

Is Real Estate Becoming Important Again? A Neo-Ricardian Model of Land Rent

David Barker* and Jay Sa-Aadu**

Classical economists believed that land rent as a share of total income would increase with economic growth. This belief was important to many 19th and 20th century critiques of capitalism. Land rents as a share of national income apparently declined for most of the 20th century, but increased during the 1990s. In this paper, we develop a model of the classical theory of land rent that allows rent to increase or decrease as a share of national income, depending on several parameters. It seems likely that the long decline in land rent is over and that land rent in the future will slowly increase as a share of national income.

The ordinary progress of a society which increases in wealth, is at all times to augment the incomes of landlords . . . independently of any trouble or outlay incurred by themselves.

John Stuart Mill
Principles of Political Economy, 1872

Real estate has declined in importance over the past century. The total value of U.S. real estate has declined as a fraction of total wealth, and income from rents on real property has declined as a fraction of GDP. This decline would have surprised classical economists of the 19th century, who believed that economic growth would cause rents paid to landlords to increase as a share of the total economy. However, the economic growth of the past decade has been accompanied by extraordinary increases in real estate prices. The relationship between economic growth and the share of the economy controlled by landlords might be more complex than classical economists or their critics have imagined.

In this paper we develop a simple model of the share of land rent in national income and attempt to determine whether rent as a fraction of national income should be expected to rise or fall with economic growth.

Understanding the relationship between real estate and economic growth is important for many reasons. In many developing countries, ownership of land

*University of Chicago, Chicago, IL 60637 or fdbarker@gsb.uchicago.edu.

**University of Iowa, Iowa City, IA 52242 or jsa-aadu@uiowa.edu.

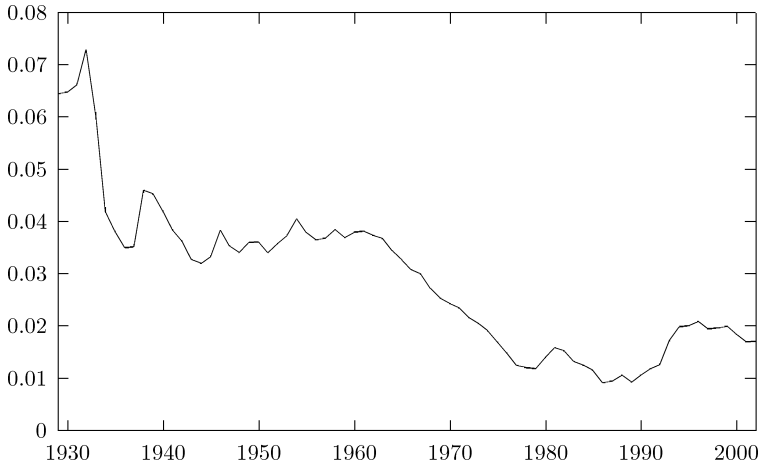
is more concentrated than ownership of other assets, so growth in the share of rent in national income has important implications for the overall concentration of wealth. In the United States, the relationship between economic growth and wealth concentration has received increased attention over the past decade, as concentration levels appear to some analysts to have increased. If the long decline in the importance of real estate is ending, then increasing real estate values might contribute to additional wealth concentration. In particular, rising real estate values might increase the wealth gap between homeowners and renters. The relationship between real estate and economic growth also has implications for the relative returns of real estate versus other investments. Finally, during the latest economic cycle, rising real estate values are believed to have helped to offset the effects of falling values of other assets. If this is the case, then changes in importance of real estate in the economy could have implications for macroeconomic stability.

Demand for land increases with economic development. Thus, if the supply of land is inelastic in the long run, we might expect the share of rental income to increase. On the other hand, changes in the relative productivity or demand elasticities of land and other assets could decrease the share of rental income over time. Thus, it is not at all clear that rent as a proportion of total wealth will increase over time.

The paper is organized as follows. The second section describes different methods of measuring land rents. The third section briefly reviews the Ricardian theory of rent and describes a model based on classical notions of land rent. The model predicts rent as a share of aggregate income. The fourth section examines possible values of the parameters of the model, and the last section summarizes our conclusions.

