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LAND POLICIES AND THEIR OUTCOMES

Edited by Gregory K. Ingram and Yu-Hung Hong

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Gregory K. Ingram and Yu-Hung Hong

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Urban Land Rents in the United States

David Barker

Measurement of aggregate land values and land rents was not a major priority of economists over most of the past century. The lack of professional interest in land dates at least to the publication of *The Distribution of Wealth* in 1899 by John Bates Clark. Clark, a vocal opponent of the "single tax" movement for higher taxes on land, defined land out of existence as a separate factor of production. His economic models contained two factors, labor and capital, instead of the classic "holy trilogy of economics": land, labor, and capital.[1] Land was nothing more than part of the overall stock of capital. The success of Clark's approach helps to explain the current prominence of fields such as labor economics and finance over land and urban economics.

The furious debate in the late nineteenth and early twentieth centuries about whether land was fundamentally different from other forms of capital was won by Clark and other neoclassical economists. Two factor models have proven to be useful tools for understanding general principles of how economies work. The usefulness of such highly abstract models is limited, however. General economic questions require models with a high degree of abstraction and highly aggregated data, but more specific questions require more detailed models and data. The capital stock is composed of a variety of types, each of which has unique aspects. For example, commercial airplanes, an important part of the world's capital stock, are much more mobile than most other forms of physical capital. Detailed economic analysis occasionally needs to take account of this mobility and thus requires information on the extent and nature of this part of the capital stock. Land, another important part of the capital stock, is the least mobile kind of capital and yet the most difficult to reproduce. For many purposes, then, it would be useful for

The author thanks the Lincoln Institute of Land Policy for its generous support.

1. This term was used by Chicago economist Frank H. Knight; see Becker (1971, 159).

economic models to take account of these characteristics, and data describing the stock of land would be useful in testing these models.

An example of the usefulness of including land in economic models was recently pointed out by Davis and Heathcote (2004), who argue that the inelasticity of land has policy implications. They point out that if land constitutes a small share of housing values, then the tax treatment of housing will affect the quantity, but not the price, of housing. If land is a significant portion of the value of housing, however, then policies that raise demand for housing, such as the mortgage interest deduction, could have significant effects on the price of housing. If land supply is inelastic and land is a significant portion of housing value, then favorable tax treatment of housing will increase the price of housing by increasing land prices. But if land is not a significant part of housing value, then housing prices will ultimately be determined only by the costs of construction, not by the level of housing demand. Models of housing value have often assumed that housing prices are determined by construction costs and have ignored the effects of land.

Often, economic models that include land can only be tested if data on aggregate land values are available. Unfortunately, accurately measuring aggregate land values is a difficult task. Land and structures are usually sold as a package, and so the values of the two components can be disentangled only indirectly. Property tax assessors in some jurisdictions separate land and building values, but they often use arbitrary methods, because this division of assessed value rarely has any practical consequence.

Although attempts have been made recently to measure the total value of residential land, none have been made to measure the value of all land, residential and commercial, in the United States. This chapter describes the use of two methods to examine total land values. The first consists of taking a broad view of land values using the Flow of Funds (FOF) data published by the Federal Reserve. The second uses data from sales of vacant land to estimate total land values in four metropolitan areas.

The next section of this chapter describes past attempts to measure land values and land rent. It is followed by a section devoted to describing trends in national land values using the FOF data. The penultimate section analyzes land transaction data from the four large metropolitan areas, and the final section offers some concluding remarks.

Past Attempts to Measure Land Values and Rent

During the early twentieth century, economists had a great deal of interest in measuring the degree of inequality of the distribution of wealth, but reliable data on land wealth were scarce. Spahr (1896) examined data from probated estates, finding that real estate amounted to 42 percent of the total wealth of the United States, but he was not able to determine the relative values of land and buildings. King (1915), using probated estates and a variety of government data, concluded that land rents constituted 8.8 percent of the national income in 1910, and that the percentage had not increased since 1860. He wrote: “As a matter of fact, indications are that rent plays a much less important role in distribution than the followers of Henry George would have us believe” (King 1915, 161).

Hoyt (1933) examined land values in Chicago from 1830 to 1932, documenting remarkably high levels of volatility. He found that booms and busts in land values were related to changes in the outlook for population growth in the city. Doane (1940) estimated land to be 30 percent of the national wealth in 1938, and he learned that land values had declined significantly during the 1930s, consistent with the findings of Hoyt (1933).

In 1961 the Lincoln Foundation sponsored an ambitious project to measure aggregate land rents and land values in the United States using property tax assessment data (Keiper et al. 1961). Because some states reported assessed value for land and buildings separately, the average ratio of land to building value in these states could be applied to other states to estimate land values. And yet property tax assessment data have many limitations, many of which were acknowledged by Keiper et al. Assessments are not always equal to market value, sometimes by design—and often because some property owners are better able to appeal assessments than others. Also, the frequency and quality of assessments vary considerably by jurisdiction. Perhaps most important for the purposes of this chapter, assessors have very little incentive to divide value accurately between land and buildings, because in the vast majority of jurisdictions the tax rate is the same for both. In other words, the tax bill is not affected in any way by the division of value between land and buildings, and so the assessor and the taxpayer are only concerned with the total assessment.

Keiper et al. (1961) found that in 1956 land values were equal to 23 percent of total national wealth and that land rent was approximately 6.4 percent of national income. The difficulties of this estimation are illustrated by a similar study undertaken by Goldsmith (1962), which was updated to estimate aggregate land value for the same year, 1956, examined by Keiper et al. The updated Goldsmith study valued all taxable land in the United States at $212 billion, while Keiper et al. (1961, 157) placed the value at $249 billion. Small differences in assumptions and methodology can result in large differences in estimates of aggregate land values.

Until 1994, the Federal Reserve published data on aggregate land values as part of its regular publication *Balance Sheets for the United States Economy*. Estimated land values increased from 1945 until the late 1980s, when they began to decline. Jorgenson and Wessner (2002) report that the series was discontinued because the underlying data, which included tax assessment information, became unreliable.

Until the 1990s, then, interest in land values was sporadic at best and often practically nonexistent. The dramatic increases in housing prices beginning in the 1990s, however, created an explosion of interest in land values. Pollakowski and Wachter (1990), Malpezzi (1996), Malpezzi, Chun, and Green (1998), Mayer and Somerville (2000), Glaeser, Gyourko, and Saks (2005), and Quigley and Raphael (2005) all find that regulatory constraints on development have contributed to higher housing prices, which means that the price of developable residential land has increased. Barker and Sa-Aadu (2004) provide a theoretical framework to explain recent increases in land prices. Bostic, Longhofer, and Redfearn (2006) examine the effects of higher land prices on housing price volatility. And Davis and Heathcote (2004) and Davis and Palumbo (2006) attempt to estimate the total value of residential land—Davis and Heathcote for the entire United States and Davis and Palumbo for 46 metropolitan areas.

Davis and Heathcote (2004) use data on the replacement cost of structures and a price index of the total cost of housing to back out the value of residential land. They find that since 1983 land has increased in value much more quickly than structures, and that its value has been much more volatile than the value of structures. They estimate that the value of the stock of residential land in 2003 was about equal to the annual gross domestic product (GDP).

Davis and Palumbo (2006) use similar methods to estimate the value of residential land by metropolitan area. They find that land price increases have been widespread across the country, and they confirm that land prices have been volatile.

The rediscovery of land as a unique and important factor of production has parallels in other branches of economics. In 1975 Milton Friedman claimed that most recent advances in macroeconomics were simply rediscoveries of points made by Scottish economist David Hume two centuries earlier (Friedman 1975). Ivor Pearce (1978), commenting on twentieth-century developments in economics, wrote: "Human history is guided not by new ideas, for there are none."[2] Similarly, the recent discovery that land prices may be playing a role in rising housing prices is in some ways a rediscovery of the principles of classical economics. The importance of the irreproducibility of land is stressed in many of these papers, as is the idea that land values tend to increase more rapidly than the values of other assets under certain circumstances.

