the actual price (which is assumed to be stationary) is regressed on the spread variable, which unit-root tests suggests is stationary. The coefficient and standard error from this second regression is reported in the table.

Table 4: House Price Levels, Growth Rates, Volatility, and Per-Capita Income Growth by MSA

MSA	Estimated Average House Value, 1998*	Estimated w_t^l 1998:2**	Nominal Growth, OFHEO 1998:2 - 2006:2	SD of Qtrly. Growth Rate, OFHEO 1990:2 - 2006:2
	(1)	(2)	(3)	(4)
San Francisco, CA	$456,669	80.4%	150.5%	2.14
San Jose, CA	$416,432	74.7%	138.9%	2.51
Oakland, CA	$285,177	NA	183.7%	2.27
Boston, MA	$236,569	58.9%	130.9%	1.75
Washington, DC	$223,140	49.4%	164.6%	2.10
Seattle, WA+	$221,344	54.0%	99.4%	1.45
Baltimore, MD	$175,124	48.3%	131.0%	1.77
Sacramento, CA+	$173,058	37.6%	175.8%	2.45
Salt Lake City, UT	$168,358	38.0%	46.9%	1.44
Hartford, CT+	$163,917	38.7%	86.6%	1.68
Minneapolis, MN	$146,234	23.4%	98.2%	0.95
Providence, RI	$145,906	49.4%	142.1%	1.95
Atlanta, GA+	$144,248	27.5%	53.7%	0.73
Cincinnati, OH	$134,363	33.1%	38.2%	0.40
Cleveland, OH+	$133,498	35.6%	32.7%	0.62
Norfolk, VA	$131,105	41.9%	123.2%	1.79
Birmingham, AL	$121,532	31.2%	48.6%	0.74
Rochester, NY	$111,519	20.8%	30.1%	0.91
Tampa Bay, FL	$111,167	31.9%	154.3%	1.83
Indianapolis, IN+	$110,784	24.4%	28.9%	0.51
St. Louis, MO+	$109,694	11.5%	63.9%	0.68
Houston, TX	$106,826	17.7%	53.8%	0.83
Memphis, TN+	$105,534	28.7%	32.2%	0.85
Oklahoma City, OK+	$80,497	12.6%	49.2%	0.71
Spearman Rank Correlation Coef., Avg. House Value and Nominal Growth of OFHEO				0.65
Spearman Rank Correlation Coef., Avg. House Value and S.D. of Growth of OFHEO				0.70

* Average values for single-family detached homes in the MSA as calculated from the AHS-M. For AHS-M Year 1998, the value is directly computed from micro data. For AHS-M Year 1996 (marked with + by the MSA name), the 1996 average value is calculated from micro data, and then scaled by growth in the OFHEO for that MSA from 1996:2 to 1998:2.

** Land share estimates are taken from Davis and Palumbo (2006).

Table 5: Decade-on-Decade Growth Rates

	Changes in Prices					Changes in Quality	
	Using Equation (7)			Shiller	Avg. Value,	Based on	Based on
	Structures Prices*	Land Prices	House Prices	House Prices	Own.-Occ. Homes	Eq. (7) =(5)-(3)	Shiller =(5)-(4)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1930-1950	2.08	-3.27	1.73	1.84	0.78	-0.95	-1.06
1950-1960	-0.87	5.39	0.10	0.23	0.29	0.19	0.06
1960-1970	0.21	1.76	0.62	0.11	1.49	0.87	1.38
1970-1980	2.94	8.36	4.35	1.79	4.66	0.31	2.87
1980-1990	-1.30	6.12	1.32	0.63	2.14	0.82	1.51
1990-2000	0.87	1.08	1.01	0.81	1.23	0.22	0.42
2000-2005**	2.97	13.05	6.95	8.96	NA	NA	NA

* All growth rates are reported as annualized percentages. Column (1) is the real growth of constant-quality structures prices, as measured by the BEA; columns (2) and (3) are real growth in the price of land and housing respectively, as computed using equation (7) (see text for details); column (4) is the real growth in constant-quality house prices as used in Shiller (2005); column (5) is the real growth in the average value of owner-occupied homes, as we calculate using DCH micro data and other sources (see data appendix for details); column (6) is the real increase in the quality of housing as implied by equation (7), calculated as the average growth of value of owner-occupied homes (column 5) less the increase in constant-quality home prices as implied by our data (column 3); and, column (7) is the real increase in the quality of housing as implied by Shiller's house price data, calculated as the average growth of value of owner-occupied homes (column 5) less the increase in constant-quality home prices as used in Shiller (2005) (column 4). See the appendix for more details on all data and sources.

** The quarterly data series are used to compute columns (1), (2), and (3) for the 2000-2005 period.

Figure 1: Real Land, Home, and Structures Prices (Log Scale)

