THE PRICE AND QUANTITY OF RESIDENTIAL LAND IN THE UNITED STATES (SHORTER PAPER)

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We estimate the market value of the housing stock in the United States to be $24.2 trillion in the second quarter of 2004. This figure is more than twice annual US GDP and 1.7 times the combined capitalizations of the NYSE, Nasdaq and Amex exchanges at the end of 2003. 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 the macroeconomic effects of house price fluctuations has been heightened by the current boom in the housing market: the house price index for the aggregate United States rose by 48 percent in real terms between 1996 and the second quarter of 2004.

In this paper we argue that one way to progress towards a better understanding of house price dynamics is to split house prices into two factors. The first factor, structures, can be priced explicitly for a particular house as the replacement cost, after accounting for depreciation, of the physical building. The second factor, which we call land, is the factor that makes a house worth more than the cost of putting up a new structure of similar size and quality on a vacant plot. Thus land is the market value associated with a home's location, and the size and attractiveness of the plot.

We show that the growth rate of the aggregate price of housing is a weighted average of the growth rate of the price of structures and the price of land, where 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 structures. Our series are the

[1] A large empirical literature investigates wealth effects from house price changes on aggregate consumption and saving (see, for example, Case, Quigley and Shiller, 2001). Changes in the price of housing also have implications for risk-sharing and asset pricing (see, for example, Lustig and van Nieuwerburgh 2004 and Piazzesi, Schneider and Tuzel 2003), as well as distributional effects in heterogeneous-agent economies (Bajari, Benkard and Krainer, 2004).

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.

Decomposing the price of a house into the price of a structure and the price of land is a useful exercise, since very different forces are likely to drive prices of the two components. The cost of putting up new structures is driven largely by the productivity of the construction industry relative to other sectors of the economy, and to the cost of some basic materials.[2] Thus one should not expect changes in demand-side factors such 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. By contrast, land is largely non-reproducible, and therefore the price of land is primarily driven by changes in the demand for housing.[3]

The distinction between structures and land may therefore shed new light on empirical work that attempts to uncover the driving forces behind house price dynamics. For example, 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.[4] One important lesson from our decomposition is that one should expect house

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[2] See Davis and Heathcote (2004a) for an analysis of the shares of residential structures accounted for by value-added from the construction, manufacturing, and services industries.

[3] We define residential land as land with a residential structure on its surface. We estimate that the stock of residential land has grown quite slowly over the past thirty years, leading us to believe that high-quality residential land is inelastically produced.

[4] A well known example of a failure to predict house prices on the basis of fundamentals is Mankiw and Weil (1988), who argued that the baby bust of the 1970s would lead to declines in house prices in the 1990s.

price dynamics to look quite different in regions where land's share of house value is high (such as San Francisco and Boston) compared to regions where it is relatively small. In particular, changes in demographics or interest rates 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 regions that share similar fundamentals might experience noticeably different house price dynamics.

Our distinction between structures and land is analogous to the tangible versus non-tangible capital distinction in stock market valuation. A second analogy is the decomposition of the Consumer Price Index into a core component, and a second component capturing energy (and possibly food) prices. Just as changes in interest rates likely are correlated with energy and non-energy prices differently, we will show that interest rates are quite differently correlated with land and structures prices.

Findings: Between 1970 and 2004, we estimate that land accounts, on average, for 47 percent of the value of the housing stock. Land's share in the value of the entire housing stock is large despite the fact that the cost of raw land typically accounts for a small fraction (around 11 percent) of the market value of new homes. We conclude that a large fraction of the market value of existing homes reflects the value of attractive locations.

At business cycle frequencies we find that the price of land is 1.6 times as volatile as GDP and almost twice as volatile as the price of structures. Given that land accounts for around half the total value of housing stock, we conclude that fluctuations in house prices are primarily attributable to fluctuations in the price of land. The correlation between the price of residential land and structures prices is low, as is the correlation between residential land prices and farm land prices.

Our decomposition has some testable implications for house prices at the regional level. First, we verify that over the current land price boom, house price gains have typically been largest in regions where house prices (and thus land's share) were relatively high at the start of the boom. Second, regions where prices are higher (indicating higher land values) tend to be the same regions where prices are more volatile, consistent with our claim that land prices are more volatile than structures prices. Third, there is a long-run correlation between initial price levels and subsequent price growth, consistent with the finding that the trend growth rate for land prices exceeds that for structures.