Measuring Land Rent

Measuring total land rent is a difficult task. As real estate has declined in importance, efforts to collect data on land values and rents have diminished. The only relevant series from the National Income and Product Account data is titled "Rental Income of Persons." These data have many limitations, since they do not include rents received by corporations and partnerships or imputed rent for owner-occupied commercial real estate. If REITs, other corporations and partnerships have increased their share of real estate ownership, then these data may understate rent as a share of national income in recent years. Changes in whether utilities and other costs are included in rent may also affect the accuracy of the data. The data do include imputed rent on owner-occupied housing, so the shift towards individual ownership of residential real estate should not bias the data, although imputed rent may not be measured with a high degree of

Figure 1 ■ Ratio of rental income of persons to national income, 1929–2002.

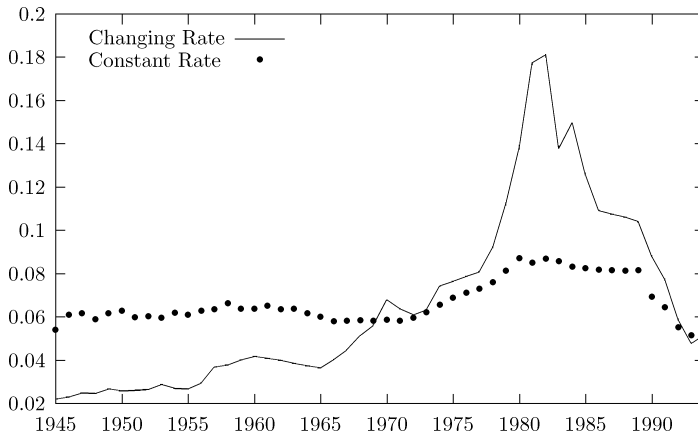
accuracy. The data also do not include rent on government-owned land and lump return on capital invested in land improvements together with land rent. Keiper, Kurnow, Clark and Segal (1961) point out that the series has been cited as proof that land rent is an insignificant portion of national income, even though the government agencies that publish the data caution that it does not exactly correspond to the economic concept of land rent. They conclude that the series Rental Income of Persons probably understates true land rent. Figure 1 shows this series as a fraction of GDP from 1929 to 2002.

Guesses can be made about the magnitude of rents that are left out of Rental Income of Persons. Since 1988, the IRS has published data on the net real estate rental income of partnerships. Rapid depreciation for tax purposes understates true net income, but even if reported depreciation is cut in half, net real estate rental income of partnerships has not exceeded 0.7% of national income, and was negative during the years 1998–1991. Net rental income of corporations is not reported, but gross rents received by corporations were approximately 49% of gross rents received by partnerships in 2000, so net rental income of partnerships and corporations combined is unlikely to be much greater than 1% of national income. Rent from owner-occupied commercial real estate is difficult to estimate, but a government survey of buildings (Energy Information Administration 2002) found that 68.7% of commercial buildings in the United States are owner occupied. National Income Accounts data show that nonresidential structures represent 38.3% of the value of all structures in the United States. If 38.3% of all rents are derived from nonresidential land, and if 68.7% of all

nonresidential property is owner occupied, then 26.3% of all rents would be from owner-occupied nonresidential property. Finally, if property taxes are paid out of land rent and the services received from government do not contribute to the production of real estate services, then property taxes should be added back to net rental income. In 2000, property taxes represented 3.1% of national income. Rental Income of Persons was 1.8% of national income in 2000. An upper bound of the sum of property taxes, net rental income received by partnerships and corporations and net rental income from owner-occupied nonresidential property is therefore around 6.2% of national income, and so total rent would be, at most, 8% of national income, not including rent on government-owned land. Unfortunately, necessary data are not available to estimate a time series of total land rent. It seems reasonable, however, to expect that the path of total land rent over time may have been similar to that of Rental Income of Persons, although the level of rents would have been somewhat higher.

An alternative measure of land rents used by Keiper et al. (1961) is to use estimates of total land values, and multiply these estimates by a market rate of return. From 1945 to 1994 the U.S. Department of Commerce published estimates of the total market value of land in the United States. These estimates relied on some sources of questionable accuracy, such as local property tax assessments, which divide values between land and buildings. For 1956, Keiper et al. (1961) multiply a total land value of \$323.1 billion (later revised by the Department of Commerce to \$343.4 billion) by the then current mortgage rate of 6%. As a fraction of national income, this amounts to 6.4%, which compares to an estimate of 3.7% using the series Rental Income of Persons.

