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LAND LEVERAGE: DECOMPOSING HOME PRICE DYNAMICS

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Abstract

This paper demonstrates the importance of separating the bundled good of housing into land and improvements, arguing that changes in a property's overall value will depend critically on how much of its total value is contained in the land, a proportion we call land leverage. The importance of this deconstruction is demonstrated by highlighting how land leverage helps to explain variation in house price appreciation in Wichita, Kansas. Noting that land leverage should be relevant for many real estate issues and policies, we highlight four specific areas where consideration of land leverage could significantly improve our understanding of real estate markets.

> *"Land is the only thing in the world that amounts to anything…for 'tis the only thing in this world that lasts, and don't you be forgetting it! 'Tis the only thing worth working for, worth fighting for—worth dying for."*
>
> Gerald O'Hara in *Gone with the Wind*[1]

It has long been recognized that housing, despite its frequent treatment as single good in the press (e.g., *the* housing market, *the* housing bubble, etc.), is a bundled good. The academic literature has recognized the magnitude of the variation across dwellings, which has led to a general acceptance of "quality-controlled" price indexes over simple price indexes, such as those based on mean or median prices. At the same time, it is common to assume (often implicitly) that the prices of these heterogeneous attributes all appreciate at the same rate. In considering how the value of a home changes over time, however, it is important to recognize that the values of these bundled components do not necessarily move in conjunction with one another: Overall changes in home values will in fact reflect a weighted average of the changes in the value of each individual component.

In this article, we show that a simple partitioning of housing values into that derived from the value of land as distinct from the value of improvements can help explain many important housing market phenomena, particularly those dealing with how prices evolve over time. We argue that "land leverage" – which we define as the ratio of land value to overall value – is important, and present a series of cases in which consideration of land leverage can enhance our understanding of home price dynamics within and between markets and inform the choices faced by housing policy makers.

The paper begins by considering housing as a bundled good and motivating our choice to use a simple partition of housing into land and improvements. In the following section, we introduce land leverage as a mathematical identity, propose the "Land Leverage Hypothesis," and discuss its implications for housing price responses to economic stimuli. The ensuing sections introduce and implement an empirical test of the Land Leverage Hypothesis using Wichita, Kansas as an experimental case. The paper concludes with a discussion of the implications of the Land Leverage Hypothesis and other testable hypotheses that can be pursued.

Housing as a Bundled Good and the Importance of Land

This article focuses on a limited decomposition of housing's bundled goods to make clear the unique importance of land and location among the vector of dwelling characteristics. In particular, we note that the value of a dwelling is simply the sum of the value of the land and the value of the improvements. Because construction costs are generally uniform within a housing market (labor and materials are mobile), it must be the case that asymmetric appreciation across properties within a market must arise from asymmetric exposure to common shocks to land values.

Though there is no explicit need to tie this inquiry to any specific economic model, the approach used here harkens back to the early literature on urban economics. The classic Alonso (1964), Mills (1967, 1972), and Muth (1969) models all relate commuting costs and distance from the urban core to explain spatial price trends in the price of land.[2] From their work a price gradient emerges because of demand for land near the employment-rich central city. For the homogeneous dwellings that populate the traditional urban models, this price gradient will result in a land leverage gradient (that is, a gradient of the land-to-total value ratio).[3] More generally, a land leverage surface will arise because structures are long-lived and the fundamentals that generate the price gradient typically evolve more rapidly than the changes in the existing housing stock. This implies that land leverage is likely to vary substantially within urban areas.

We therefore focus on a decomposition of housing into the land associated with a property and the improvements on the land. This has an intuitive appeal as land is non-transportable, and its associated benefits can only be enjoyed at a fixed location. Improvements, on the other hand, are, in principle, transportable; indeed, though it might be cost prohibitive in many cases, entire structures can be relocated. In the context of understanding and explaining house price movements, the decomposition of housing into land and improvements is important because it is possible that the value of a parcel of land evolves with a different trajectory than the value of the improvements on it.4

Standard urban economic theory suggests that land values should generally increase in urban areas with population and economic growth as the increased competition for each urban parcel will drive up its price until economic profit is zero. In a monocentric city, those areas closest to the urban core are most productive and therefore will be most expensive. For polycentric cities, the same general finding of higher prices holds, although the exact shape of the resultant price gradient can be considerably more complex.

By contrast, the value of an improvement at any given point in time is simply its replacement cost less any accumulated depreciation. As a result, improvements can never appreciate at a rate above the increase in construction costs. Furthermore, if depreciation is sufficiently large, the improvements on a land parcel can actually decrease rather than increase in value over time.[5] One reason to expect declines in the value of improvements over time is that housing is a long-lived asset and, as with any durable good, use over time reduces the productive capacity of the asset. A second reason is that the evolution of technologies and tastes that affect preferences for residential living can make a home functionally obsolete and less valuable. Current examples of factors that induce functional obsolescence might include high speed internet connections, fiber optical phone lines, expansive master bedroom suites, and two- and three-car attached garages.[6]

Thus, absent an increase in the cost of construction, one would expect the value of the physical structure of the home to fall over time as the improvements are "consumed." This theoretical expectation has been borne out in many hedonic housing studies that have shown a negative relationship between house price and age of the housing structure.[7] This insight has driven theories on the evolution of neighborhoods and housing markets over time, such as the filtering hypothesis.[8] It has also spawned a large literature on housing maintenance as a means for retarding the rate of depreciation.[9]

Despite this general result, there are some factors that might cause the value of improvements to appreciate at a rate faster than increases in construction costs. One is if the property owner sufficiently invests in maintenance to extend the productive life of the structure and add amenities valued by the marketplace.[10] A second situation in which structural improvements might appreciate over time arises when the age of the improvement becomes an amenity on its own accord. A primary example of this is a district in which homes are designated as having particular historic value. Research has shown that houses designated as historic see their values increase.[11]

Save this exception of homes valued for their historic character, it is possible to make a general statement regarding the source of appreciation in single-family dwellings. First, it is clear that the value of a dwelling is the sum of the value of the land and the value of the improvements. Since construction costs are generally uniform within a housing market (labor and materials are mobile), it must be the case that asymmetric appreciation must arise from asymmetric exposure to common shocks to land values. We call this the Land Leverage Hypothesis. In a housing market where house prices have risen faster than construction costs, it must be that land values have risen even faster. Within this market, those dwellings with a greater fraction of value derived from land – greater land leverage – should experience higher price appreciation.12

The ensuing sections introduce and implement an empirical test of the Land Leverage Hypothesis using Wichita, Kansas as an experimental case. Test results are consistent with the hypothesis' predictions. This is strong validation of the hypothesis, because Wichita is small enough that transportation costs are not likely to impart any significant advantage to one location over another. That is, Wichita's house price dynamics might have been deemed too invariant to be able to detect a land leverage effect.