Extracting Land Values from Flow of Funds Data

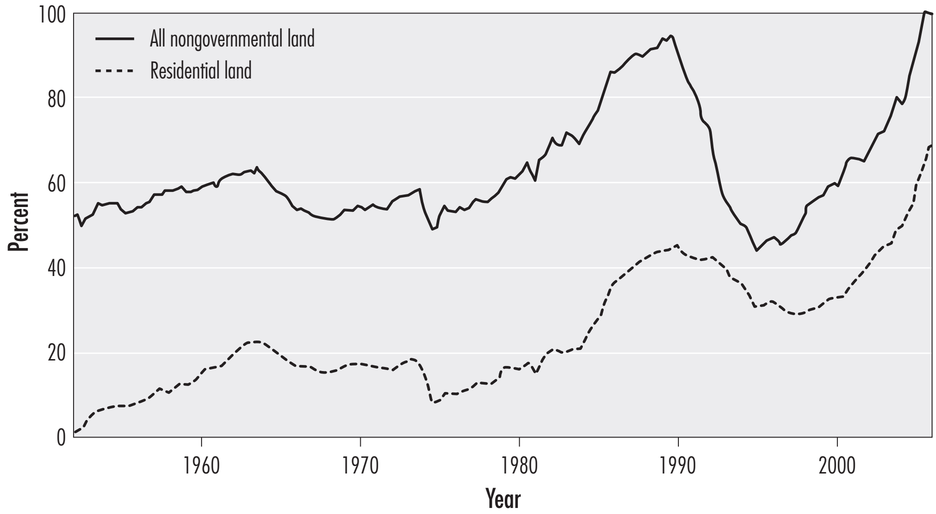
In this section, FOF data published by the Federal Reserve and data from Davis and Heathcote (2004) are used to construct rough estimates of the value of land for the entire United States and for four U.S. cities. These estimates are then compared with estimates obtained from vacant land sales, which are described in the next section.

Although the Federal Reserve no longer publishes an estimate of aggregate land values for the United States, it does list the total estimated market value of real estate held by households and businesses, as well as the replacement cost of structures owned by the same groups. Logically, land value should be the difference between these two items. But difficulties can arise in interpreting these numbers, some of which are pointed out by Davis and Heathcote (2004). One problem is the inclusion of brokers' commissions in the estimates of the replacement cost of structures. This factor biases the land value estimate downward, because building values are artificially increased by the inclusion of commissions. Another problem is that some types of properties, such as vacant houses, are not included. Finally, at times Davis and Heathcote (2004) uncover unusual changes in the indices when sources of data changed. They also report that the FOF series is being reviewed by the Federal Reserve to consider these problems.

In view of these difficulties, it is not surprising that estimates of commercial land values using other methodologies may differ substantially from estimates constructed from FOF data. The data are useful, however, as a ballpark estimate of

2. These references are from Humphrey (1998).

Figure 7.1
Land Value as a Percentage of Total Personal Income: United States, 1952–2005



Note: Land values are estimated using Flow of Funds data.

aggregate land values. The estimates shown in figures 7.1–7.3, which are for land owned by households and businesses, were constructed by subtracting the replacement cost of buildings from total real estate value.

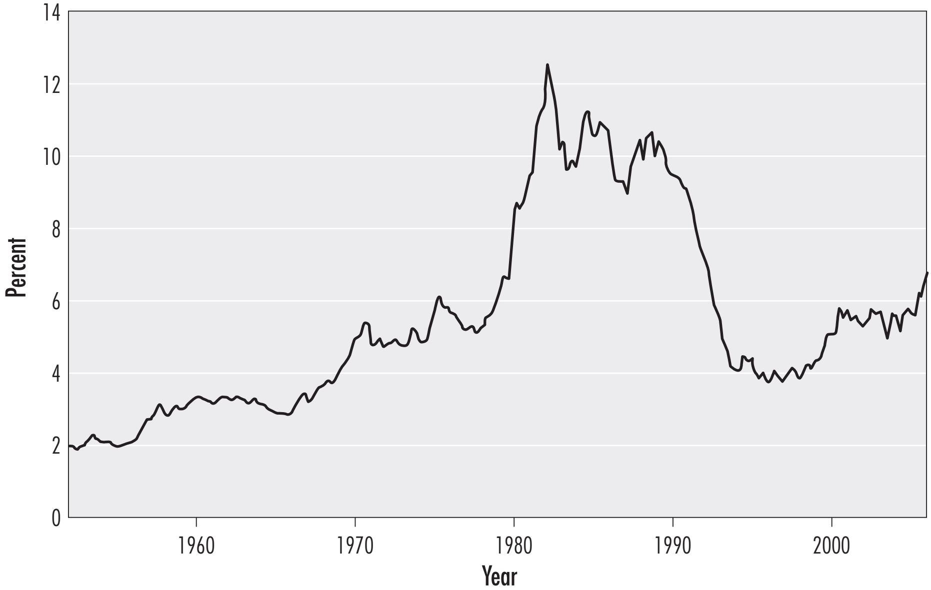
Figure 7.1 presents total nongovernment and residential land as a percentage of total U.S. personal income.[3] After falling dramatically during the early 1990s, land values are now higher than they have been since 1952, with residential land values increasing the most rapidly. Total land values are now greater than total personal income, according to this measure.

Following Keiper et al. (1961), land rent is estimated by multiplying land value by a rate of return. The rate of return chosen should reflect returns that were available in real estate at the time of the transactions that produced the land price data. A common benchmark for real estate returns is the average Baa corporate bond yield, reported regularly by Moody's, because real estate returns have historically been more closely correlated with this rate than with Treasury rates.[4] Commercial properties tend to have yields above the Baa rate, and owner-occupied residential properties tend to have yields below this rate. The rate, which is a reasonable estimate of the average rate of return on real estate over time, can be used as an estimate of a real estate capitalization (cap) rate. Figure 7.2 shows total land value

3. Many of the studies discussed earlier calculated land rent as a fraction of national income. Here personal income is used in order to be compatible with metropolitan statistical area (MSA) estimates. Only personal income is available at the MSA level.

4. See, for example, Green Street Advisors, http://www.greenstreetadvisors.com/sectorreports/valqrtly0305.pdf.

Figure 7.2
Land Rent as a Percentage of Total Personal Income: United States, 1952–2005



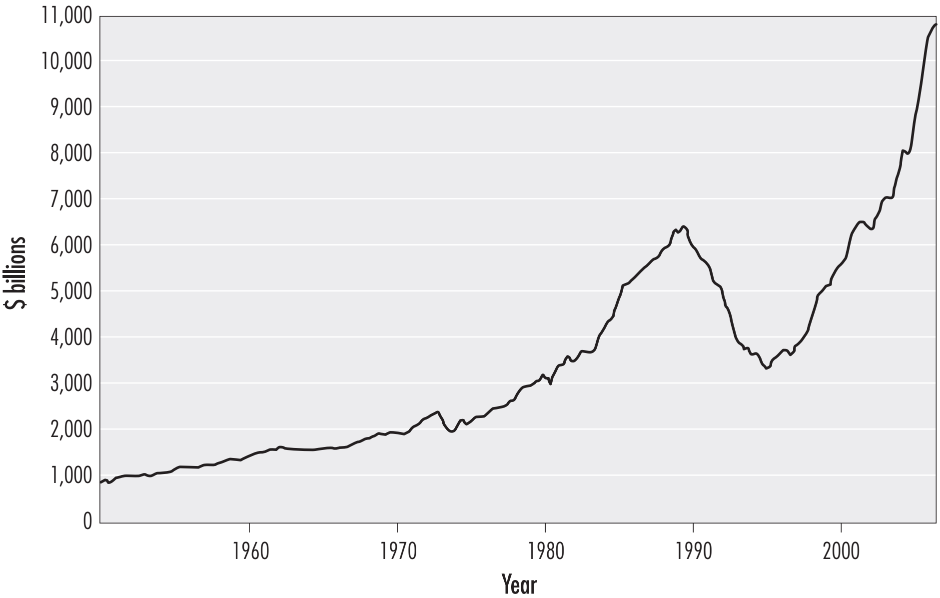
Note: Land rent is estimated as total land value, which is estimated, in turn, using Flow of Funds data multiplied by the Baa corporate bond rate reported by Moody's.

multiplied by this rate of return as a percentage of total U.S. personal income. It reached a high of about 12 percent in 1982 and was still above 10 percent in 1989. The 1980s were a period of high interest rates and high land values. After 1989, interest rates and land values fell, and estimated land rents fell to less than 4 percent of total U.S. personal income. Rising land values increased this figure to 6.5 percent in 2005.