Finally, we look for factors that might be able to account for land price dynamics by running some simple regressions. We regress house prices, structures prices and land prices on income and interest rates. Interestingly we find that while the coefficient on interest rates in the land price regression is negative, as one might expect, the coefficient on the same variable in the structures regression is positive. Thus the overall correlation of interest rate changes with aggregate house prices is small.[5]

Accounting and Measurement

We start by defining the market value of a home in period t, $p_t^h h_t$, as the sum of the replacement cost of the structure after accounting for depreciation, $p_t^s s_t$, and the market value of the land and associated amenities, $p_t^l l_t$:

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

In the above equation, p_t^h, p_t^s, and p_t^l are the quality-adjusted prices per unit of the home, physical structure, and land and amenities (hereafter called "land") and h_t, s_t and l_t are the quality-adjusted quantities.

Our key assumption is that if the replacement cost of structures and the nominal value of land are revalued between periods t and $t+1$, then the house itself is appropriately revalued, implying

$$\left(\frac{p_{t+1}^h}{p_t^h}\right) p_t^h h_t = \left(\frac{p_{t+1}^s}{p_t^s}\right) p_t^s s_t + \left(\frac{p_{t+1}^l}{p_t^l}\right) p_t^l l_t . \tag{2}$$

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[5] These simple regressions indicate that slower future house price growth is likely because short-term interest rates are likely to rise.

Rearranging terms, equation (2) may be rewritten as

$$\left(\frac{p_{t+1}^{h}}{p_{t}^{h}}\right)=\left(\frac{p_{t+1}^{s}}{p_{t}^{s}}\right)\frac{p_{t}^{s}s_{t}}{p_{t}^{h}h_{t}}+\left(\frac{p_{t+1}^{l}}{p_{t}^{l}}\right)\frac{p_{t}^{l}l_{t}}{p_{t}^{h}h_{t}}. \tag{3}$$

Equation (3) implies that the growth rate of the price of a house between periods t and $t+1$ is a simple weighted average of the growth rate of the replacement cost of the structure and the growth rate of the value of the land.

Based on equation (3), if we were to observe time series for the growth rate of home prices, the growth rate of structures costs, the replacement cost of structures and the market value of the housing stock, then we could infer a time series of growth rates of land prices. In principle, these data are publicly available. Freddie Mac publishes the "Conventional Mortgage Home Price Index" (CMHPI), a quarterly price index for homes that starts in 1970:Q1 for the aggregate United States. Since this series is based on repeat sales, in principle it captures the growth rate of home prices holding quality constant. The Bureau of Economic Analysis (BEA) publishes a quarterly price index for residential structures that measures the growth rate of structures costs; the BEA also publishes estimates of the aggregate replacement cost of residential structures. Finally, Census data can be used to estimate the market value of all homes in the United States.

We modify and adjust these data in order to produce a continuous quarterly price and quantity series for residential land that is free of conceptual and statistical measurement errors. We now highlight our most important modifications. All prices, except where noted, have been deflated by the NIPA price index for core consumption.[6]

House Prices: We suspect that the CMHPI is measured with error, and that measurement error is responsible for growth-rate spikes that are especially prevalent from 1970-75 (see the solid line in Figure 1). To see how measurement error in the CMHPI would impact our estimated volatility of land prices, consider the following model for measurement

[6] All of our price indexes are end-of-quarter measures with base year 1996. We convert the NIPA core consumption price index (a middle-of-quarter measure) to an end-of-quarter measure by using the geometric mean of the published NIPA data for the current and subsequent quarter. For more details, see the Appendix of Davis and Heathcote (2004b).

error. Suppose that the natural log of the (inflation-adjusted) CMHPI is measured with error that is distributed independently and identically over time, that is

(4) $$\log\left(p_{t+1}^{h}\right) = \log\left(p_{t+1}^{h*}\right) + e_{t+1}^{h},$$

where p_{t+1}^{h*} is the true level of the real CMHPI and e_{t+1}^{h} is measurement error. Letting g_{t+1}^{h} denote the observed growth rate of house prices, and g_{t+1}^{h*} the true but unobserved growth rate, equation (4) implies