The Land Leverage Hypothesis

A simple stylized example demonstrates how a divergence in the trajectories of land and improvement values can help explain how house prices evolve over time. Consider two homes, one located in southern California and the other in Kansas, both valued at $250,000. In Southern California, this $250,000 home would be a lower-end home; suppose that the improvements on this home are worth $50,000 while the land is worth $200,000. In Kansas, however, a more typical allocation would be a $200,000 improvement on a $50,000 lot.

Now suppose that economic fundamentals (population/household growth, availability of developable land, transportation costs, etc.) are such that land prices in both markets increase by 10 percent per year. For simplicity, assume there is no depreciation associated with the housing structure and that construction costs are stable. The 10 percent increase in land prices would translate into a $20,000 increase in the California home, and the overall appreciation for this home would be 8 percent. By contrast, this same 10 percent increase in land values would only result in a 2 percent increase in the value of the Kansas home. Despite facing the same magnitude of economic shock to land prices, house prices in California would appreciate four times faster than those in Kansas.

In essence, the property in California is highly land levered and, analogous to financial leverage, high land leverage implies higher exposure to the local fundamentals that influence land prices. To the extent that it is location that is the ultimate source of price appreciation and volatility, this results in both a higher average "return" – home price appreciation – and higher price volatility. To see this latter point, note that if economic fundamentals were to weaken so that land values dropped by 10 percent, it is the California home that would suffer the larger overall decline in property value, despite the fact that underlying land values changed by the same proportion in the two markets. Of course, outside urban areas, where land is essentially priced by agricultural uses, it may be the cost and cost volatility of improvements that may guide housing markets. This case is not counter-evidence of the importance of land leverage, rather it is an example of the impact of low land leverage.

In light of these observations, we propose the following Land Leverage Hypothesis:

> *House price appreciation and house price volatility are directly related to land leverage, measured as the ratio of land value to total value.*

The main implication of this is that price responses to economic shocks to the market will be larger for properties with higher land leverage, holding all else equal.

This hypothesis can be derived via a simple model. The total value of a home or any property, V, can be separated into the value of the lot, L, and the value of the building, B:

V = L + B.

Let g_L, g_B, and g_V, denote the periodic percentage change in the land, building, and overall property values, respectively. With these appreciation rates, the value of a property at date t +1 can be expressed in two ways:

$$V_{t+1} = V_t(1 + g_V)$$

and

$$V_{t+1} = L_t(1 + g_L) + B_t(1 + g_B).$$

Combining these two expressions and rearranging, we see that the overall property appreciation can be decomposed as

$$g_V = g_B + (g_L - g_B)\lambda_t, \tag{1}$$

where $\lambda_t = L_t / V_t$ is the property's land-to-total value ratio, or land leverage, as of date t.

Equation (1) is an identity. It only has material impact from an intellectual perspective or for describing housing market dynamics if g_L does not equal g_B. Otherwise, one could track the appreciation in the value of either the land or the improvements and fully capture the market price dynamics both within and across various housing markets. If, however, g_L does not equal g_B then there are two dimensions along which housing market price dynamics can differ, which allows for considerably more complexity in understanding how market prices evolve over time and across space.

The Land Leverage Hypothesis takes the view that g_L can differ from g_B. From equation (1), it is clear that if leverage is positively related to price appreciation then g_L must exceed g_B. As discussed earlier, there are several compelling reasons to believe that this should be the case. Moreover, simple observation of historical construction cost and home price indices show that home prices have appreciated at a much faster pace than residential construction costs over the past 15 years (shown in Figure 1), implying that g_L does in fact exceed g_B on average.

The Land Leverage Hypothesis has a number of directly testable implications. This paper focuses on the following one:

> *Within a market area – defined as an area where land values are all subject to the same economic fundamentals and thus tied to the same aggregate rate of appreciation – each property's overall price appreciation over time will be positively related to its land leverage.*

We are interested in understanding the average effect of land leverage within a housing market. To estimate this we estimate the following:

$$g_V = \beta_0 + \beta_1 \lambda_t + \varepsilon . \tag{2}$$

By implementing this regression, we can obtain separate estimates of $g_B = \beta_0$ and $g_L = \beta_1 + \beta_0$. The Land Leverage Hypothesis implies $\beta_1 > 0$, which in turn implies that $g_L > g_B$.

The land leverage identity in equation (1) is developed using periodic appreciation rates. Implicitly, therefore, the reduced form regression model in expression (2) assumes that g_V can be observed for each parcel in each period. In fact, however, we only observe transactions prices at irregular intervals and these intervals differ from parcel to parcel. To account for this, we use the total appreciation over the owner's holding period to rewrite equation (1) as

$$(1+g_V)^T = (1+g_B)^T + \left[(1+g_L)^T - (1+g_B)^T\right]\lambda$$

or

$$g_V = \left((1+g_B)^T + \left[(1+g_L)^T - (1+g_B)^T\right]\lambda\right)^{1/T} - 1 \tag{3}$$

Expression (3) explicitly accounts for the varying time between the sales of different properties and is inherently nonlinear in our independent variables *T* and *λ*. Equation (3) can be estimated using nonlinear least squares to estimate population parameters g_B and g_L for a given sample of dwellings.

In the next section, we use data from Wichita, Kansas to estimate both the structural and reduced form versions of our model to test the above stated implication of the land leverage hypothesis and seek validation and verification of its foundations.

Empirical Tests of the Land Leverage Hypothesis

Equations (2) and (3) are estimated using residential sales data from Sedgwick County, Kansas, which is home to Wichita, the largest city in Kansas and the largest MSA contained entirely within the state. Located in the middle of the Great Plains, Wichita in many respects approximates the prototypical "flat featureless plain" of urban economic theory that has a perfectly elastic supply of land and no natural or legal barriers to new development.

At the 2000 census, Wichita's population was 344,284, a 9.75 percent increase since the 1990 census.[13] Much of Wichita's population growth is associated with annexation of new development into the city; in 2000 Wichita covered 140 square miles.[14] Although a few small cities lie on the outskirts of Wichita, much of the surrounding area is farmland.

The data used in this analysis come from a historical sales database maintained by the Sedgwick County Appraiser's Office (hereinafter "Assessor"). Although real property transaction prices are not public information in Kansas, state law requires that a Certificate of Value (COV) form be filled out each time a parcel of real estate sells. This COV lists the price and date of the sale, and indicates whether there were any special conditions of the sale that might have caused the sale price to differ from market value. The Assessor combines the information from the COV form for each "valid" sale (transactions that are determined to be arms-length) with property data it collects to form a historical sales database, which it uses to conduct the computer-assisted mass appraisal portion of its annual property assessments, which are required by state law. This database contains more than 80 property characteristic variables for 149,927 transactions between 1985 and 2004 involving 92,377 residential parcels. We then add codes that identify each parcel's neighborhood, as defined by the South Central Kansas Multiple Listing Service, and city sector, as defined by the Wichita State University Center for Real Estate.15

To calculate land leverage for a parcel, the value of the land must be identified separately from the value of the improvements. We do this in two ways using two different types of data. Our first empirical strategy – the "market approach" – is to obtain market values of land and improvements directly. This is only possible for new construction, where the sale of a vacant lot can be identified prior to the sale of a completed home. To be included in this approach a parcel must have sold three times, first as a vacant lot and then twice as a completed home.16 Of the 92,377 parcels in our database, 1,346 had this pattern of sales.17 Let p_L denote the sale price of the vacant lot, p_1 and p_2 the prices of the first and second sales of the parcel after the new home is constructed, and T the time between the post-construction sales in years. For each parcel, land leverage for the market approach is calculated as $\lambda = p_L / p_1$ and property's gross appreciation rate is $g_V = (p_2 / p_1) - 1$.