Figure 2 shows the results of using the government estimates of total land values to estimate land rent as a fraction of national income. The solid line shows rent calculated by multiplying land values by mortgage rates from 1974 to 1994 and BAA corporate bond rates from 1945 to 1973. Mortgage rates might have been more volatile than rates of return on land, and so this method might overestimate land rents during the 1970s and 1980s, when mortgage rates were very high. The dotted line shows rent calculated as a constant of 8% of total land value as a fraction of national income. Both methods show this fraction to be relatively stable during the 1950s and 1960s, rising during the 1970s, and then falling during the 1990s. The series Rental Income of Persons also shows this fraction to be fairly stable during the 1950s, but it shows the fraction generally falling from 1960 to 1990, and then rising during the 1990s. The estimates of the magnitude of rent as a fraction of national income are much higher than those using the Rental Income of Persons series. In part, this might be due to the different treatment of agricultural land. Agricultural land rents are not included in Rental Income of Persons, but agricultural land is included in the data shown

Figure 2 ■ Ratio of land value times return to national income, 1945–1994.

in Figure 2. Agricultural land values increased during the 1960s and 1970s, and this could account for some of the pattern shown in Figure 2.

There has not been a great deal of empirical research with regard to land rents as a fraction of national income. The predictions of classical economists that rents would increase have been evaluated with respect to agricultural rents (Schultz 1953, p. 125–145; Hayami and Ruttan 1971), but the conclusions reached could be deceptive. Urban and agricultural rents are determined by very different factors (Lindert 1974), and agricultural rents are quite small relative to urban rents. George Stigler discussed the question using data from the late 19th century and concluded that rents in the U.S. were trifling as early as the 1800s and were on balance (including urban rents) declining relative to national income (Stigler 1959, p. 475). A few other studies have also documented the decline of land as a share of national wealth (Keiper et al. 1961; Deane 1962; Goldsmith 1962). Goldsmith (1962, p. 96) predicted that the share of agricultural land in national wealth will fall, but we said that the share of urban land might increase or decrease. Lindert (1974, p. 862) predicted that land rents would increase, but believed that land value as a fraction of aggregate wealth would continue to fall, mostly due to shifts from land-intensive sectors to other sectors.

Indirectly, some studies have attempted to shed light on this issue by examining the share of housing construction in the total output of countries at various stages of economic growth. Burns and Grebler (1976) suggested that at the earliest stage of economic growth the share of housing in total output is low, presumably because housing yields lower expected returns relative to nonhousing

investments. As the economy grows, housing share rises as it outbids other investments. Others have tried to estimate the extent of overconsumption of housing and the relative returns to housing under the assumption that real estate (housing) is a favored investment. Hendershott and Hu (1980), Feldstein (1981), Hendershott (1982) and Hendershott and Shilling (1982) have estimated distortions in housing investments resulting from federal tax law.¹ More recently, Mills (1987) estimated that the return to housing capital is about half that of nonhousing and concluded that housing investments have been excessive relative to other investments.

From the empirical data and research alone, however, it is difficult to determine what has been the pattern of rent as a fraction of national income. To understand this pattern and what is likely to happen in the future, it is necessary to examine and extend the theory of land rent.

Model

Ricardian land rent in a simple economy is modeled in this section. David Ricardo defined rent as “that portion of the produce of the earth which is paid to the landlord for the use of the original and indestructible powers of the soil” (Ricardo 1911, p. 33). In other words, rent is not the total payment made by a tenant to a landlord; it is only the portion of that payment that the landlord receives solely as a result of owning the land. A modern institutional arrangement that illustrates this point is the triple net lease. Under a triple net lease, a tenant pays all of the operating expenses of a property in addition to the payment of rent to the landlord. Suppose that an individual owns a piece of land and leases it to a tenant, with the tenant paying for all improvements (including the construction of buildings), maintenance, insurance, taxes, and other costs. The amount that this tenant pays to the landlord could be considered rent in the Ricardian sense, for the only contribution of the landlord to the real estate project is permission to use the land. Clearly, if high quality land is superabundant, this rent will be zero. However, if all high quality land is taken, economic growth might lead to the use of marginal land. Use of marginal land implies that tenants can earn an adequate profit on marginal land and a higher-than-adequate profit on high-quality land. Owners of high-quality land will be able to capture this extra profit as land rent.