(5) $$g_{t+1}^{h} = g_{t+1}^{h*} + \Delta e_{t+1}^{h}.$$

Now let the observed growth rates of structures costs and the inferred growth rate of land prices between *t* and *t*+1 be denoted g_{t+1}^{s} and g_{t+1}^{l} respectively. Suppose (for simplicity) that g_{t+1}^{s} is not measured with error. Equations (3) and (5) can be combined to express g_{t+1}^{l} as the true but unobserved growth rate of land prices plus a term that depends on the error in the observed growth rate of the CMHPI,

(6) $$g_{t+1}^{l} = \frac{p_t^h h_t}{p_t^l l_t}\left(g_{t+1}^{h*} - \frac{p_t^s s_t}{p_t^h h_t} g_{t+1}^{s}\right) + \frac{p_t^h h_t}{p_t^l l_t}\Delta e_{t+1}^{h}.$$

Notice that as long as the expected value of Δe_{t+1}^{h} is zero, the inferred growth rate of land prices is unbiased. In the analysis section, we show that land's share of market value ($p_t^l l_t / p_t^h h_t$) historically ranges between 0.40 and 0.55, implying the unconditional standard deviation of measurement error in land prices is somewhere 1.75 and 2.5 times the standard deviation of the measurement error in the observed growth rate of house prices (Δe_{t+1}^{h}).

To obtain an accurate estimate of the volatility of house prices and, by equation (6), of land prices, we use the Kalman Filter to uncover a series for house prices that is free of measurement error. In particular, we assume the growth rate of the true but unobserved real CMHPI is a random walk,

(7) $$g_{t+1}^{h*} = g_t^{h*} + u_{t+1},$$

where the growth rate shocks, u_{t+1}, are independently and identically distributed over time, with $E[u_t e_s] = 0$ for all t and s. We allow the variance of e_{t+1} to change in 1975, since the growth rates of the real CMHPI appear much less volatile after this date.[7] Although the statistical model described by equations (4) and (7) is relatively simple, it fits the data well.[8] The estimated standard deviation of u_{t+1} is 0.4 percent, the standard deviation of e_{t+1} in the 1970-75 data is 1.5 percent, and the standard deviation of e_{t+1} in the post-1975 data is 0.4 percent. The estimates for the sequence g_{t+1}^{h*}, along with growth-rates of the raw inflation-adjusted CMHPI data, are plotted in Figure 1 as the dashed line. The corrected growth estimates are less volatile than the raw CMHPI, especially in the early part of the sample.[9] Given our specification of the measurement error process, it is not surprising that the inferred true log level of the real CMHPI, $\log\left(p_{t+1}^{h*}\right)$, tracks the reported series extremely closely.

Replacement Cost of Structures: We make two adjustments to the BEA's published series for the replacement cost of residential structures. First, we use quarterly National Income and Product Accounts (NIPA) data on gross investment in residential structures, along with a quarterly estimate of depreciation, in a perpetual inventory accounting system that converts the published annual replacement cost series to a quarterly series. Second, the BEA treats expenditures on commissions from existing home sales as if it is residential investment when calculating an estimate of the replacement cost of structures. We believe this is a conceptual error and subtract our estimate of the accumulated value of commissions on existing home sales from the BEA's published estimate of the

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[7] Documents on the Freddie Mac web site suggest that the 1970-1975 CMHPI is constructed with significantly less data than the post-1975 series.
[8] In particular, simulations show that the model closely reproduces first-order autocorrelations of observed growth rates.
[9] We use the filtering procedure in the EViews package to produce the smoothed estimates of g_{t+1}^{h*}. Davis and Heathcote (2004b) use a 3-quarter centered moving average of observed growth rates to correct for measurement error in the CMHPI. The post-1975 estimates of g_{t+1}^{h*} from the Kalman filter procedure are very similar to the 3-quarter centered moving average.

replacement cost of all residential structures.[10] This correction reduces the BEA's published estimate of the replacement cost of structures by approximately 8 percent.

Market Value of Homes: We create an estimate of the market value of all homes (owned, rented, and vacant) from 1970:Q1 to 2004:Q2 using the following perpetual inventory system:[11]

$$p_{t+1}^{h}h_{t+1} = \left(\frac{p_{t+1}^{h}}{p_{t}^{h}}\right)p_{t}^{h}h_{t} + p_{t+1}^{h}\Delta h_{t+1}. \tag{9}$$

In this system, the market value of housing at t+1 (the left-hand side) is set equal to the revalued market value of housing at t (first term, right-hand side) plus any net-new additions to the stock of housing (second term, right-hand side).