The second approach uses assessment data, relying on the Assessor for an accurate relative valuation of a parcel's land and improvements. Parcels are included in this approach if they sold twice over the sample period and contained a single-family home at the time of both sales. Land leverage is given directly by taking the ratio of the Assessor's land and total value estimates in the year of the first sale; the property's appreciation rate is calculated as

$g_V = (p_2/p_1) - 1$ as before. This "assessment approach" allows for broader coverage than the market approach, as every single-family dwelling in the county is assigned these values on an annual basis. Of particular importance, our assessment sample is not restricted to new construction, as is the case for the market sample. This broad coverage, however, comes with the possible disadvantage that land leverage is estimated using assessment values, not market transactions. In the end, 6,615 parcels met the requirements to be included in the assessment sample.

This two-sample, two-method, approach provides a strong test of the robustness of our conclusions, as each of the methods and samples used has strengths that offset potential weaknesses in the others. The structural (nonlinear) estimation explicitly accounts for the time between sales in a mathematically correct way, allowing it to provide the most theoretically accurate estimates of gL and gB. Our reduced form specification, on the other had, allows us to test for the effects of land leverage in the more conventional hedonic regression format.

In the same way, the strengths of each of our samples offset potential weaknesses in the other. For example, one might be concerned that the price of the initial sale, p1, is used both to calculate the property's growth rate, y, and its land leverage, □. This potential source of bias is not present with the assessment sample, however. Conversely, the market sample is not subject to any concerns about appraiser bias in the estimate of the property's land and building values.[18] Furthermore, the samples differ in the ages of the homes included, the time frame of the analysis and the geographic distribution of the homes.

These four sample-method combinations represent a much stronger set of robustness checks than is typically possible for analysis of this type. To preview, the results are qualitatively the same across the four sample-method combinations, suggesting that our conclusions are not an artifact of unobserved idiosyncrasies.

Table 1 provides a summary of the parcel characteristics and their sale dates for the assessment and market samples.[19] For the market sample, the vacant lot sales took place between September 1990 and April 2003, while the most recent sale of a completed house occurred in December 2004. On average, it took 8.25 months to build a home on a vacant lot and slightly more than 48 months for the initial owner of the improved property to resell it. The lots ranged between 1,759 and 50,283 square feet in size, with a median lot size of 10,452 square feet.[20] The homes themselves contained between 808 and 6,489 square feet of finished living area with a median size of 1,734 square feet. Perhaps not surprisingly, prices varied considerably in the sample. For example, unimproved lot prices ranged from $2,000 to $91,000 and final sale prices ranged from $63,000 and $650,000.[21] Median prices, which tended to be closer to the lower end of the range, suggest a skewed distribution.

In contrast, the initial sales in the assessment sample begin in 1997, because this is the first year for which assessment data are available. The average age of the home at the second sale is 33.74 years, much greater than the 4.49 years in the market sample, reflecting the fact that the assessment sample includes the entire age spectrum rather than just new homes. Accordingly, the building and lot sizes are somewhat smaller in the assessment sample, although 46 of the parcels contain more than one acre of land. Sale prices are significantly lower in the assessment sample than they are in the market sample.

Turning to the key variable, land leverage is fairly low in the market sample, with eighty percent of the parcels in the final dataset having between 6.86 to 18.59 of their initial values attributable to land (not shown). Average and median land leverage are approximately twice as high in the assessment sample, reflecting in part the depreciation associated with the older structures in this sample. Regarding annualized appreciation rates of the completed homes, there is wide variation. Just over 10 percent of the homes in our market sample showed a nominal decline in price between the two sales, even as the average appreciation rate was 3.77 percent per year; in the assessment sample, only 8.75 percent of the homes showed nominal price declines.

Table 2 shows the geographic distribution of the data in our samples, while Figure 2 provides a map of the different sectors of the city.22 For the market sample, over 95 percent of our observations come from the east and west sectors. This is reflects our use of new construction to estimate initial land leverage, since most new construction in the Wichita area occurs on the far east and west sides of the city. Parcels in the assessment sample are more evenly distributed across Wichita. Table 2 also shows that the average appreciation of homes in both samples was slightly higher than the comparable-period county-wide appreciation rate as measured by a hedonic home price index. This likely reflects some upward appreciation bias in our appreciation measure due to the fact that we measure appreciation using repeat sales. Within the market sample, realized appreciation was generally slower in the east sector than it was in the inner sectors. This stands in contrast to the appreciation measured by the home price index, which revealed stronger appreciation on the east and west sides. This difference is due to the differing time periods covered by our two samples, and the fact that the home price index measures appreciation using all existing homes that have sold, whereas our market sample contains only new construction that has resold.

Structural Regression Results

Table 3 shows the estimation results from our nonlinear structural model. Estimates using both samples reveal highly significant estimates for both land and building appreciation rates. These estimates indicate that building values grew at an annual rate of between 3.4 and 4.4 percent, depending on the sample. There are two possible explanations for this difference. First, the market sample covers nearly 14 years, while the assessment sample only covers 7 years. Thus, the difference could be due to differences in construction cost inflation over those different time periods. Moreover, given that g_B measures the increase in construction costs less any physical or functional depreciation, the difference could be the result of differences in depreciation rates between the older homes in the assessment sample and the new homes used in the market sample, with new homes depreciating at a faster rate. Both explanations likely play a role.

Land values in our samples appreciated at an annual rate of 6.3 to 8.7 percent. Consistent with our discussion earlier and the prediction of the Land Leverage Hypothesis, land values in the Wichita area have been growing at a faster rate than building values. In addition, the estimates are fairly consistent in suggesting that land values have been growing almost twice as fast as building values.

We can rewrite expression (1) as

$$g_V = g_B(1-\lambda) + g_L\lambda ,$$

which shows that that the growth rate in overall property values can be decomposed as the weighted average of the building and land growth rates, with the weights based on land leverage. Using the regression coefficients shown in Table 3 and the average land leverage in our market sample of 11.73 percent, we see that the average predicted property value growth rate is 3.74 percent. This is very close to our market sample mean growth rate of 3.77 percent, providing some confirmation of the validity of our estimates. The same check can be undertaken for the assessment sample estimates, which indicated an average predicted property value growth rate of 5.34 percent, quite close to the actual figure of 5.43 percent.