Figure 7.3 shows total land value in constant 2005 dollars. Real land values generally increased from 1952 to 2005, but there were occasional significant downturns. In 1974 total real land value declined by 17 percent, and from 1990 to 1995 the values declined by 48 percent. From 1995 to 2005, real land values more than tripled, to a total value of $10.7 trillion, with residential land totaling $7.3 trillion.

Updated figures using the same methodology as in Davis and Heathcote (2004) yield a 2005 value of $16.3 trillion for residential land. The FOF data for the end of 2005 indicate that residential land is equal to 64.7 percent of total land value. Assuming that Davis and Heathcote's estimate is correct and that the relative value of residential and commercial land from the FOF data is correct, the total value of U.S. land would be $23.9 trillion. This value is significantly higher than the value shown in figure 7.3. That figure shows estimates derived from the FOF data, while the $23.9 trillion estimate takes account of the corrections described in Davis and Heathcote (2004) and applies the same percentage correction to commercial land values.

Figure 7.3
Real Aggregate Land Value: United States, 1952–2005 ($ billions)



Note: Total U.S. land values were estimated using Flow of Funds data in billions of constant 2005 dollars.

Davis and Palumbo (2006) estimate residential land values in selected U.S. cities. More specifically, they estimate each city's percentage of the total value of U.S. residential real estate, as well as the percentage of total real estate value represented by land for residential property for each city. From these estimates, it is possible to obtain the total value of land in each city. If c represents the fraction, by value, of total U.S. residential real estate in a city, l_c represents land as a fraction of total real estate value in the city, l_{US} represents land as a fraction of total real estate value for the entire United States, and L_{US} is the total value of U.S. residential and commercial land, then the total value of land in the city L_c is

(1) $$L_c = L_{US} \frac{cl_c}{l_{US}}.$$

Suppose, for example, that a hypothetical city contains 10 percent of all of the real estate, by value, in the United States. The implication is then that c for this city equals 0.1. If land represents 40 percent of total real estate value for the United States, then l_{US} is equal to 0.4. Finally, if land represents 80 percent of total real estate value in the city, l_c is equal to 0.8. The total land value in the city is clearly more than 10 percent of U.S. land value, because land is a much greater portion of total value in the city than it is for the entire United States. Suppose that land in the United States is worth 100 measured in some unit. Because l_{US} is equal to 0.4, then total U.S. real estate will be worth 250. Because c is equal to 0.1, real estate in the city is worth 25. And because l_c is equal to 0.8, land in the city is worth 20.

This calculation assumes that commercial land value in a city as a fraction of total U.S. land value is the same as residential land value in a city as a fraction of total U.S. land value. Another way to express this assumption is to let RE_{cr} equal the value of residential real estate in a city, RE_c equal the value of all real estate in a city, RE_{usr} equal the value of all U.S. residential real estate, and RE_{US} equal the value of all U.S. real estate, which yields $RE_{cr} / RE_{usr} = RE_c / RE_{US}$.

Although this assumption is needed to use the Davis and Heathcote (2004) results to estimate total (residential and commercial) land values, it is likely to be wrong. Commercial property is more likely to be located on the highest-value land in a city, and the ratio of land to building value is generally higher for commercial property than for residential property. Thus, the estimates of total land value in table 7.1 are likely to be lower than the true values. In the past, residential land values have increased more than commercial values, probably because of the rising home ownership rate, encouraged by various government subsidies, which has increased the demand for land suitable for residential uses. Urban economics models suggest that land values are more elastic in relation to increases in population and income in city centers than elsewhere, and so it is possible that recent land price increases have been at least as great for commercial property as for residential property.

Figures from Davis and Palumbo (2006) for c and l_c are shown in table 7.1, along with the calculation of total land value for four U.S. cities: Los Angeles, Chicago, Philadelphia, and Dallas. These cities were chosen because they were the largest cities for which vacant land sale data could be purchased. The calculation of L_c assumes a value of 0.509 for l_{US} and of $23.9 trillion for L_{US}.

Personal income per capita is roughly constant for these four cities. The largest metropolitan statistical area (MSA) by population, Los Angeles, actually has the smallest income per capita, while Philadelphia, ranked third out of the four MSAs by population, has the highest income per capita. Land values per capita, however, fall quickly and monotonically with MSA population. Land value per capita is 2.7 times greater in Los Angeles than in Dallas, with total land value in Los Angeles estimated at $1.67 trillion.

Table 7.1
Metropolitan Statistical Area Land Value Estimates, Selected Cities

	Los Angeles	Chicago	Philadelphia	Dallas
c	0.0452	0.0355	0.0164	0.0127
l_c	0.7870	0.5210	0.5470	0.4620
L_c (land value, billions)	$1,670	$868	$421	$276
Personal income (billions)	$454	$349	$225	$202
Income per capita	$35,189	$37,166	$38,772	$35,499
Land value per capita	$129,467	$92,409	$72,611	$48,455
Population (millions)	12.899	9.393	5.798	5.696

Source: Values for c and l_c are from Davis and Palumbo (2006).

MSA Land Values from Vacant Land Sales

This section describes the construction of estimates of total land value for Los Angeles, Chicago, Philadelphia, and Dallas using vacant land sales data. The data, purchased from American Real Estate Solutions, were gathered from local government records. Only sales of land classified as vacant were included, and all included sales occurred in 2004 or 2005. The following sales were omitted: sales for $100 or less, because these were most likely gifts of land that were assigned a nominal price for legal purposes; sales of parcels containing fewer than 1,000 square feet, because many of these sales appeared to be either unusual situations or reported with error; multiparcel sales, because many of these sales included parcels that were not vacant;[5] and sales for which the addresses could not be exactly matched to latitude and longitude coordinates.[6] As a final screen for errors, records were sorted by price per acre, and total acres and the highest 1 percent were omitted. Most of the records omitted in this screen appeared to be data entry errors. The final estimate of value for the cities was not significantly affected by these omissions.

Once all these observations were omitted, the remaining data consisted of 2,025 sales for Los Angeles, 3,645 for Chicago, 3,179 for Philadelphia, and 2,943 for Dallas. Table 7.2 summarizes the statistics on these data.

LAND VALUE SURFACE ESTIMATION METHODOLOGY

Once each of the vacant land transaction observations is assigned latitude and longitude coordinates, the next step is to fit a land value surface to the data. A parametric approach might be to assume a functional form for land value as a function of distance from employment and amenity centers. A basic urban model, such as those developed by Alonso (1964), Mills (1969), and Muth (1969) would suggest a form such as

$$P_L(D) = e^{\frac{-c}{\alpha}D + k}, \tag{2}$$

where $P_L(D)$ is the rental price of land per unit of time as a function of distance from the central business district (CBD); c is the transportation cost per unit of distance per unit of time; and α and k are parameters that can be estimated from available data. For example, P_L might be measured in dollars per month; D might be measured in miles from the CBD; and c might be measured in dollars per mile per month. The approach would be to identify employment and amenity centers along with their relative importance, and then assume that land values are the importance-weighted

5. For example, a house might be sold along with an adjacent lot. The individual parcel of land sold would appear from the records to be vacant, but the total price may have been negotiated for the package of land and buildings, with the lot price arbitrarily assigned.