¹ The kernel of the argument is that federal income tax, by failing to tax imputed rents on owner-occupied housing and by taxing capital gains only when they are recognized, results in overconsumption of housing compared to other assets. Similar arguments can be made about the effects of accelerated depreciation on rental housing.

By this reasoning, economic growth leads to increases in land rents. The Ricardian theory goes further than this, however, and asserts that the proportion of total income that goes towards rent payments will increase. Following Malthus, Ricardo assumes that the supply of labor is perfectly elastic. Any increase in wages will increase the population, which will bring wages back to a subsistence level. The marginal product of capital declines as lower and lower quality land is used in production, so competitive capital markets will force down the return on capital. Any production that is left after paying wages and return to capital will go to landlords as rent. Since wages and return to capital are both constant or declining, and since production is increasing as the economy grows, landlords must control an ever growing share of the economy, net of the payment of subsistence wages to labor.²

Modern economists see less of a distinction between land and other factors of production than did the classical economists. Technology and capital investment are now much more important in the production of goods and services from land. It is still the case, however, that the supply of land is relatively inelastic. The combined effects of inelasticity of supply, technology, capital investment and economic growth are complicated, and it is unclear whether economic growth is likely to increase or decrease the share of rent in national income. The model of this section is an attempt to extend the Ricardian model to take account of these complications.

In the model, services are produced from inputs of land and capital, and the productivity of land varies with distance from the city center, or Central Business District (CBD). The entire economy is a collection of cities of varying sizes, with land in large cities more productive than land in small cities. Capitalists build structures on plots of land in these cities and pay rent to landlords. Rent on each plot of land, $R(r, \chi)$ will be a function of distance from the CBD, r , and city size, χ . Total rent in a city will be the sum of the rent for each plot of land in that city, and total rent in the economy will be the sum of the total rents for each city. If all cities are ranked by size, with ρ being the rank of the city from 1 to infinity,³ and the size of a city is a function of its rank, $\chi(\rho)$, then total rent in the economy, TR , can be calculated as follows:

² The end result of the “progress of society and wealth” as summarized by Ricardo was that “almost the whole produce of the country, after paying the labourers, will be the property of the owners of land and the receivers of tithes and taxes” (Ricardo 1911, p. 72). John Stuart Mill comes to a similar conclusion: “The economical progress of a society constituted of landlords, capitalists, and labourers, tends to the progressive enrichment of the landlord class” (Mill 1872, p. 439).

³ The results of our simulations are changed very little if we assume a finite number of cities, but the solution of the integral is more difficult.

$$TR = \int_1^\infty \int_0^\infty 2\pi r R(r, \chi(\rho)) dr d\rho \tag{1}$$

Real estate services are measured in standardized units of area. A given actual land area will produce some number of standardized units of area depending on the capital investment on the land and the location of the land. The production function for real estate services is given by $S(b, r, \chi)$. The level of capital investment, or building, on a unit of land is given by b . If b is equal to one, then the area inside buildings constructed on the land is equal to the area of the land. b can be greater than one if multistory buildings are constructed, and b will be equal to zero for unimproved land. Buildings constructed on land at a particular location produce some amount of real estate services, measured in standardized units of area. If p is the price per unit of real estate services, then $pS(b, r, \chi)$ will equal total revenue for a unit of land for one period at a distance r from the CBD of a city of size χ . The cost per period of a unit of capital investment is given by $(i + \delta)c$. c is equal to the dollar cost of building construction per unit of area, i is the interest rate and δ is the rate at which buildings depreciate. Profits for the capitalist, π , will be as follows:

$$\pi = pS(b, r, \chi) - (i + \delta)cb - R(r, \chi). \tag{2}$$

For a given plot of land, the capitalist will choose a level of b that will maximize profits. The first-order condition for profit maximization for the capitalist is

$$p \frac{\partial S(b, r, \chi)}{\partial b} = (i + \delta)c \tag{3}$$

We make several assumptions about the production function. These assumptions are summarized in the list below and Table 1.

1. The marginal product of capital is always positive, but it declines as more capital is added.
2. Land productivity is determined by proximity to the CBD. As distance from the CBD declines, land productivity declines, but at a decreasing rate as distance increases.

Table 1 ■ Production function assumptions.