These nonlinear regression results can be used to emphasize how land leverage impacts overall property appreciation rates. Consider an alternative community of new homes with the same economic fundamentals as the communities in our market sample (i.e., supply of developable land, transportation costs, population growth, construction labor and materials costs, etc). Because the economic fundamentals are identical, land and building growth rates should be as well. If, however, homes in this alternative community had an average land leverage of, say, 90 percent, the overall property appreciation rate in the community would be 6.01 percent.23 Thus, the higher average land leverage in this community would result in nearly twice the average annual housing appreciation despite the same economic fundamentals driving the housing market.

Reduced Form Regression Results

The advantage of our structural specification is that it accurately accounts for the differing holding periods among the properties in our sample. The disadvantage is that it is very difficult to incorporate control variables and check the robustness of the model specification. For example, it is entirely plausible that the physical characteristics of the house may affect the building appreciation rate, g_B, and hence the property's overall appreciation rate, g_V.

Tables 4 and 5 show the results from various reduced form model specifications. The first model in each table is a simple linear regression of initial land leverage on annualized growth (expression (2)). Recall that the constant term provides an estimate of g_B, the building value growth rate, while the land value growth rate is the sum of the coefficient on □ and the constant term. Thus, the reduced form estimates of $g_B = 3.3\%$ and $g_L = 7.2\%$ for the market sample and $g_B = 4.2\%$ and $g_L = 9.7\%$ for the assessment sample are roughly consistent with the more technically accurate nonlinear regression results. As before, land values grow faster than building values, implying that land leverage can help explain a property's overall appreciation rate.

Because the varying time between the sales in the factor that motivated the use of a nonlinear specification above, Model 2 in the tables includes the time between the two sales and (in the market sample) the time between the lot sale and the first sale, in years, as control variables. These time variables are highly significant and their inclusion in the model raises the estimated coefficients of the constant term in both samples and □ in the market sample.

Model 3 in these tables controls for the sector in which the property is located. Because construction costs should be roughly equal throughout the metropolitan area, location effects should only impact g_L, not g_B. Thus, these variables are incorporated as interaction terms between □ and sector dummy variables with the west sector serving as the omitted category. These regressions show that land values have grown at different rates throughout the city. Both the assessment and market estimates suggest that land values in the east sector grew more slowly than values elsewhere in Wichita. This estimate is plausible given events that occurred in east Wichita during our sample period. This sector was home to the corporate headquarters of Pizza Hut and Rent-a-Center. Both moved out of Wichita in the late 1990s, which dampened the market for high-end homes on the east side of Wichita for a number of years. The lower estimated growth rate in land values for this sector is therefore not unexpected.

The models offer different implications for how land values have evolved in other sectors in the city as well. Estimates using the assessment sample suggest that land value growth has been greater in inner quadrants than in the west sector.[24]

The fourth and fifth models in these tables include control variables for the year in which the property was purchased, while the fifth model also includes the physical characteristics of the homes.[25] The year dummies are interacted with □, while the physical characteristic variables are entered into the model directly because they affect building growth rates rather than land value growth rates. Though the point estimates for the growth rates in the final model are considerably higher, the same qualitative story remains: Land in Wichita appreciated more rapidly than improvements and, in accordance with the prediction of the Land Leverage Hypothesis, homes with higher land leverage appreciated at a faster rate than those with lower land leverage.

It is important to remember that the dependent variable in these regressions is the annualized growth in the property's value. Thus, the coefficients are interpreted as the impact on growth rates rather than the direct impact of these characteristics on home values.

Thus, the negative coefficient on the size of the home simply implies that large homes appreciate at a slower rate than do smaller homes.

So What? Implications of the Land Leverage Hypothesis

The previous sections demonstrate that changes in overall property value depend critically on how much of a property's value is represented by land value, a proportion we call land leverage. Our use of Wichita to show the land leverage effect is particularly noteworthy, because Wichita's limited variation in house price appreciation and low average land leverage should bias the analysis against finding a land leverage effect.

Considering land leverage can be important for achieving a better understanding of many real estate market phenomena and conducting more informative evaluations of many real estate policies. This section highlights four specific areas – house price measurement, zoning and housing investment, housing subsidy policy, and housing bubbles – where land leverage could have real and direct effects, and can either improve or sharpen the nature of analysis. All are areas ripe for future research. Although the discussion in this section focuses on housing issues, land leverage should in principle be relevant for all types of real estate.

Measurement of house prices

Current hedonic methods for measuring house prices are accurate to the degree that all the features that contributed to a property's value are accounted for. However, hedonic indexes typically either lack locational controls or include only crude ones, such as distance from city center or dummies for fixed locations. Moreover, they are generally not allowed to vary over time. Our findings support the notion that land and improvements need not appreciate at the same rate. Imposing this, or omitting it, is likely to lead to bias in measured prices.

In this context, land leverage represents an aggregate measure of the value of all the locational amenities that contribute to a house's total value. Its inclusion in a hedonic regression should remove the coefficient bias associated with the omitted locational amenity variables and yield a hedonic price index that more accurately characterizes how house prices in a market have evolved over time. Future research should establish the extent to which the hedonic methodology produces biased coefficient estimates and indexes, and the extent to which incorporating land leverage into hedonic analyses changes inferences regarding market dynamics.

House prices and the housing bubble

Perhaps no housing issue has been more prevalent in the popular press and among academics as the question of whether the unprecedented rise in home prices since 2001 is sustainable or reflecting of a speculative price bubble. Whether a large price increase reflects a well-functioning market or is beyond what could be expected given market fundamentals depends on the underlying fundamentals and on which properties are transacting. Regarding the latter point, given the preceding analysis, if there has been a shift in the land leverage associated with transacting properties over time, then historical housing market relationships may no longer hold. In particular, if high land leverage properties are becoming a larger fraction of total transactions, then one should expect higher price responses to changes in economic conditions and more volatile markets overall. Such a dynamic could explain the recent steep trajectories for home prices. Further, if land leverage varied systematically across markets, it could also potentially help explain the variation in price movements across housing markets and be the underlying reason why there are larger price changes in certain "hot" markets on the coasts. Such an explanation for the recent large increases in prices would also suggest that any correction, if it occurred and if the high land leverage proportion of transactions remained above historic levels, might be equally steep.

Housing subsidy policy

U.S. federal housing policy seeks to ensure the availability of "a decent home and suitable living environment for all" (National Housing Act of 1949, preamble), with a key element being lower-income households receiving financial subsidies to make the unit they occupy affordable given their income. To the extent that subsidized units have different degrees of land leverage, units requiring comparable subsidies at a point in time will require significantly different levels of subsidy in the future, with those households in high-leverage units and high-leverage metropolitan areas needing an ever-increasing share of the available subsidy pool to preserve affordability.