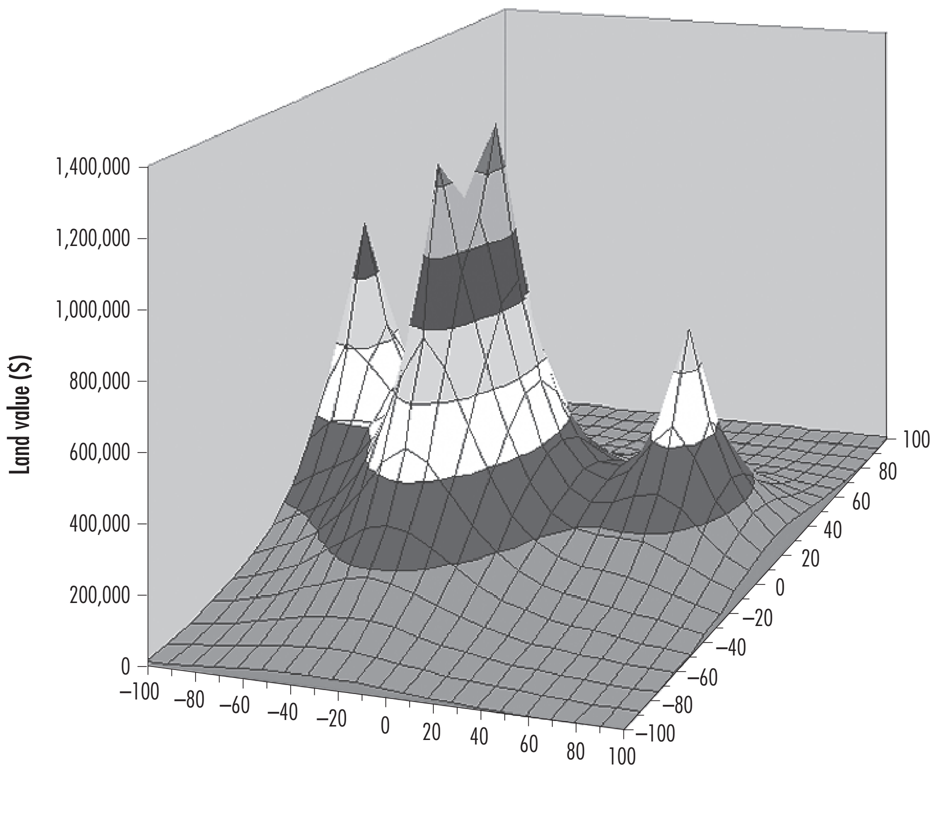
6. The data included the parcel size, street address, purchase price, and sale date. Street addresses were converted to latitude and longitude coordinates using the commercial service geocode.com. If an address could not be exactly matched to latitude and longitude coordinates, the observation was omitted.

Table 7.2
Summary Statistics of Land Values by Metropolitan Statistical Area, Selected Cities

	Los Angeles	Chicago	Philadelphia	Dallas
Mean price/acre ($)	2,087,203	2,067,886	1,126,783	927,125
Median price/acre ($)	1,392,857	930,000	509,615	686,319
Min. price/acre ($)	5,377	4,000	295	761
Max. price/acre ($)	16,619,014	21,513,250	10,108,303	8,701,697
Mean acres	0.60	0.26	1.12	0.73
Median acres	0.19	0.09	0.22	0.24
Min. acres	0.02	0.02	0.02	0.03
Max. acres	10.00	5.18	24.80	18.25
Number of observations	2,025	3,645	3,179	2,943

sum of the value obtained from equation (2) for each employment and amenity center. The parameters α and *k* would be chosen to minimize the sum of squared deviations of actual land prices from their predicted values. Figure 7.4 depicts a theoretical land value surface generated from equation (2) using multiple centers.

Figure 7.4
Theoretical Land Value Surface



The major difficulty with this approach is identifying employment and amenity centers. Employment centers do not always coincide with the central business districts of cities, and no measures are available for the relative importance of amenity centers, such as beaches, shopping centers, and parks.

The approach used in this chapter is a nonparametric estimation of the relationship between location and land prices. The basic idea is to fit a surface to the data that balances two objectives: minimization of prediction error and minimization of curvature. Curvature can be minimized by fitting a flat plane to the data—in other words, an ordinary least squares regression. Prediction error can be minimized by fitting a "bumpy" surface that is bent wildly in order to intersect with each data point. By weighting the two objectives, a surface that is in between these two extremes can be generated. Peaks in the resulting surface will show the location of employment and amenity centers, and the curvature of the surface can be compared with the theoretical surface implied by equation (2).

With either a parametric estimation or a nonparametric estimation, it is assumed that a basic relationship exists between location and the value of land per acre. Many random factors influencing observed land prices are unrelated to location, such as reporting error, sales to related parties, asymmetric information of buyers and sellers, and factors that are localized in extremely small areas. The goal of both methods of estimation is to filter out this random noise in order to reveal the basic underlying relationship between location and value.

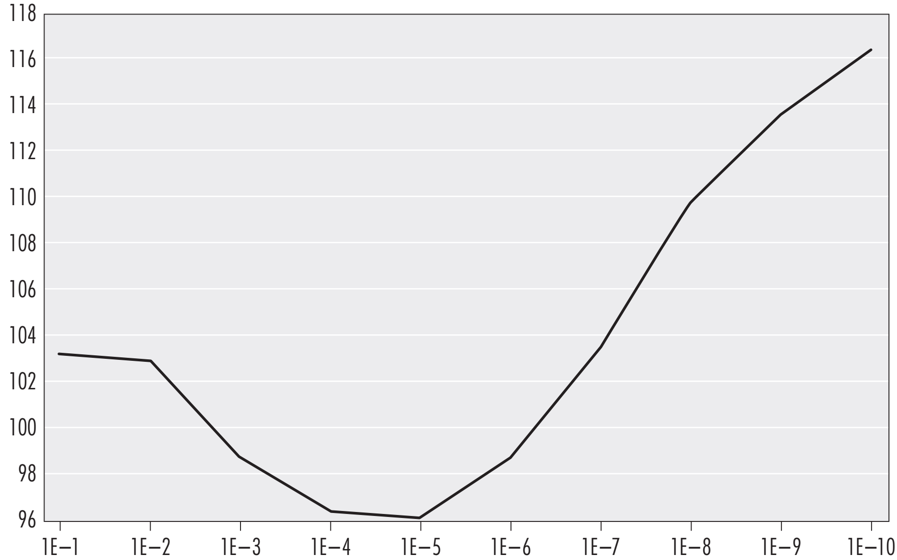
A cubic smoothing spline is used to balance error and curvature. Suppose v_i is the value of land for observation i, and x_i is a variable used to predict v_i (in this case, x_i is location). The cubic spline estimate, $s(x_i)$, minimizes the expression

$$(3) \qquad p \sum_i (v_i - s(v_i))^2 + (1 - p) \int \left(\frac{d^2 s}{dx^2} \right)^2 dx.$$

The smoothness of the curve is determined by the choice of the smoothing parameter p. If p is equal to zero, the curve will simply be an ordinary linear least squares fit. If p is equal to one, then the curve will be forced to go through each point, although it will still be a continuous, differentiable curve. With very noisy data and p equal to one, the curve will wiggle wildly. As p is reduced from one, the curve smoothes out, ignores noise, and, it is hoped, reveals the underlying relationship (Davison and Hinkley 1997).

The difficulty with this method, however, is selecting the optimal smoothing parameter. This selection process is straightforward, but it is computationally intensive if the objective is to minimize out-of-sample prediction errors. Consider, for example, the land value surface for Los Angeles. Land values in Los Angeles are high along the coast and generally decline with inland distance. A flat plane that slopes down from the coast to the desert might capture a good deal of the basic relationship between location and value. This plane, however, would miss important details, such as the high land values near downtown Los Angeles or the inland communities such as Beverly Hills and Pasadena. Land value estimates in these areas would have large errors. By contrast, a surface that bends to fit each point would be influenced by random errors. Such a surface would have no in-sample error at all, because it would pass through each observation. The drawback of such a surface

Figure 7.5
Out-of-Sample Error for Different Smoothing Parameters, Los Angeles County



Note: The vertical axis shows the sum of squared out-of-sample prediction errors divided by 10^{14}. Errors are from the leave-one-out method of cross validation. The horizontal axis is equal to one minus the smoothing parameter *p*. The minimum is reached at 1E − 5, which implies an optimal smoothing parameter of 0.99999.

is that noisy data might obscure the underlying relationship between location and value. The surface also might do a poor job of predicting out-of-sample, because predicted values near random errors would be influenced more by the errors than by the underlying relationship between location and value.

To overcome this difficulty, a smoothing parameter that minimizes out-of-sample prediction error is selected by means of the leave-one-out method of cross-validation. In this technique, the surface is estimated once for each observation in the data set. Each time, one observation is left out, and the prediction error for that point is calculated. The squared errors of each of these estimations are then summed. If this process is repeated for many possible smoothing parameters, then the parameter that minimizes the sum of squared errors can be selected. Figure 7.5 presents the results of this process for Los Angeles County. Out-of-sample prediction errors are minimized with a smoothing parameter p of 0.99999. This parameter was used for all four MSAs.