Derivative	b	r	χ
First	$\frac{\partial S(b, r, \chi)}{\partial b} > 0$	$\frac{\partial S(b, r, \chi)}{\partial r} < 0$	$\frac{\partial S(b, r, \chi)}{\partial \chi} > 0$
Second	$\frac{\partial^2 S(b, r, \chi)}{\partial b^2} < 0$	$\frac{\partial^2 S(b, r, \chi)}{\partial r^2} > 0$	$\frac{\partial^2 S(b, r, \chi)}{\partial \chi^2} < 0$
Cross	$\frac{\partial^2 S(b, r, \chi)}{\partial r \partial \chi} < 0$	$\frac{\partial^2 S(b, r, \chi)}{\partial b \partial \chi} > 0$	$\frac{\partial^2 S(b, r, \chi)}{\partial b \partial r} < 0$

3. Land in large cities is more productive than land in small cities, but population increases have diminishing marginal returns to land productivity.
4. The slope of the bid-rent function is steeper in large than in small cities.
5. The marginal product of capital is higher in large than in small cities, and declines with distance from the CBD.

For each plot of land, the capitalist will solve equation (3) for $b^*(r, \chi)$, the optimal capital investment. If competitive capitalists bid up the rent of scarce land to the highest level they are able to pay, then rent for each plot will increase to the point where profits are equal to zero.

$$R(r) = pS(b^*(r, \chi), r, \chi) - (i + \delta)cb^*(r, \chi) \quad (4)$$

Total rent in a city will be equal to the sum of the rent on each plot in the city. As r , the distance from the CBD, increases, the number of plots will increase as the area of a circle increases with its radius, as shown in Equation (1). Total rent in the economy will be the sum of rent in all cities, and it can be determined by substituting Equation (4) into Equation (1) and solving the integrals.

The price of real estate services, p , will be determined by the intersection of aggregate demand and aggregate supply. Aggregate supply, AS , will be given by

$$AS = \int_1^\infty \int_0^\infty 2\pi rS(b^*(r, \chi(\rho)), r, \chi(\rho)) dr d\rho \quad (5)$$

Aggregate demand for real estate services, AD , will be some function of the price of real estate services and aggregate income, y . Equating supply and demand will allow us to solve for p . A simple aggregate demand function is necessary for the model to be easily solved. The following specification has income elasticity equal to η , own price elasticity equal to ε and zero cross-price elasticity.

$$AD = \frac{\sigma y^\eta}{p^\varepsilon} \quad (6)$$

Next, we assume a specific functional form of $S(b, r, \chi)$. A functional form for $S(b, r, \chi)$ that meets the requirements of the assumptions summarized in Table 1 is as follows:

$$S(b, r, \chi) = b^\lambda e^{-\phi r} \chi^\gamma \quad 0 < \lambda < 1, \quad \phi > 0, \quad 0 < \gamma < 1 \quad (7)$$

With this specification, we can solve for b^* , the optimal capital investment on a particular plot of land:

$$b^* = \left(\frac{(i + \delta) c e^{\phi r}}{p \lambda \chi^\gamma} \right)^{\frac{1}{\lambda-1}} \tag{8}$$

Finally, we need to specify the distribution of city size. The relationship between city size, χ , and rank, ρ , has been extensively studied (see Alperovich 1984), and the following appears to be a reasonable specification:

$$\chi(\rho) = \frac{\alpha}{\rho^\beta} \tag{9}$$

Equations (7), (8) and (9) can be substituted into Equation (5), which can then be set equal to Equation (6), which can then be solved for p , the price of real estate services.

$$p = \left(\frac{y^\eta \alpha^{\frac{\gamma}{\lambda-1}} \lambda^{\frac{1}{\lambda-1} + \frac{\lambda}{\lambda-1}} (1 - \beta \gamma - \lambda) \sigma \phi^2}{2 \pi c^{\frac{\lambda}{\lambda-1}} (i + \delta)^{\frac{\lambda}{\lambda-1}} \left(-3 \lambda^{2 + \frac{1}{\lambda-1}} + \lambda^{3 + \frac{1}{\lambda-1}} - \lambda^{\frac{1}{\lambda-1}} + 3 \lambda^{\frac{\lambda}{\lambda-1}} \right)} \right)^{\frac{1-\lambda}{\epsilon + \lambda - \epsilon \lambda}} \tag{10}$$