This reality has clear implications for the conduct of housing subsidy policy. Significant subsidies to households living in high-leverage units and metropolitan areas limits the number of lower-income households that can receive a subsidy, yet prohibiting or reducing assistance to such households would have clear distributional implications – housing assistance would not be available for homes located in some of the nation's most affluent communities. Ultimately, policy-makers will need an analysis weighing the costs of the limited distribution of subsidy against the benefits accruing to the potentially large number of new households that would be able to receive assistance if subsidy was spatially restricted. Alternatively, if the objective is to maintain a given geographic distribution of assistance, policy-makers might consider a policy in which subsidization is made available only for properties whose land leverage does not exceed some threshold, which would limit the degree to which the geographic concentration of funding would shift significantly over time.

Investment, zoning, and renovation

Owners continually assess a property's highest and best use, and as land leverage increases a property's highest and best use shifts away from single-family residential to multi-family residential and commercial uses. However, if zoning limits an owner's ability to reposition a property, owners of properties with high land leverage might rationally be expected to increase consumption within the existing land use through renovation.

This link between leverage and renovation through zoning is important given increased attention being placed on the price of housing relative to the cost of renting. The recent run-up in the price of housing without an attendant increase in rent levels, resulting in elevated housing price-to-earnings (P/E) ratios (with rent representing a house's earnings), has led some to question the rationality of the housing market and argue for the existence of a housing bubble (Leamer, 2001). However, a P/E ratio makes sense for housing only if the ownership and rental properties remain fixed in terms of their quality. If the relationship between land leverage and renovation activity holds, then quality may not be fixed for ownership properties and the quality of ownership properties might be increasing faster than the quality of rental properties in high leverage areas.[26] If so, one might expect P/E ratios in these areas to grow and exceed levels seen historically. Research that helps highlight the nature of the relationship between land leverage and renovation propensity can thus potentially further the ability to assess the effects of land use restrictions and the rationality of housing markets.

Conclusion

This paper introduces the notion of land leverage, which reflects the proportion of the total property value embodied in the value of the land, as a significant factor for establishing the trajectory of house prices. The Land Leverage Hypothesis emerges from a recognition that the value of land and value of improvements on that land are likely to evolve differently over time. Because total property appreciation is a weighted average of these, properties that vary in terms of how value is distributed between land and improvements will show different prices changes in response to the same economic shock to land values. We argue that the magnitude of the price response to market shocks will be positively related to the extent of land leverage, and present evidence using data on parcels located in Wichita, Kansas that is strongly supportive of this view. Moreover, it is likely the influence of land leverage may be quite small in a market such as Wichita, where locational premia derived from transportation costs cannot be as significant as they may be in larger cities.

The notion of land leverage is then shown to have potentially important implications for understanding how housing markets operate. It is shown to be potentially relevant for determining house prices, building price indexes, assessing the costs of land use restrictions, shaping housing policy, and assessing the rationality of housing markets. Future research should focus on highlighting the role of land leverage in these and other areas.

This framework is consistent with other research that has emphasized the role that regulation can play in affecting land values. For example, Glaeser and Gyourko (2002) and Glaeser, Gyourko and Saks (2005) argue that zoning restrictions in urban areas serve to amplify house price changes by creating scarcity that increases land values. The current work would suggest that the effects of these regulatory restrictions is more acute in those areas and for those properties that feature higher land leverage.

Although the focus of this paper has been on home price appreciation, there is nothing that limits the Land Leverage Hypothesis to housing. In principle, land and building appreciation rates can be decomposed in the same way for all property types. The implications of this research may be of particular interest for commercial property analysts and investors because of the wide variation in the degree of land leverage among such properties within market areas and the rewards from accurately forecasting future returns.

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References

Alonso, W. 1964. *Location and Land Use*. Harvard University Press: Cambridge.

Arnott, R.J., R. Davidson and D. Pines. 1983. Housing Quality, Maintenance and Rehabilitation. *Review of Economic Studies* 50: 467-494.

Chinloy, P. 1980. The Effect of Maintenance Expenditures on the Measurement of Depreciation in Housing. *Journal of Urban Economics* 8: 86-107.

Clark, D.E. and W.E. Herrin. 1997. Historical Preservation and Home Sale Prices: Evidence from the Sacramento Housing Market. *Review of Regional Studies* 27: 29-48.

Coulson, N.E. 1989. The Empirical Content of the Linearity-As-Repackaging Hypothesis. *Journal of Urban Economics* 25: 295-309.

Coulson, N.E. and R.M. Leichenko. 2001. The Internal and External Impacts of Historical Designation on Property Values. *Journal of Real Estate Finance and Economics* 23: 113-124.

Davidoff, T. 2004. Maintenance and the Home Equity of the Elderly. Unpublished manuscript, University of California at Berkeley.

Davis, M.A. and M.P. Palumbo. 2006. The Price of Residential Land in Large U.S. Cities. Federal Reserve Board Finance and Economics Discussion Series #2006-25.

Glaeser, E.L. and J. Gyourko. 2002. The Impact of Zoning on Housing Affordability. Harvard Institute of Economics Research Discussion Paper No. 1948.

Glaeser, E.L. J. Gyourko and R.E. Saks. 2005. Why Have Housing Prices Gone Up? Harvard Institute of Economics Research Discussion Paper No. 2061.

Goodman, A.C. and T.G. Thibodeau. 1995. Age-Related Heteroskedasticity in Hedonic House Price Equations. *Journal of Housing Research* 6: 25-42.

Kain, J.F. and J.M. Quigley. 1970. Measuring the Value Of Housing Quality. *Journal of the American Statistical Association* 65: 532-548.

Knight, J.R. and C.F. Sirmans. 1996. Depreciation, Maintenance, and Housing Prices. *Journal of Housing Economics* 5: 369-389.

Leamer, E.E. 2001. *Bubble Trouble: Your Home Has a P/E Ratio Too.* UCLA Anderson Forecast report, June.

Leichenko, R.M., E. Coulson and D. Listokin. 2001. Historic Preservation and Residential Property Values: An Analysis Of Texas Cities. *Urban Studies* 38: 1973-1987.

Malpezzi, S., L. Ozanne, and T. Thibodeau. 1987. Microeconomic Estimates of Housing Depreciation. *Land Economics* 6: 372-385.

Margulis, H.L. 1998. Predicting the Growth and Filtering of At-Risk Housing: Structure Ageing, Poverty and Redlining. *Urban Studies* 35: 1231-1259.

Mills, E. 1967. An Aggregative Model of Resource Allocation in a Metropolitan Area. *American Economic Review* 57: 197-210.

Mills, E. 1972. *Urban Economics.* Scott Foresman: Glenview, IL.

Muth, R. 1969. *Cities and Housing.* University of Chicago Press: Chicago, IL.