The fact that the smoothing parameter is close to one does not mean that the surface is fitted to be close to every point. The algorithm used to compute the surfaces produces a great deal of smoothing, even for parameters that appear to be close to one.[7] This smoothing can be seen by computing an r-squared measure of

7. The algorithm is csaps in Matlab.

the fit of the estimated land value surface to the data. Using the smoothing parameter that minimizes out-of-sample prediction errors for Los Angeles County, for example, produces an r-squared measure of 35.3 percent.

Some idea of the sensitivity of the estimate of total land value to the parameter used is provided by extreme cases—that is, when smoothing is complete and when there is no smoothing at all. If smoothing were complete, then the estimate of land value would simply be the mean price per acre for all transactions multiplied by the number of acres in the MSA. For Los Angeles County, this calculation would produce a value of $5.4 trillion. At the other extreme, where value is assumed only for parcels for which a transaction has taken place and values in all other areas are assumed to be zero, the value would be $0.015 trillion. Using the smoothing parameter that minimizes out-of-sample prediction errors produces a value of $2.85 trillion. Changing the smoothing parameter from 0.99999 to 0.99, as shown later in figures 7.7–7.17, changes the total estimate of land value by about 5 percent.

The surfaces are estimated by dividing a rectangular area containing each of the four MSAs examined into a grid of 100,000 sections. For Los Angeles County, for example, each of these sections has an area of 30.6 acres. Land values within a grid section are averaged. Nonsmoothing cubic splines are used to construct a uniformly distributed grid of land values, and this grid is then smoothed using the method described earlier. The surface is extrapolated to the county boundary, and values beyond the county boundary are set to zero. Boundary vectors were obtained electronically from the *National Atlas of the United States* published by the U.S. Department of the Interior. The land values of areas with estimated land values below zero were set to zero.

The surfaces just described include land under roads and highways. The U.S. Census Bureau's electronic TIGER files contain information on the location and type of all roads in the country.[8] Satellite imagery from Google Earth was used to estimate the average width of each type of road. And land values from the land value surface were calculated for each point along each road, which allowed the calculation of the value of land under roads and highways. That value could then be subtracted from the total land value estimate.

Other methods also are available to construct land value surfaces. D'Errico (2006) has developed a technique similar to a ridge regression to bias the smoothness of an estimated surface. This method appears to do a better job of extrapolating surfaces out to county boundaries when data are sparse, but it is much more computationally intensive than the cubic spline method.

RESULTS

Once the surface has been estimated, total land value is simply the integral of the surface—in other words, the volume under the estimated surface. The height of the surface at a section of the grid represents the price per acre of land at that point, so that the sum of the heights across all of the grid sections multiplied by the area of an individual grid section will be the total land value for the MSA or county.

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8. For Los Angeles County, for example, the TIGER files contain the latitude and longitude of 981,643 geographic points along roadways.

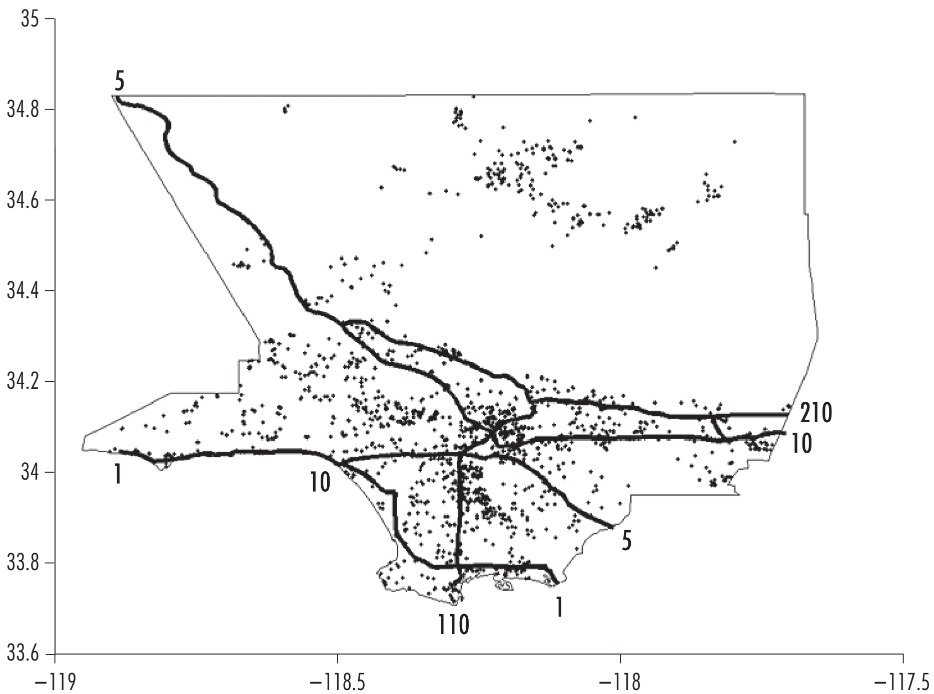
Figure 7.6 shows the distribution of vacant land transactions in Los Angeles County. Transactions are fairly evenly distributed south of Interstate 210, but to the north of this highway is a large section of the county with very few land transactions, and in the far northern area of the county are clusters of vacant land transactions. Figure 7.7 depicts the estimated land value surface for Los Angeles County with a map draped over the surface. High land values near the Pacific coast, particularly near Santa Monica, are clearly visible, as are value peaks near inland city and suburban centers. The lowest land values are in pockets of the city and in the eastern desert areas of the county.

Figure 7.8 also shows the land value surface, but the surface is calculated using a different smoothing parameter. Although use of this smoothing parameter will produce a less accurate estimate of aggregate land values, it is a useful way of visualizing general patterns of land value and location.

The total estimated value of all land in Los Angeles County using the optimal smoothing parameter is $2.85 trillion. Roads account for some 15.4 percent of total land value, which leaves a nonroad land value of $2.41 trillion.

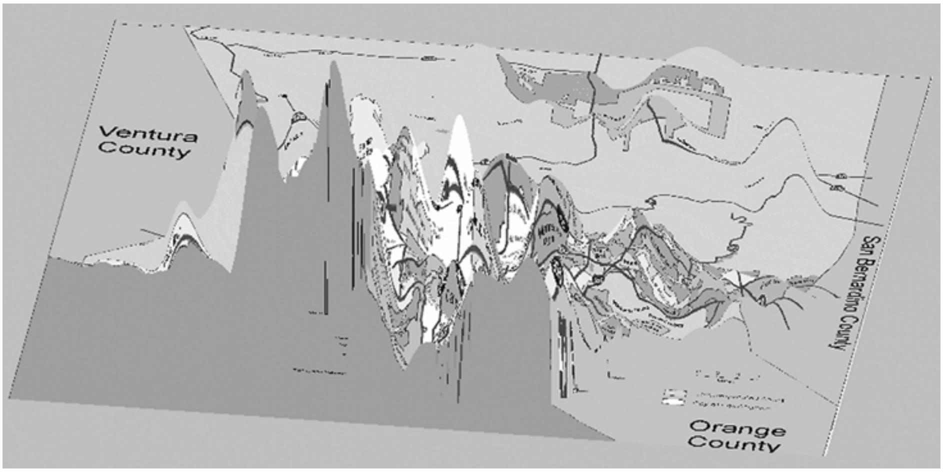
In Table 7.1, the land value figure for Los Angeles was for the entire Los Angeles MSA, which includes both Orange County and Los Angeles County. The