To generate a time series for the market value of all residential housing units, we benchmark equation (9) to an estimate of the market value of the housing stock that is derived from micro data from the 2000 Decennial Census of Housing, and use the (corrected) CMHPI to revalue the stock between any two periods. We calculate net new additions to the stock of housing as the sum of net new additions to the replacement cost of structures and net new additions to the stock of residential land, i.e.[12]

$$p_{t+1}^{h}\Delta h_{t+1} = p_{t+1}^{s}\Delta s_{t+1} + p_{t+1}^{l}\Delta l_{t+1}. \tag{10}$$

To calculate net new additions to structures, $p_{t+1}^{s}\Delta s_{t+1}$, we subtract estimates of expenditures on commissions and depreciation from NIPA gross investment in structures. Our estimate of net new additions to residential land, $p_{t+1}^{l}\Delta l_{t+1}$, is based on assumptions

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[10] Our reasoning is the following: if a house transacts three times in one year, the cost of rebuilding the structure should not automatically increase by 18 percent. We derive an estimate of the stock of commissions implicit in the BEA's published estimate of the replacement cost of structures using a perpetual inventory system. See the Appendix of Davis and Heathcote (2004b) for details.

[11] The Flow of Funds Accounts, published by the Federal Reserve Board, has an estimate of the market value of owner-occupied housing. We do not use this estimate because it does not include the value of rental homes or vacant homes. Also, we have uncovered measurement problems with the published Flow of Funds estimates - specifically, the growth rate of capital gains implied by the published series tend to be unusually large or small when data sources used to benchmark the estimates change. One such example is the 1980-1985 period, when the benchmark data source changed from the Annual Housing Survey to the American Housing Survey. As a consequence of these findings, the Flow of Funds estimates are currently under review by staff members of the Federal Reserve Board.

[12] Note that equations (1) and (10) jointly imply equation (3), the equation from which our land price series is derived.

the Census Bureau uses to infer the value of structures put in place from sales prices of newly-built homes.[13] Thus our series for net new additions to the stock of housing is consistent with the way the Census Bureau measures construction value put in place.

We compare the predicted market value of all housing units for 1980 and 1990, calculated via equations (9) and (10) and benchmarked exclusively to the 2000 Census, to the aggregate market value of housing units when calculated using micro data from the 1980 and 1990 Decennial Census of Housing. In 1990, we under-predict the market value relative to the Decennial Census by 4% and in 1980 we over-predict by 4%. We view a 4% discrepancy over a twenty year period as broadly vindicating our methodology.

ANALYSIS

In Figure 2 we plot price indexes for residential land, existing homes, and the replacement cost of structures.[14] In real terms, land prices have increased by a factor of 2.7 since 1970, while home and structures prices have increased by 88 percent and 38 percent respectively. In addition to having different trend growth rates, land and structures prices also exhibit different patterns within the sample. For example, between 1970 and 1982, the real price of land declined, whereas real replacement costs rose by 26 percent. By contrast, from 1982 through the end of 1995, land prices rose by 40 percent (mostly between 1982 and 1989), while structures prices fell. Between 1996 and the second quarter of 2004, real house prices increased 48 percent. Over the same period, replacement costs rose by only 21 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 84 percent.

[13] The Census assumes that raw land accounts for approximately 11 percent of the sales price of new homes built for sale.
[14] Note that the numbers reported in this section are different from those of Davis and Heathcote (2004b). Davis and Heathcote (2004b) report figures appropriate for the value of residential land under 1-4 unit structures, whereas we report statistics relevant for the value of residential land under all structures, including structures in 1-4 unit buildings and 5+ buildings.

Averaging over our sample period, residential land accounts for 47 percent of the value of the housing stock and 88 percent of GDP. There are no clear long-term trends in the market value of the stock of land relative to either of these variables. Since the mid 1990s, however, the value of land has been rising quickly, such that by the second quarter of 2004 residential land accounted for 53 percent of the value of the housing stock, and 114 percent of GDP, a record for our sample. The constant-quality stock of residential land and associated amenities in residential use has grown at an annualized rate of between 0.3 and 0.6 percent since the first quarter of 1970. The average annual growth rate is just over 0.4 percent.[15] The fact that the real quantity of residential land has risen so smoothly over time means that fluctuations in the value of the stock of land are almost entirely attributable to fluctuations in land prices.