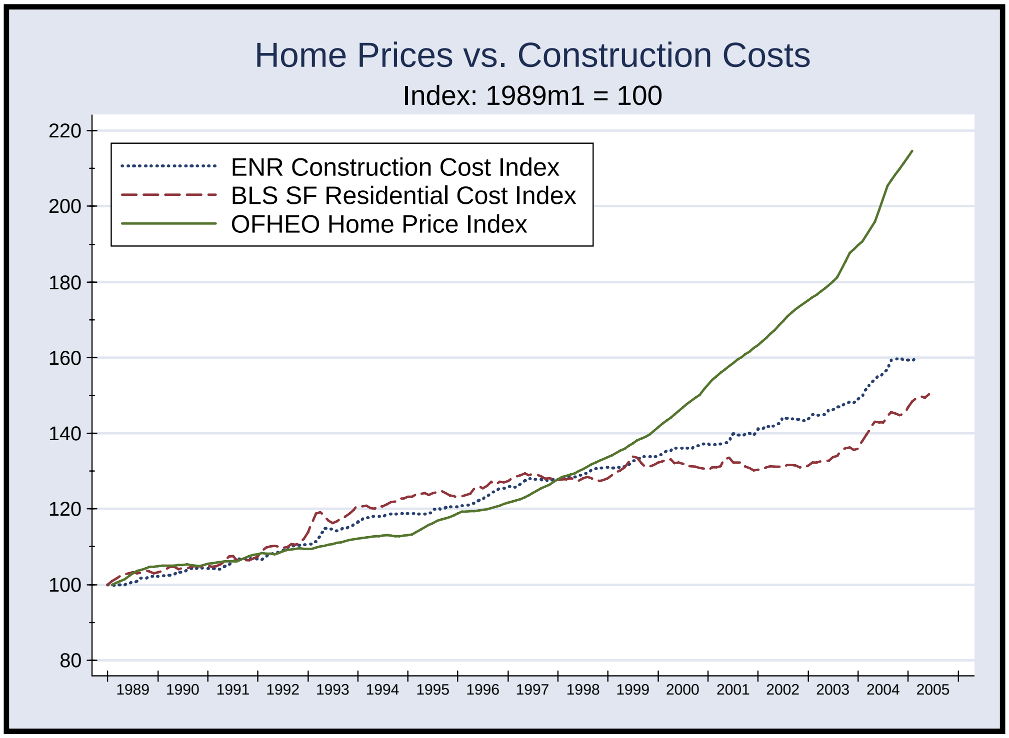
Ricardo, D. 1821. *Principles of Political Economy And Taxation.*

Rosen, S. 1974. Hedonic Prices and Implicit Markets: Produce Differentiation in Pure Competition. *Journal of Political Economy* 82: 34-55.

Schaeffer, P.V. and C.A. Millerick. 1991. The Impact of Historic District Designation on Property Values: An Empirical Study. *Economic Development Quarterly* 5: 301-331.

Somerville, C.T. and C. Holmes. 2001. Dynamics of the Affordable Housing Stock: Microdata Analysis of Filtering. *Journal of Housing Research* 12: 115-140.

Figure 1



NOTE: The ENR Construction Cost Index is an index of construction costs published in *Engineering News Record*. This index covers all types of construction. The BLS SF Residential Cost Index is the single-family residential cost index produced by the Bureau of Labor Statistics as a part of the Producer Price Index series. Finally, the OFHEO Home Price Index is the 2005Q1 release of the national home price index published by the Office of Federal Housing Enterprise Oversight; monthly values of this index were imputed from the quarterly figures. All indices were rescaled to 1989m1 = 100.

Table 1 – Summary Statistics of Parcels in Market and Assessment Samples

Variable	*Market Sample*					*Assessment Sample*				
	Min	**Median**	**Max**	**Mean**	**Std. Dev.**	**Min**	**Median**	**Max**	**Mean**	**Std. Dev.**
Lot Sale	1990m9	1995m11	2003m4	1995m12		n/a				
Sale$_1$	1991m5	1996m6	2003m9	1996m8		1997m1	1999m1	2003m10	1999m3	
Sale$_2$	1993m6	2000m9	2004m12	2000m9		1998m1	2002m8	2004m12	2002m5	
Const. Time	1 mo	7 mo	24 mo	8.25 mo	4.75 mo	n/a				
Resale Time	12 mo	43 mo	135 mo	48.40 mo	25.64 mo	12 mo	35 mo	93 mo	37.62 mo	17.97 mo
Age at Sale$_2$	0 yr	4 yr	11 yr	4.49 yr	2.16 yr	1 yr	30 yr	131 yr	33.74 yr	24.73 yr
Bldg. SF	808	1,734	6,489	1,944	783	483	1,304	6,916	1,495	673
Lot SF	1,759	10,452	50,283	11,869	5,074	1,790	8,623	211,200	10,262	6,555
Lot Price	$2,000	$14,900	$91,000	$17,769	$11,540	n/a				
Price$_1$	$45,000	$128,320	$626,617	$153,378	$79,078	$3,500	$88,125	$749,500	$102,739	$66,717
Price$_2$	$63,000	$146,950	$650,000	$172,873	$78,662	$5,000	$101,400	$903,503	$115,444	$68,091
g_V	-18.91%	3.57%	47.75%	3.77%	4.30%	-36.09%	4.23%	160.00%	5.43%	7.77%
λ	1.68%	10.25%	38.92%	11.73%	4.69%	2.14%	21.54%	98.28%	23.26%	9.84%
N	1,346					6,615				

Table 2 – Geographic Distribution of Parcels in Assessment and Market Samples

	Market Sample				*Assessment Sample*			
Sector	**Parcels**	λ	g_V	**HPI Δ***	**Parcels**	λ	g_V	**HPI Δ***
East	631	11.58%	3.07%	4.03%	1,441	23.18%	3.07%	3.45%
NE	7	15.58%	4.16%	2.97%	844	22.58%	6.19%	4.60%
NW	14	12.16%	3.45%	3.73%	982	22.85%	7.01%	5.29%
SE	6	10.87%	4.53%	2.75%	929	23.94%	6.97%	4.50%
SW	17	14.66%	5.11%	3.84%	648	23.36%	7.77%	5.09%
West	671	11.76%	4.40%	4.25%	1,771	23.50%	4.44%	4.05%
Total	1,346	11.73%	3.77%	3.68%	6,615	23.26%	5.43%	4.32%

NOTE: Sectors are defined by the Wichita State University Center for Real Estate.

* HPI Δ is the annualized change in a hedonic home price index. For the market sample, this is measured between 1990 and 2004, while it is measured between 1997 and 2004 for the assessment sample. This HPI is based on all existing home sales and is generated by the Wichita State University Center for Real Estate (http://realestate.wichita.edu); the data in this table were derived from the 4th Quarter 2004 revision of the index.

λ = land leverage; g_V = annualized appreciation.