Figure 7.6
Vacant Land Transactions, Los Angeles County



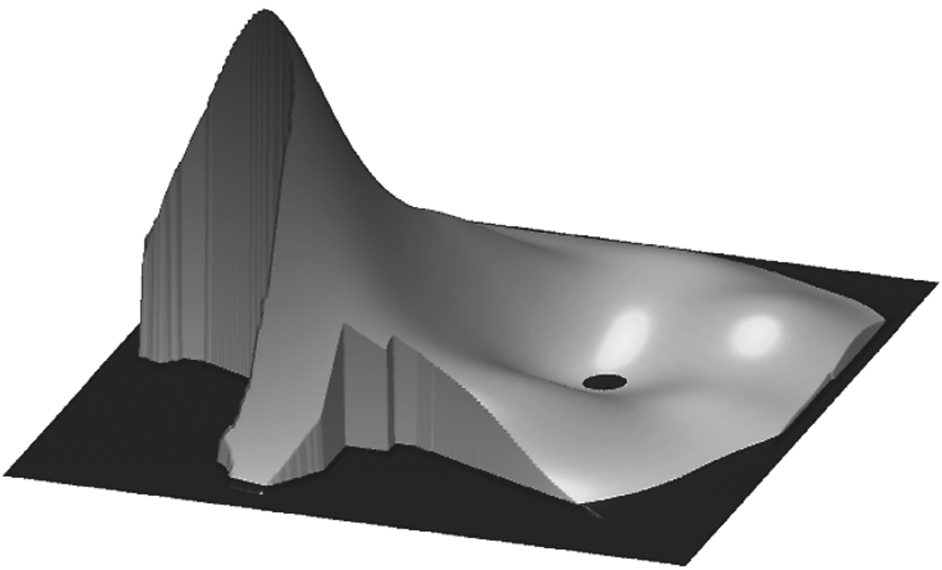
Note: Axes are latitude and longitude. Interior numbers are those of interstate highways.

Figure 7.7
Land Value Surface, Los Angeles County: The smoothing parameter is 0.99999



Note: The view is from the south.

Figure 7.8
Land Value Surface, Los Angeles County: The smoothing parameter is 0.99



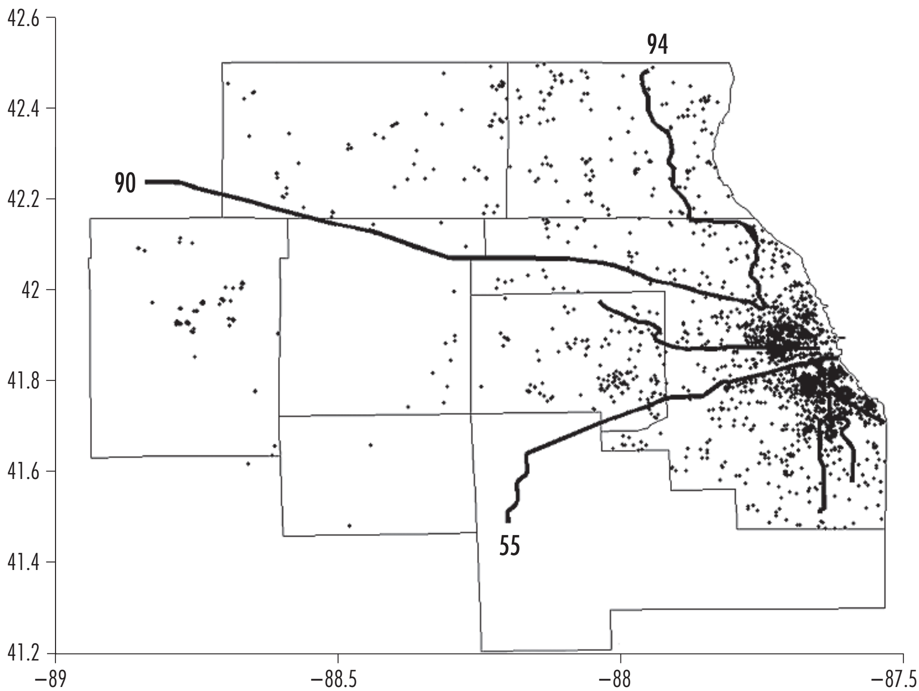
Note: The curved boundary that cuts through the highest land values (in Santa Monica) is the Pacific Ocean. The dark floor represents either areas outside of the county boundaries or land with zero estimated value.

population of Los Angeles County is 76.9 percent of the total population of the Los Angeles MSA, which suggests an estimate of total land value using the Davis and Palumbo (2006) methodology of $1.28 trillion for Los Angeles County alone, which is 50 percent of the estimate obtained using the land value surface.

Figures 7.9–7.11 show the distribution of transactions and land value surfaces for the Chicago MSA. The figures reveal a pattern similar to that of Los Angeles, with high land values near Lake Michigan and the downtown area, declining with distance from the lake. The total value indicated by the surface is $2.12 trillion, or $1.87 trillion excluding roads. Again, this value is about double the estimate using the methodology of Davis and Palumbo (2006). Roads account for 14.4 percent of the total land value, or less than that for Los Angeles but more than those for the other two MSAs.

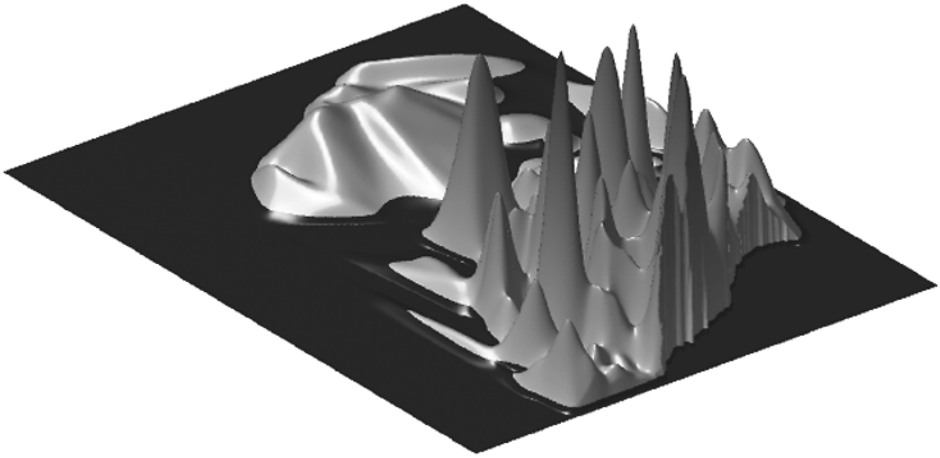
Figures 7.12–7.17 depict the distribution of transactions and land value surfaces for Philadelphia and Dallas. Both show multiple centers of high value land, with land values generally declining with distance from the center. The land value gradient from value peaks is mostly convex, just as in the theoretical land value surface. Overall, the appearance of the land value surfaces closely resembles that of the theoretical model shown in figure 7.4.

Figure 7.9
Vacant Land Transactions, Chicago



Note: Axes are latitude and longitude. Interior numbers are those of interstate highways.

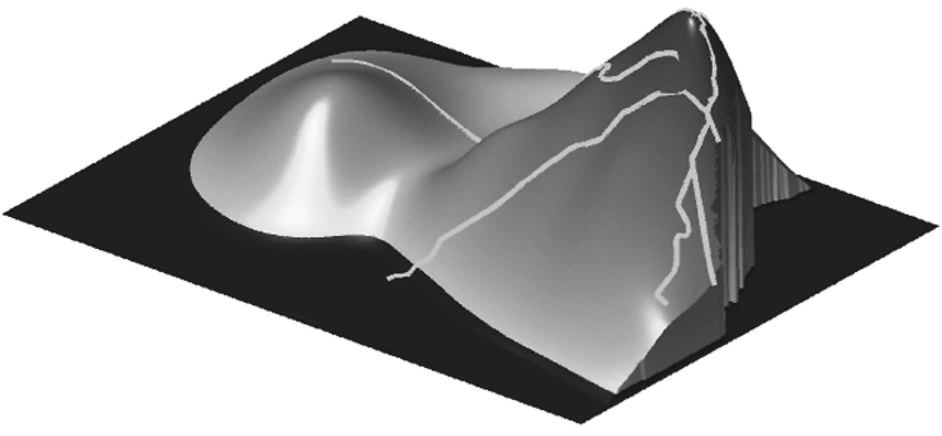
Figure 7.10
Land Value Surface, Chicago: The smoothing parameter is 0.99999



Note: The jagged boundary in the lower right-hand corner is Lake Michigan.