Note that while land accounts for approximately 50 percent of the value of the entire housing stock, the cost of purchasing raw land for newly-built houses is only around 11 percent of what these houses sell for. 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.

Table 1 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 1.6 times as volatile as GDP, 1.5 times as volatile as the price series for existing homes, and 1.8 times as volatile as the series for structures prices. This last finding, coupled with the fact that land accounts for around half 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.[16] Indeed, the contemporaneous correlation between land and home prices is 0.92, while the correlation between land and structures prices is only 0.47. Interestingly, residential investment leads the price of residential land. This suggests that changes in the demand for housing, which should

[15] For comparison, the real stock of residential structures has been growing at an average rate of 2.7 percent while the US population has been growing at 1.4 percent per year.

[16] This mirrors the consensus that most fluctuations in the value of corporate capital are driven by fluctuations in the value of intangible rather than tangible capital.

show up immediately in land prices, are not the primary factor driving changes in residential investment.

Figure 3 compares our land-price series to the price-per-acre of farm land for the aggregate United States.[17] This is the only other published aggregate price series for land in the United States of which we are aware. Figure 3 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 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 house stock, and because land accounts for a smaller fraction of the price of new homes. We conclude that farm land and residential land are essentially different goods, whose prices are determined by different factors.[18]

REGIONAL IMPLICATIONS

Our analysis has some interesting testable predictions for prices at the regional level. We do not have estimates for land's share by region, but it is reasonable to assume that cross-regional differences in construction costs are small relative to differences in land prices, and therefore that differences in house prices are primarily attributable to differences in the fraction of a typical home's market value attributable to the value of the associated land.[19] Three implications follow.

[17] 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.

[18] There is some evidence to suggest 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. According to the USDA web site, in January 2002, the average price per acre of farmland in the US was $1,210. The average for the Northeast region was $2,810, and the average for New Jersey (the priciest state) was $8,000.

[19] See Gyourko and Saiz (2004) for evidence on regional variation in construction costs.

First, regions in which house prices (and thus land's share) are higher should exhibit more dramatic house price appreciation in periods when land prices are rising faster than construction costs. In particular, regions in which prices were already highest at the start of the most recent boom should have also experienced the fastest subsequent price growth. Second, regions with more expensive housing (and higher land shares) should exhibit greater house price volatility, since land prices are more volatile than structures prices. Third, over the past 25 years or so, price growth in regions with high initial prices should exceed growth in regions with low initial prices, since the trend growth of land prices has exceeded that of structures prices, especially since the early 1980s.

Table 2 reports MSA ("Metropolitan Statistical Area") level data that we use to formally test the first two of these predictions. In the first column, we list the estimated average price of a single-family owner-occupied detached house for various MSAs in 1998, sorted from most expensive to least expensive. The average house prices for these metro areas were calculated using micro data from the 1996 and 1998 Metropolitan American Housing Surveys (AHS-M).[20] The second column of Table 2 lists the cumulative nominal percentage growth to house prices from 1998:Q2 to 2004:Q2 as measured by the MSA-specific CMHPI.[21] The final column of Table 3 lists the standard deviation of quarterly growth in the MSA-specific CMHPI from 1992:Q2 to 2004:Q2.[22]

Casual inspection suggests that the MSAs with the highest home values experienced both the fastest house price appreciation and highest price volatility, consistent with our estimates of the relative appreciation and volatilities of land prices and structures costs. The top-five MSAs in this table, ranked by average house value in 1998, experienced

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[20] 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 CMHPI 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.
[21] We believe that the MSA definitions used in the CMHPI are the same as those in the AHS-M.
[22] 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 1992 so that rankings of house values in 1998 represent something like the average for the 1992-2004 period.

average cumulative growth in nominal house prices over the past 6 years of 94 percent and a standard deviation of growth in the past 12 years of 1.9 percent while the bottom five MSAs experienced average nominal growth in house prices of 33 percent and average standard deviation of 0.7 percent. 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 growth in home prices.

Finally, to investigate the long-run correlation between initial price levels and growth, 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 1980:2 and 2004:2.[23] The associated Spearman rank-correlation coefficient is 0.52, positive and statistically significant, as expected.