Figure 2 – Sectors of the City of Wichita

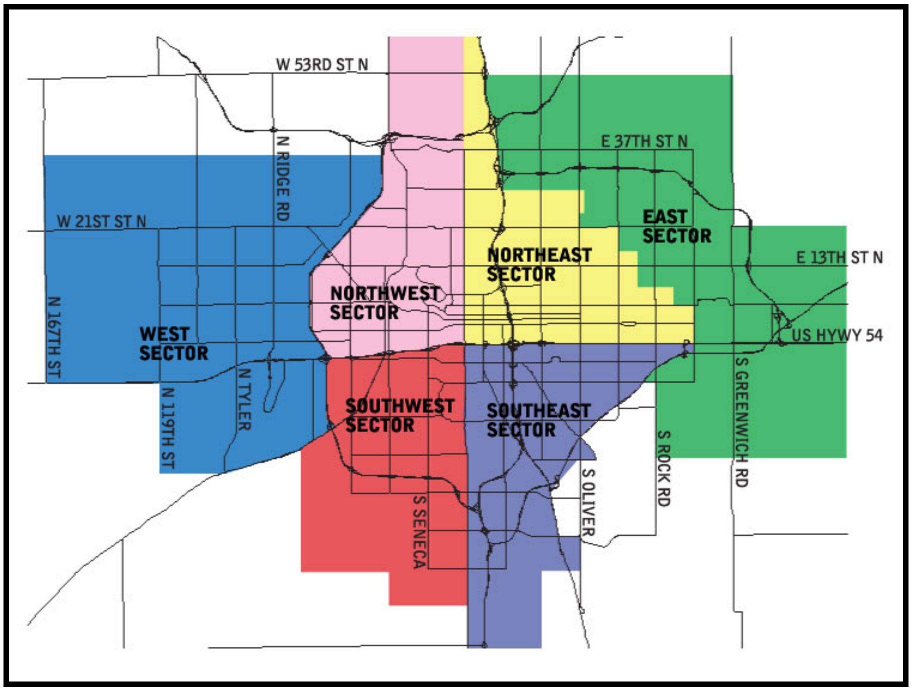


Table 3 - Nonlinear Regression Results

	Market sample	Assessment sample
g_L	0.063	0.087
	(3.17)**	(11.94)**
g_B	0.034	0.044
	(11.03)**	(17.11)**
Observations	1,346	6,615
R-squared	0.44	0.3300

Absolute value of t statistics in parentheses

* significant at 5%; ** significant at 1%

Table 4 - Reduced Form Regression Results, Market Sample

	Model 1	***Model 2***	***Model 3***	***Model 4***	***Model 5***
Constant (g_B)	0.033	0.053	0.054	0.047	0.089
	(10.62)**	(12.73)**	(13.08)**	(9.72)**	(10.36)**
$\lambda\,(g_L - g_B)$	0.039	0.042	0.082	0.193	0.254
	(1.56)	(1.63)	(2.84)**	(2.98)**	(3.39)**
Time to resale		-0.002	-0.002	-0.002	-0.002
		(2.97)**	(3.40)**	(2.45)*	(3.23)**
Time to first sale		-0.018	-0.018	-0.018	-0.010
		(6.16)**	(6.02)**	(6.00)**	(3.54)**
SW × λ			0.022	-0.013	-0.070
			(0.65)	(0.34)	(1.58)
NW × λ			-0.044	-0.041	-0.029
			(0.76)	(0.64)	(0.33)
NE × λ			-0.038	-0.019	-0.077
			(0.57)	(0.28)	(1.15)
SE × λ			0.094	0.134	0.098
			(5.26)**	(0.74)	(0.55)
EAST × λ			-0.100	-0.098	-0.032
			(5.26)**	(5.19)**	(1.72)
1992 × λ				-0.025	-0.060
				(0.29)	(0.68)
1993 × λ				-0.078	-0.144
				(1.21)	(1.87)
1994 × λ				-0.113	-0.196
				(2.04)*	(2.89)**
1995 × λ				-0.103	-0.181
				(1.81)	(2.64)**

Table 4 - Reduced Form Regression Results, Market Sample

	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*
1996 × λ				-0.043	-0.104
				(0.74)	(1.47)
1997 × λ				0.006	-0.072
				(0.10)	(1.01)
1998 × λ				-0.121	-0.213
				(1.73)	(2.80)**
1999 × λ				-0.159	-0.270
				(2.01)*	(2.93)**
2000 × λ				-0.087	-0.172
				(0.55)	(1.07)
2001 × λ				0.113	-0.019
				(1.13)	(0.20)
2002 × λ				0.137	0.063
				(1.12)	(0.48)
2003 × λ				0.278	0.135
				(1.42)	(0.70)
Total SF					-0.013
					(2.69)**
Basement SF					0.020
					(3.61)**
Bedrooms					-0.002
					(1.07)
Full baths					0.005
					(1.55)
Total plumbing fixtures					-0.003
					(2.74)**

Table 4 - Reduced Form Regression Results, Market Sample

	Model 1	***Model 2***	***Model 3***	***Model 4***	***Model 5***
Style: Ranch					0.000
					(0.08)
Style: Split level					-0.018
					(2.53)*
Style: Conventional					0.003
					(0.48)
Style: Colonial					-0.075
					(5.44)**
Style: Twinhome					0.098
					(1.12)
Style: Walk-out ranch					-0.004
					(0.70)
Siding: Stucco					-0.020
					(1.92)
Siding: Alum./vinyl/steel					0.004
					(0.63)
Siding: Brick					0.005
					(0.42)
Siding: Masonry/frame					0.003
					(0.37)
Observations	1,346	1,346	1,346	1,346	1,346
R-squared	0.0011	0.0333	0.0517	0.0705	0.1419

Robust t statistics in parentheses

* significant at 5%; ** significant at 1%

Table 5 - Reduced Form Regression Models, Assessment Sample

	Model 1	***Model 2***	***Model 3***	***Model 4***	***Model 5***
Constant (g_B)	0.042	0.066	0.060	0.063	0.092
	(16.78)**	(20.99)**	(20.11)**	(18.94)**	(11.75)**
$\lambda\,(g_L - g_B)$	0.055	0.052	0.037	0.063	0.060
	(4.70)**	(4.55)**	(3.78)**	(5.31)**	(5.32)**
Time to resale		-0.008	-0.009	-0.009	-0.010
		(11.07)**	(12.15)**	(11.96)**	(12.67)**
SW × λ			0.157	0.157	0.085
			(7.69)**	(7.72)**	(4.32)**
NW × λ			0.129	0.128	0.052
			(7.27)**	(7.27)**	(2.78)**
NE × λ			0.090	0.088	0.039
			(4.48)**	(4.37)**	(1.81)
SE × λ			0.121	0.119	0.045
			(8.16)**	(8.04)**	(2.55)*
EAST × λ			-0.050	-0.052	-0.032
			(8.47)**	(8.53)**	(5.32)**
1998 × λ				-0.014	-0.016
				(1.15)	(1.28)
1999 × λ				-0.035	-0.038
				(3.38)**	(3.87)**
2000 × λ				-0.036	-0.038
				(2.66)**	(2.90)**
2001 × λ				-0.046	-0.054
				(2.13)*	(2.46)*
2002 × λ				-0.036	-0.038
				(1.70)	(1.80)
2003 × λ				-0.068	-0.080
				(2.02)*	(2.37)*