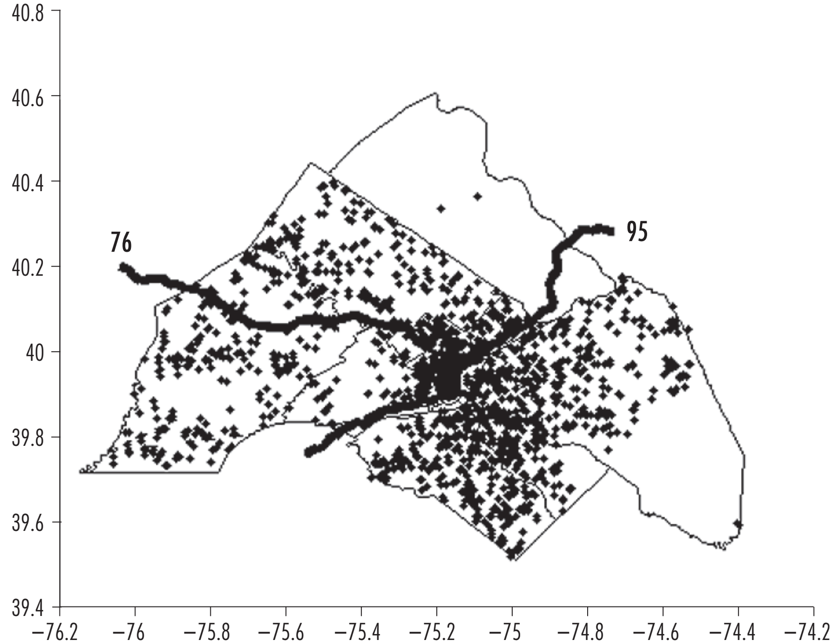
Described earlier was the calculation of land rent for the entire United States. The land rent as a percentage of total city personal income can be calculated as well. Land rent is first estimated as total land value multiplied by the Baa corporate bond yield, as reported by Moody's. In early 2005, the midpoint of the sales in this sample, this rate was 5.82 percent. Table 7.3 shows these estimates

Figure 7.11
Land Value Surface, Chicago: The smoothing parameter is 0.99



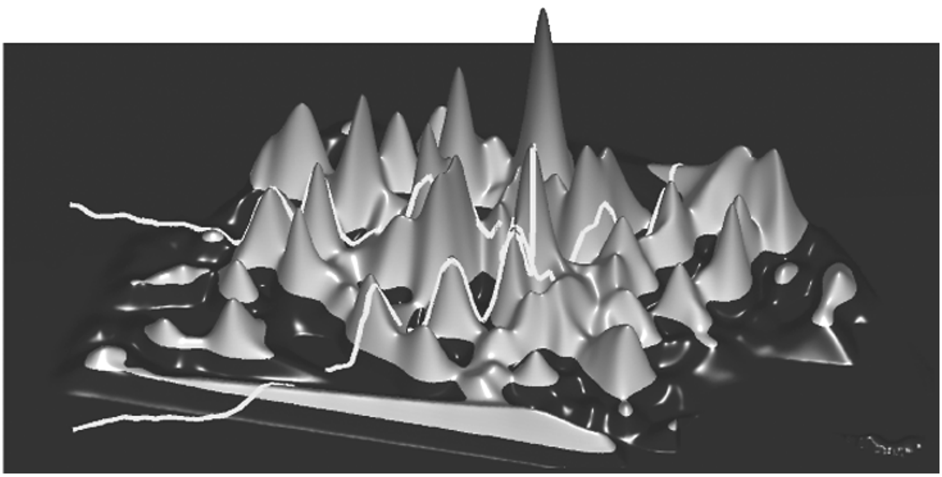
Note: The jagged boundary in the lower right-hand corner is Lake Michigan. Interstate 90 is in the far west. Interstate 55 runs southwest down the slope. Interstate 94 runs close to Lake Michigan.

Figure 7.12
Vacant Land Transactions, Philadelphia



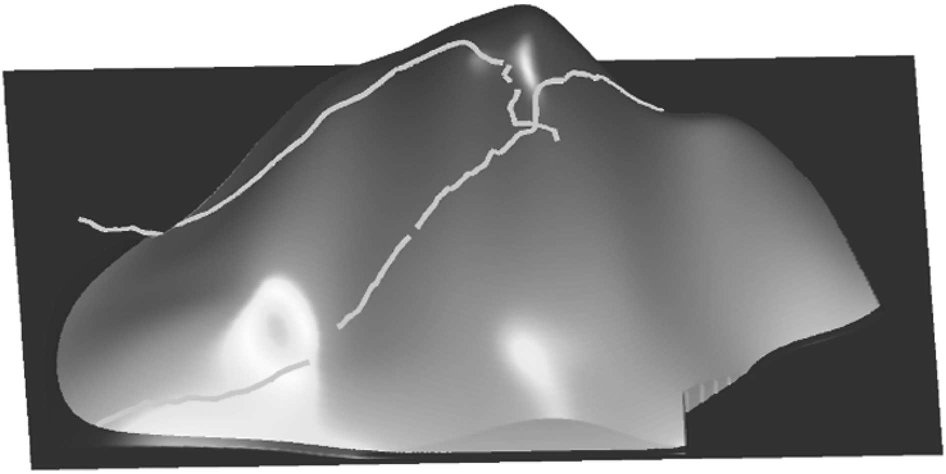
Note: Axes are latitude and longitude. Interior numbers are those of interstate highways.

Figure 7.13
Land Value Surface, Philadelphia: The smoothing parameter is 0.99999



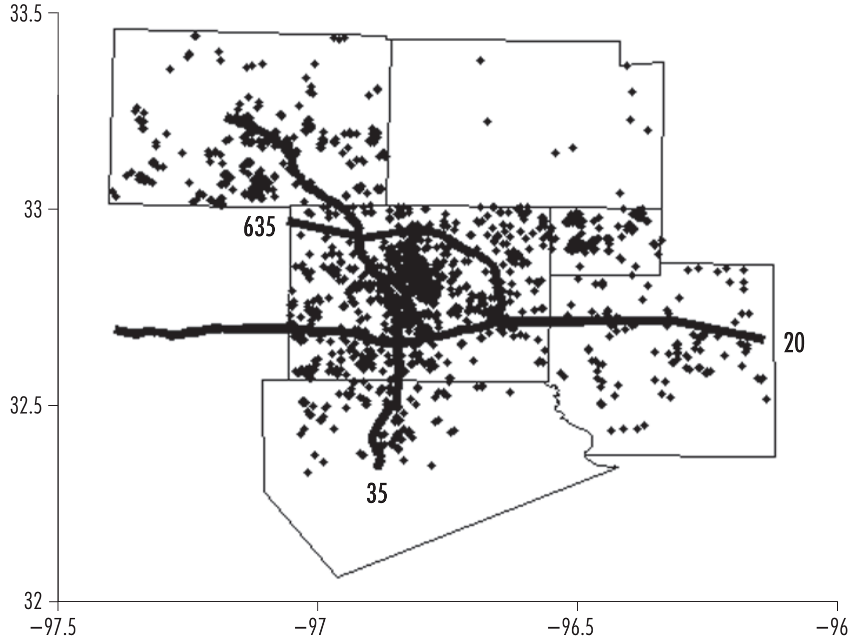
Note: Interstate 95 runs northeast–southwest. Interstate 76 runs north after crossing Interstate 95 and then runs west.

Figure 7.14
Land Value Surface, Philadelphia: The smoothing parameter is 0.99



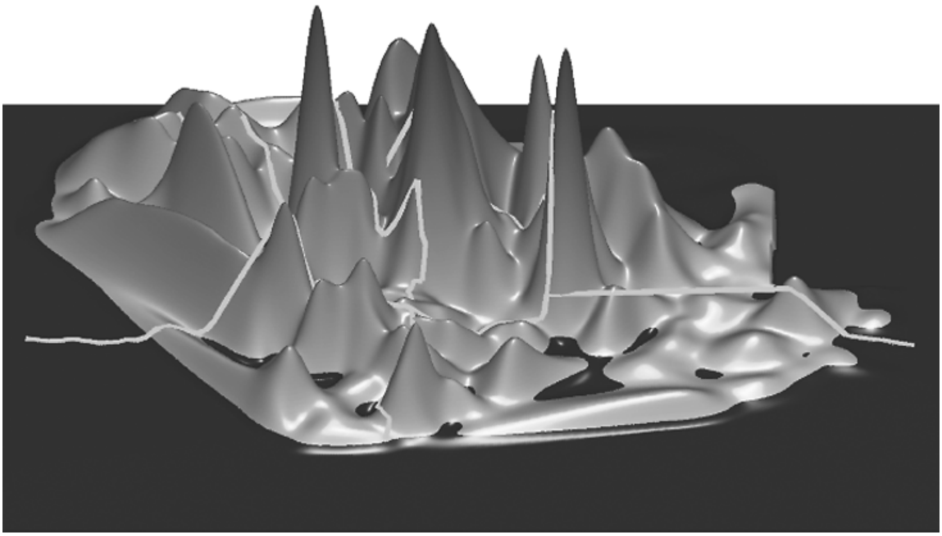
Note: Interstate 95 runs northeast–southwest. Interstate 76 runs north after crossing Interstate 95 and then runs west.