REGRESSION ANALYSIS

It is a commonly held belief among real estate professionals and some business economists that house prices are systematically positively correlated with income and negatively correlated with interest rates.[24] To explore the relationship between prices and fundamentals, we regress log real house prices, structures prices, and land prices on log real aggregate personal disposable income, the log nominal 3-month annualized T-Bill rate, and the log of the inflation rate (to capture the effect of changes in real interest rates). The coefficient estimates, adjusted standard errors, and unit root tests on residuals are reported in Table 3.[25]

[23] Note this is not the same set of cities reported in the 1998-2004 data in Table 2. A table summarizing the 1980-2004 data is available on request.
[24] See, for example, Duca (2004).
[25] See footnotes to Table 3 for more details on the reported coefficients, standard errors, and unit root tests. Qualitatively, our results appear to be robust to many different variable choices and functional form specifications.

Consider first the land price regression in the third row of the table. We find that real land prices are (i) negatively correlated with interest rates, (ii) strongly increasing in real income, and (iii) co-integrated with income and interest rates. These findings are consistent both with conventional wisdom in the real estate profession, and with our argument in the introduction that land prices should be primarily determined by demand-side factors. By contrast, the structures price regression indicates little evidence of a systematic relationship between structures prices and these other variables: coefficients are insignificant or marginally significant, and unit root tests suggest a spurious regression. This is consistent with our prior that real structures prices should be largely driven by supply-side factors, such as productivity in the construction sector relative to the rest of the economy.

Focusing on the first row of Table 3, the house price regression, it appears that house prices are uncorrelated with nominal interest rates. Recall that house prices are a weighted average of land prices and structures costs. Thus 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 regression (row 2) and the significant negative estimate from the land price regression (row 3). The apparent absence of a co-integrating relationship between house prices, income and interest rates is a further consequence of this off-setting interest rate effect, coupled with the lack of a clear relationship between structures prices and fundamentals.[26]

CONCLUSIONS

We now discuss some potential future applications for the land price series we develop, and some broader implications of the properties of land prices we have discussed in this paper. Our finding that land prices are co-integrated with income and interest rates suggests that our land price series will prove useful for understanding the nature of the current boom in house prices (Terrones and Otrok 2004 and McCarthy and Peach 2004)

[26] Using panel data, Gallin (2003) also finds that it is difficult to reject the hypothesis of no co-integration between house prices and income.

as well as for forecasting future house prices.[27] The implications for regional house price dynamics of our structures versus land decomposition also merits further exploration. To this end, Davis and Palumbo (2004) are currently adapting the methodology developed in this paper in order to produce MSA-level series for land prices. The finding that the value of residential land exceeds GDP has implications for the calibration of macroeconomic models, and in particular the appropriate target capital to output ratio. Finally, our empirical evidence suggests that house prices in regions where land's share is high should be more sensitive to interest rates, with implications for monetary policy.

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[27] See Davis and Heathcote (2004b) for a simple forecasting exercise.

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TABLE 1: BUSINESS-CYCLE PROPERTIES OF LAND PRICES, 1970:1 - 2004:2*

		p_t^l	$Corr(X_{t-s},\ p_t^l / p_t^c)$		
	SD%	rel. to X	t-s = t-4	t	t-s = t+4
p_t^l	2.53	1.00	0.55	1.00	0.55
GDP	1.58	1.60	0.49	0.54	0.08
RESI	10.94	0.23	0.54	0.31	-0.20
p_t^h	1.64	1.54	0.45	0.92	0.63
p_t^s	1.39	1.81	0.17	0.47	0.53

* p_t^l = the price index for constant-quality residential land divided by the NIPA consumption price index excluding food and energy; GDP = real chain-weighted GDP ($2000); RESI = real chain-weighted residential investment in structures ($1996); p_t^h = the corrected Freddie Mac CMHPI divided by the NIPA consumption price index excluding food and energy; and p_t^s = the price index for the replacement cost of structures divided by the NIPA consumption price index excluding food and energy. All variables are measured quarterly; the price variables are measured at the end of the quarter; the NIPA consumption price index excluding food and energy is converted from an average throughout the quarter (as published) to an end-of-quarter basis by taking the geometric mean of the reported price index for the current and future quarter. All data are available for public download at http://morris.marginalq.com. GDP and RESI are taken directly from the NIPA; the CMHPI has been corrected for measurement error; and the price index for the replacement cost of structures is taken from the NIPA and adjusted as in Davis and Heathcote (2004b). All variables have been logged and HP-filtered with parameter ?=1600.