Table 5 - Reduced Form Regression Models, Assessment Sample

	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*
Total SF					-0.000
					(2.08)*
Basement SF					0.000
					(2.24)*
Bedrooms					-0.000
					(0.05)
Full baths					0.000
					(0.12)
Total plumbing fixtures					-0.002
					(3.40)**
Style: Ranch					0.005
					(1.24)
Style: Split level					0.003
					(0.61)
Style: Conventional					0.005
					(1.11)
Style: Modern					0.002
					(0.20)
Style: Earth Contact					-0.072
					(11.57)**
Style: Bungalow					0.023
					(2.74)**
Style: Old Style					0.058
					(3.77)**
Style: Colonial					0.069
					(1.87)
Style: Traditional					0.005
					(0.42)

Table 5 - Reduced Form Regression Models, Assessment Sample

	Model 1	***Model 2***	***Model 3***	***Model 4***	***Model 5***
Style: Other					-0.014
					(0.40)
Style: Twinhome					0.003
					(0.50)
Style: Walk-out ranch					-0.004
					(0.81)
Style: Cottage					0.124
					(16.34)**
Siding: Block					-0.026
					(0.97)
Siding: Stucco					-0.008
					(0.72)
Siding: Alum./vinyl/steel					0.006
					(1.67)
Siding: Composition					0.027
					(1.04)
Siding: Asbestos					0.020
					(1.89)
Siding: Brick					-0.001
					(0.28)
Siding: Stone					0.002
					(0.11)
Siding: Masonry/frame					0.000
					(0.09)
Observations	6,615	6,615	6,615	6,615	6,615
R-squared	0.0047	0.0259	0.0842	0.0860	0.1145

Robust t statistics in parentheses

* significant at 5%; ** significant at 1%

Endnotes

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[1] A referee reminded us of another motivating quotation from Woody Allen's *Love and Death*; we are indebted for the reference. "In addition to our summer and winter estate, he owned a valuable piece of land. True, it was a small piece. But he carried it with him wherever he went. 'Dimitri Pietrovich! I would like to buy your land.' 'This land is not for sale. Some day, I hope to build on it.' He was an idiot. But I loved him."

[2] One could tie this approach to Ricardo (1821) if the urban core is viewed as the most productive, or "fertile," land in an area.

[3] The empirical analysis shows that a key feature of these original location theory papers – the homogeneity of housing – is supported in principle. Our data indicate that, measured in terms of variance in value, dwelling physical characteristics are relatively homogeneous compared to the implicit locational amenities.

[4] In some circumstances, the hedonic price function should be linear with respect to housing characteristics if these inputs are mobile while land is fixed (Rosen, 1974). Coulson (1989), among others, has tested this and obtained results suggesting that this often does not hold. In any event, the tests in the current analysis are based on growth in prices rather than prices directly, which minimizes the significance of these concerns.

[5] See Malpezzi, Ozanne, and Thibodeau (1987) and Knight and Sirmans (1996), among others.

[6] A third source of depreciation is neighborhood obsolescence, in which market and demographic forces reduce a neighborhood's attractiveness from a residential perspective. Because it is a locational factor, we argue that this external obsolescence is often best attributed to the land, not the improvements.

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[7] See, for example, Kain and Quigley (1970), Chinloy (1980), Malpezzi, Ozanne, and Thibodeau (1987), and Goodman and Thibodeau (1995).

[8] Margulis (1998) and Somerville and Holmes (2001) are two examples of research that focuses on filtering.

[9] Davidoff (2004) is a recent example.

[10] To the extent that this work cures functional obsolescence, it is possible for it to increase the value of the home by more than the cost of the renovation. For example, Arnott, Davidson, and Pines (1983) presents a model where maintenance can increase value.

[11] Schaeffer and Millerick (1991), Clark and Herrin (1997), Leichenko, Coulson, and Listokin (2001), Coulson and Lahr (2005). Historic designation can also stop or slow neighborhood obsolescence. Coulson and Leichenko (2001) has shown that non-designated houses located near historic homes also see their value increase, suggesting that historic preservation has positive externalities associated with it. Dale-Johnson and Redfearn (2005) find that the value of historic neighborhood designation may be a function of the neighborhood's socioeconomic characteristics.

[12] In closely related but independent work, Davis and Polumbo (2006) use the land/improvements decomposition concept to estimate land price indices for a large number of metropolitan areas across the U.S. Our analysis shows that the land leverage effect is empirically relevant within a single metropolitan area, whereas Davis and Polumbo assume this relationship to hold across metropolitan areas to construct their land price indices.

[13] Sedgwick County's 2000 population was 452,869, while the four-county MSA's population was 571,162; county and MSA population growth since 1990 were slightly faster than that of the city itself.

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[14] Wichita/Sedgwick County Metropolitan Area Planning Department *2004 Development Trends Report*.

[15] Information about the sector definitions can be found at the WSU Center for Real Estate website (http://realestate.wichita.edu) in the section on the WSU Home Price Index.

[16] In order to be included in the final sample, the completed home must have sold within two years of the vacant lot, and the final sale must have occurred at least one year after that. The latter one-year restriction is a guard against property flipping, although it is worth noting that given the low average appreciation rates, flipping is not a common phenomenon in the Wichita area.

[17] Initially we identified 1,353 parcels in the Wichita sectors that fit this sales pattern. Seven parcels were dropped from the final data set because the initial leverage figure was implausibly large (greater than 88 percent). Manual inspection of these observations strongly suggested data entry problems, usually involving a lot price suspiciously close to the final sale price of the completed home.

[18] Systematic appraisal bias, to the extent it exists, should not be an issue because the key metric is the *relative* value of land to total value across parcels, which will generally remain largely unchanged if there are systematic errors in appraisal.

[19] For each physical characteristic of the property, our database contains values from the time of each sale. Unless otherwise noted, the values from the second sale have been used because the Assessor continually updates the data to correct data entry errors.

[20] The smallest lot size of 1,759 is likely a data entry error; the next smallest lot in the sample is 4,638 square feet. In addition, we have two parcels for which the size of the lot is missing.

All of the regressions presented below were also run after omitting these three observations with virtually identical results.

[21] All prices have been left at their nominal values because the focus in or nominal rather than real appreciation.

[22] Although the sales database contains both rural and urban parcels, all of the observations in our final sample came from the city or its contiguous neighbors.

[23] Using the market sample estimate, because the example highlights new homes, this quantity is calculated as follows: $0.034 \times (1 - 0.90) + 0.063 \times 0.90$.

[24] There is very little power to estimate the inner-quadrant land values in the market sample because of the paucity of observations in these sectors.

[25] We also explored how the effect of land leverage may vary by subsample, including large and small homes, homes on big and small lots, and sector of the city. These regressions (not shown) resulted in only minor differences in point estimates and no qualitative differences in our key land leverage conclusions.

[26] Some communities have seen a marked increase in home purchase transactions in which a buyer razes the existing structure and replaces it with a significantly larger one. This is an extreme example of the renovation motive.