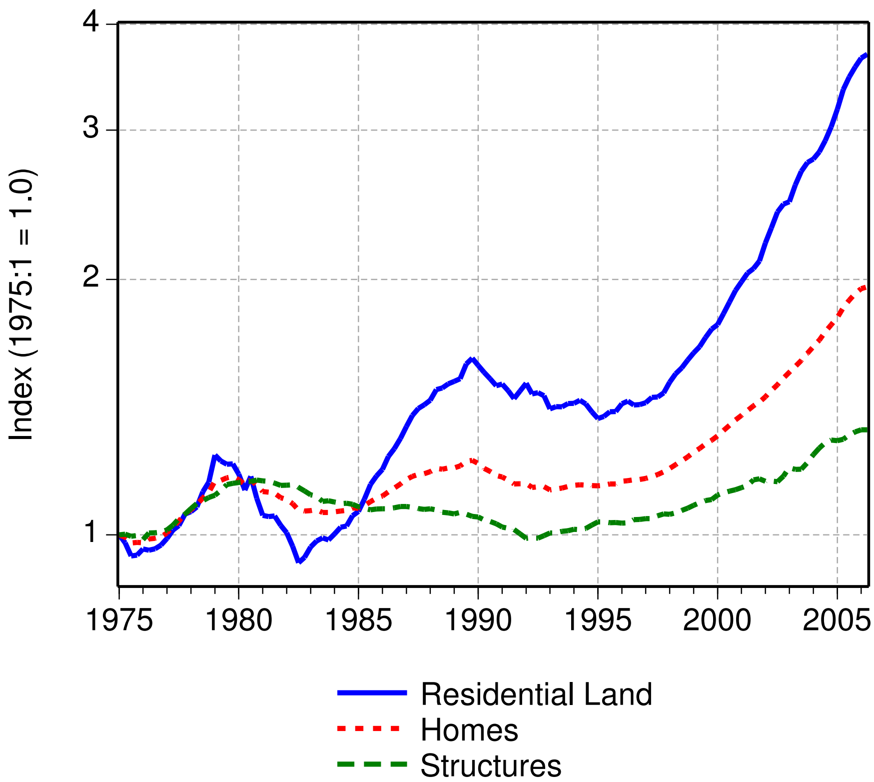

Figure 2: Land's Share of Home Value

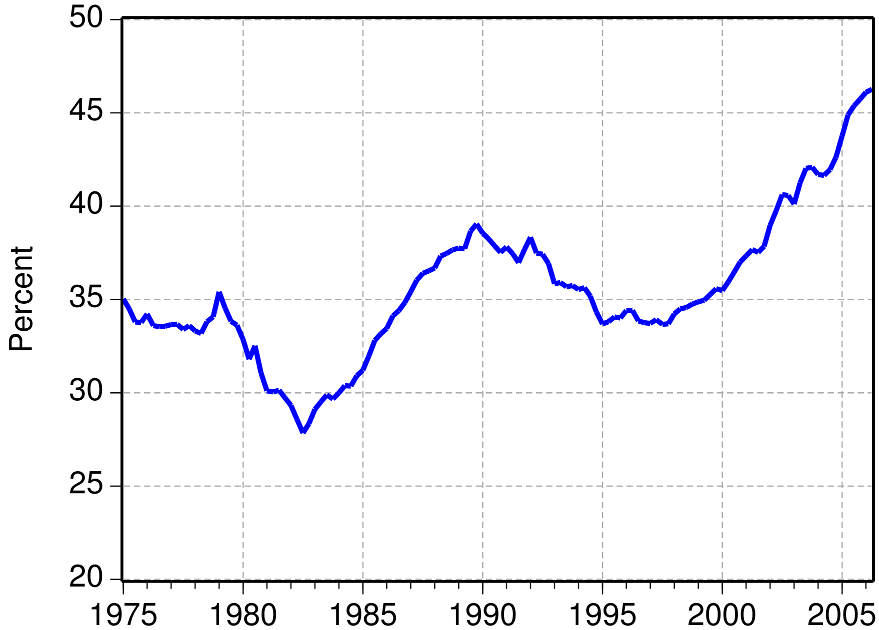

Figure 3: Year-on-Year Growth of Real Land, Home, and Structures Quantities

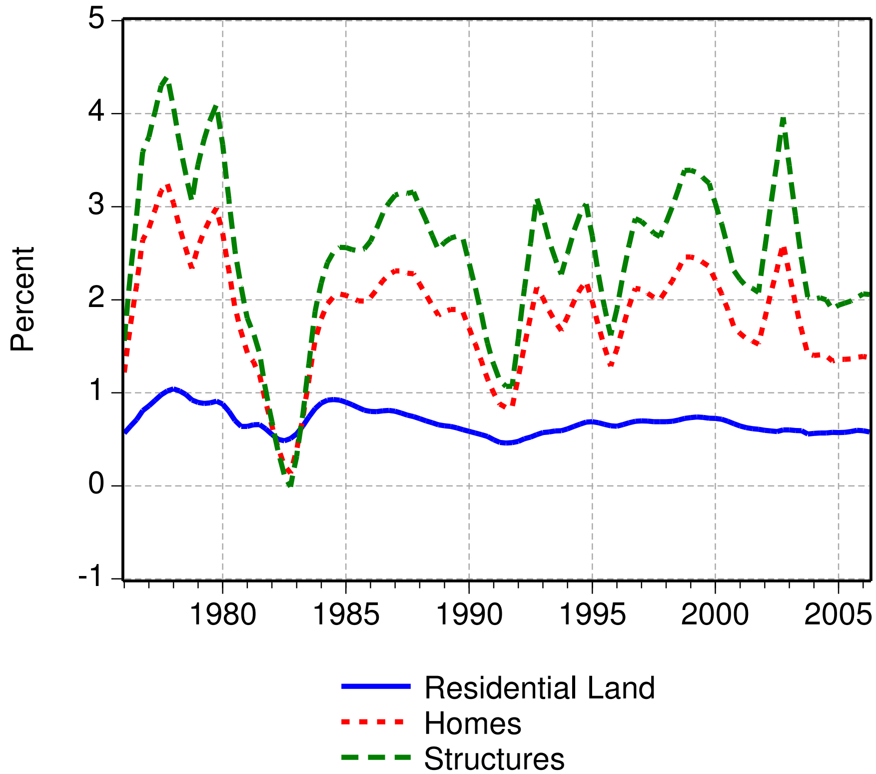

Figure 4: Real Residential Land and Farm Land Prices (Log Scale)