TABLE 2: HOUSE PRICE LEVELS, GROWTH RATES, AND VOLATILITY BY CITY

MSA	AHS-M Survey Year	Estimated Average House Value, 1998*	Nominal Growth in CMHPI, 1998:Q2 - 2004:Q2	SD, Quarterly Nominal Growth 1992Q2 - 2004:Q2
San Francisco, CA	1998	$456,669	96.0%	2.02%
San Jose, CA	1998	$416,432	87.8%	2.46%
Oakland, CA	1998	$285,177	113.6%	2.07%
Boston, MA	1998	$236,569	93.7%	1.35%
Washington, DC	1998	$223,140	79.6%	1.55%
Seattle, WA	1996	$221,344	48.8%	0.82%
Baltimore, MD	1998	$175,124	63.4%	1.40%
Sacramento, CA	1996	$173,058	120.3%	2.22%
Providence, RI	1998	$145,906	98.4%	1.91%
Salt Lake City, UT	1998	$168,358	14.0%	1.36%
Hartford, CT	1996	$163,917	58.7%	1.55%
Minneapolis, MN	1998	$146,234	73.7%	0.96%
Atlanta, GA	1996	$144,248	41.4%	0.64%
Norfolk, VA	1998	$131,105	52.1%	1.16%
Cincinnati, OH	1998	$134,363	31.5%	0.38%
Cleveland, OH	1996	$133,498	28.7%	0.57%
Birmingham, AL	1998	$121,532	29.4%	0.71%
Rochester, NY	1998	$111,519	21.9%	0.84%
Tampa Bay, FL	1998	$111,167	70.6%	1.22%
Indianapolis, IN	1996	$110,784	23.8%	0.46%
St. Louis, MO	1996	$109,694	45.0%	0.64%
Houston, TX	1998	$106,826	42.0%	0.92%
Memphis, TN	1996	$105,534	24.0%	0.79%
Oklahoma City, OK	1996	$80,497	29.4%	0.72%
Avg. House Value and Nominal Growth, Spearman Rank Correlation Coefficient				0.70
Avg. House Value and Std. Dev. of Growth, Spearman Rank Correlation Coefficient				0.72

* Average value for single-family detached homes in the MSA as defined by the AHS-M.
For AHS Survey Year 1998, the value is calculated directly from AHS-M micro data.
For AHS Survey Year 1996, the 1996 average value is calculated from the AHS-M micro data and this average is scaled by growth in the MSA CMHPI from 1996:Q2 to 1998:Q2.

TABLE 3: REGRESSIONS OF HOUSE, STRUCTURES, AND LAND PRICES ON FUNDAMENTALS

		*Coefficients and T-Statistics**			*Unit Root Tests***	
		Log real disposable income	Log nominal 3-month T-Bill***	Log nominal inflation rate***	Augmented Dickey-Fuller	Phillips-Perron
(1)	Log real house prices	0.511 (2.34)	-0.048 (-0.47)	0.103 (0.83)	Do Not Reject	Do Not Reject
(2)	Log real structures prices	0.380 (2.03)	0.062 (0.66)	0.138 (1.46)	Reject at 5%	Reject at 10%
(3)	Log real land prices	0.806 (4.98)	-0.162 (-2.24)	0.096 (1.33)	Reject at 1%	Reject at 1%

* Coefficients are estimated using Stock-Watson procedure with two leads and two lags of the growth rates of all variables, quarterly data, sample period 1970:Q4 to 2003:Q3. T-Statistics (in parentheses) are calc ulated according to Hamilton (1994), p. 611.

** Unit-root tests on residuals assuming no constant and no time trend. The test statistic reports whether the null hypothesis of no unit root can be rejected. When we include a constant, the assumption of a unit-root in the land price regression error can be rejected at 10% for the Augmented Dickey-Fuller and 5% for the Phillips-Perron (the results for the other regressions change slightly as well).