Figure 7.15
Vacant Land Transactions, Dallas



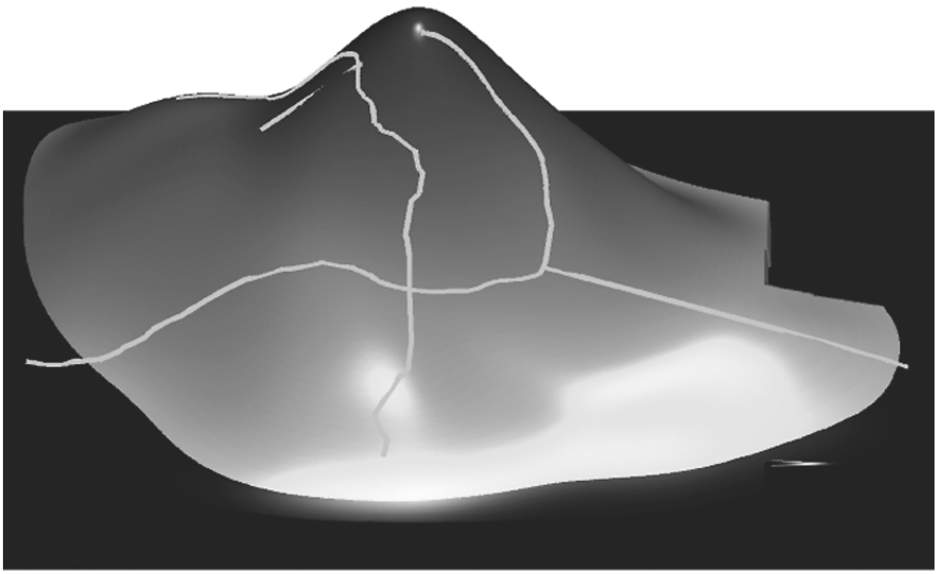
Note: Axes are latitude and longitude. Interior numbers are those of interstate highways.

Figure 7.16
Land Value Surface, Dallas: The smoothing parameter is 0.99999



Note: Interstate 20 runs east–west. Interstate 35 crosses Interstate 20, and Interstate 635 runs north of Interstate 20.

Figure 7.17
Land Value Surface, Dallas: The smoothing parameter is 0.99



Note: Interstate 20 runs east–west. Interstate 35 crosses Interstate 20, and Interstate 635 runs north of Interstate 20.

Table 7.3
Metropolitan Statistical Area Land Rent as a Percentage of Total Personal Income, Selected Cities

	Los Angeles	Chicago	Philadelphia	Dallas
Personal income ($ billions)	329.05	322.66	198.80	140.07
Land value ($ billions)	2,845.73	2,188.38	928.16	1,217.97
Land value without roads ($ billions)	2,408.88	1,872.22	816.30	1,105.28
Land rent to income, fixed cap rate (%)	42.6	33.8	23.9	45.9
Land rent to income, local cap rate (%)	22.0	29.0	16.4	47.3
Land rent to income, fixed cap rate, central counties (%)	42.6	27.5	17.1	26.7
Land rent to income, local cap rate, central counties (%)	22.0	23.6	14.7	27.5

for Los Angeles, Chicago, Philadelphia, and Dallas. Personal income is different from that shown in table 7.1, because the land value surface is estimated only for portions of the MSAs for these cities. For Los Angeles, only Los Angeles County is used. For Dallas, Tarrant County, which contains Fort Worth, is not included.

A potential difficulty with these estimates is that cap rates may not be the same in these cities. In fact, property cap rates tend to be low in Los Angeles, where expectations of future rent growth are high, and high in Dallas, where rent growth expectations are lower because of elastic supply. Smith and Smith (2006) report on rent/price ratios in different cities. These data were summarized as cap rates in Fitch (2006). The fifth line of table 7.3 reports land rent as a percentage of income using these local cap rates.[9]

Estimates of land rent as a percentage of total personal income vary between 16.4 percent in the Philadelphia MSA and 47.3 percent in the Dallas MSA. These estimates are much higher than usual, but that should not be surprising, because land is much more expensive in large cities than in nonurban areas.

The large estimate for Dallas appears to be attributable to the suburban counties in the MSA. The last two lines in table 7.3 show land rent as a percentage of income for the central counties of the MSAs. Here, using the local cap rates, the estimates are much more consistent, varying from 14.7 percent in Philadelphia to 27.5 percent in Dallas.

One reason why estimates of land rent as a fraction of income might be inaccurate in some counties is that only data on personal income are available at the county level. It is possible that land values in some counties are very high, but properties are owned by residents of other counties. The personal income of county residents who do not own local land will not include land rents. It is also conceivable that land rents might exceed aggregate personal income in some coun-

9. The local cap rates are as follows: Los Angeles, 3 percent; Chicago, 5 percent; Dallas, 6 percent. Philadelphia was not included. I used the Chicago cap rate, 5 percent, for Philadelphia.

ties. For this reason, the estimates from counties that are central to their MSAs are probably the most reliable.

For the estimated $23.9 trillion value of all land in the United States, the annual land rent is $1.43 trillion, or 13.6 percent of U.S. total personal income. This estimate is higher than that of Keiper et al. (1961) for the year 1956, but it is consistent with the results of Davis and Heathcote (2004) showing dramatic increases in residential land values in recent years. It is also consistent with evidence in Barker and Sa-Aadu (2004) that there are reasons to expect land rents to have increased recently. Note that this figure probably underestimates the value of commercial land, and it does not include any government land.

Land is cheap in most of the United States. Rural areas and small towns have plenty of land, and the value of real estate in these areas is close to construction costs. If this is true and if land rents for the entire United States are equal to 13.6 percent of income, then this percentage must be much higher in large cities, which is exactly what can be seen in table 7.3.

Conclusions

Land as an object of academic study has increased in importance in recent years. Empirical work on land values, however, is still relatively scarce. Fortunately, private databases are collecting more data and becoming better able to check data for errors and to distribute data easily. Researchers can benefit by finding ways to obtain these data and analyze them in order to develop a clearer picture of the role of land in a modern economy.

The work described here can be extended in many directions. The most obvious is to gather additional data on more cities in order to determine how quickly land values decline as city size declines. The opportunities to refine the empirical methods described in this chapter are also plentiful. In particular, the values of government, commercial, industrial, residential, and other types of land should be separated with more precision.

And there are many other issues to consider. For example, are land sales representative of land values generally? It is possible that land that is sold is different in some way from land that is held and not sold. Coase (1972) wrote about the implications for aggregate land value of land being kept off the market by a monopolist, concluding that, in the absence of transaction costs, this behavior would not affect total value. Perhaps research on the relationship between volume of sales and prices would yield new insights into the workings of land markets. Tests of other theories of land value, such as land as a real option, might be improved by using some of the methods outlined in this chapter.

Although a great deal can be done to refine the results presented in this chapter, they clearly show that land rents, thought by many to be disappearing with economic progress, are still a significant portion of personal income. In large cities, they are a much larger percentage of income than in the rest of the country. The most reliable estimates indicate that land rents in large urban areas are between 15 and 27 percent of aggregate personal income. As urbanization rates continue to increase and as greater world wealth increases the demand for land, this percentage could increase still further.

One criticism of American economist Henry George's 1897 proposal to substitute a land tax for other taxes has been that land rents are too small to produce enough revenue to fund government operations. The findings described in this chapter suggest that, at least in large urban areas, land taxes have the potential to provide a large fraction of government revenue.

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