*** The 3-month T-Bill and inflation rates are the average annualized rate during the quarter.

FIGURE 1: ANNUALIZED GROWTH RATES OF INFLATION-ADJUSTED CMHPI

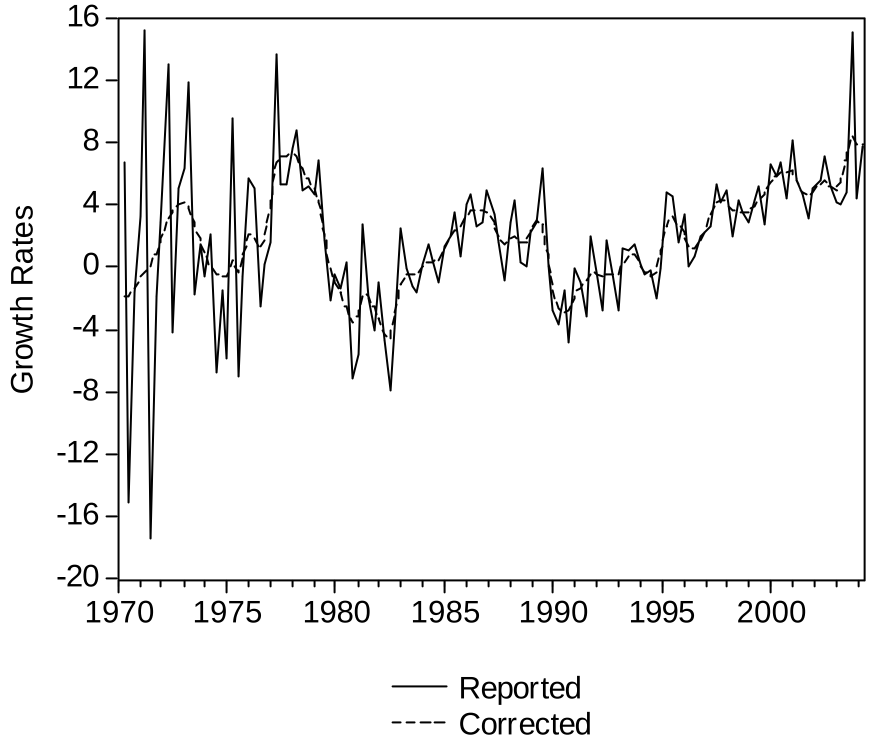

FIGURE 2: LAND, HOUSE, AND STRUCTURES PRICES

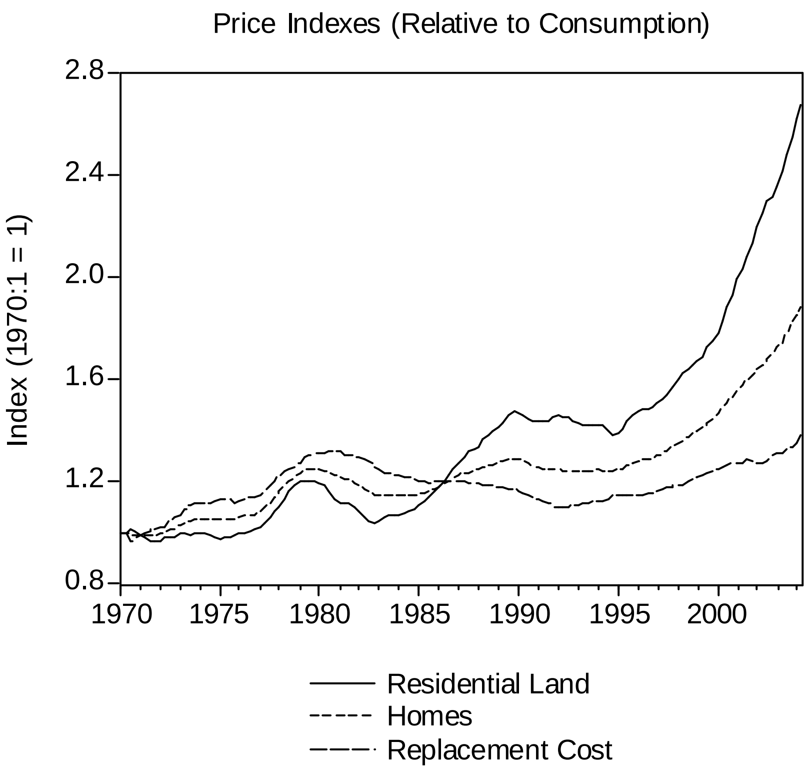

FIGURE 3: RESIDENTIAL LAND PRICES AND FARM LAND PRICES