Substituting this expression for p into Equation (4), then substituting the resulting equation and Equation (9) into Equation (1), solving and dividing by aggregate income, y , yields a complicated expression for the share of rent in aggregate income, SH , as a function of aggregate income, y , the interest rate, i , and parameters $c, \delta, \sigma, \eta, \epsilon, \lambda, \phi, \gamma, \alpha$ and β :

$$\begin{aligned} SH = & (2 \pi)^{1 - \frac{1}{\epsilon + \lambda - \epsilon \lambda}} y^{\frac{\eta}{\epsilon + \lambda - \epsilon \lambda} - 1} c^{\frac{\lambda(\epsilon + \lambda - \epsilon \lambda - 1)}{(\lambda - 1)(\epsilon + \lambda - \epsilon \lambda)}} \alpha^{\frac{\gamma(\epsilon + \lambda - \epsilon \lambda - 1)}{(1 - \lambda)(\epsilon + \lambda - \epsilon \lambda)}} \sigma^{\frac{1}{\epsilon + \lambda - \epsilon \lambda}} \phi^{\frac{2}{\epsilon + \lambda - \epsilon \lambda} - 2} \\ & \times \lambda^{\frac{1}{(\lambda - 1)(\epsilon + \lambda - \epsilon \lambda)}} (\lambda - 1) \left(-3 \lambda^{2 + \frac{1}{\lambda-1}} + \lambda^{3 + \frac{1}{\lambda-1}} - \lambda^{\frac{1}{\lambda-1}} + 3 \lambda^{\frac{\lambda}{\lambda-1}} \right)^{\frac{-1}{\epsilon + \lambda - \epsilon \lambda}} \\ & \times (2 - \beta \gamma - 2 \lambda) (1 - \beta \gamma - \lambda)^{\frac{1}{(\epsilon + \lambda - \epsilon \lambda)}} (1 - i - \delta) \left(\frac{i + \delta}{\lambda} \right)^{\frac{-\epsilon}{\epsilon + \lambda - \epsilon \lambda}} \end{aligned} \tag{11}$$

Equation (11) is complicated, but the relationship between aggregate income and the share of rent in national income is fairly simple. The sign of the derivative of SH with respect to y will depend on the sign of the exponent on y . In other words, if $\frac{\eta}{\epsilon + \lambda - \epsilon \lambda}$ is greater than one, then increases in y will, with all other variables held constant, increase SH . If, as seems likely, ϵ and λ are close to one, then $\epsilon + \lambda - \epsilon \lambda$ will be close to one, and the sign of the derivative will depend on whether η is greater or less than one. Income is not the only variable

that changes, however, so it remains to be seen whether SH will actually rise in the model as y rises, even if η is greater than one. It is also possible that SH could rise even if η is less than one because of changes in construction costs or other variables.

By making reasonable estimates of the parameters in Equation (11), we can obtain an idea of the likely share of rent in the economy, and the sign of the derivative of its share with respect to aggregate income. We can also compare the predictions of the model with the data shown in Figure 1.

Model Calibration

The model described in the previous section contains 12 unknown parameters. η , ϵ , σ , λ , ϕ , γ , δ and i are assumed to be constant. y , α , β and c are estimated for each year from 1929 to 2002 from various sources. In the sections below, each of these parameters is discussed.

Parameters of the Aggregate Demand Function

Income and price elasticities of demand, η and ϵ . Dozens of studies of the income elasticity of demand for housing conducted over the past four decades have failed to converge to a precise estimate. Several methodological problems have been discovered; the use of current instead of permanent income (Reid 1962), model misspecification with respect to housing price (Polinsky 1977), aggregation bias (Smith and Campbell 1978) and failure to take account of length of residence (Harmon 1988). A comprehensive review of the literature (Mayo 1988) reports that most estimates of studies that did not suffer from methodological problems known at the time ranged from 0.25 to 0.87. Harmon (1988) reports a range of plausible estimates from 0.14 to 1.45.

Estimates of the price elasticity of demand are also spread over a wide range. Mayo (1988, p. 103) reports that, using the same data, three different studies estimated the parameter to be 1.27, 0.56 and statistically insignificant. McMillen (1990) is unable to reject unit price elasticity using data from 1928.

Previous elasticity estimates are for housing only, while our model requires the price and income elasticities of demand for all real estate. Housing is more of a necessity than other real estate, and so demand for housing might be somewhat less price and income elastic.⁴ We set η equal to 0.7, just above the midpoint

⁴ Ioannides and Rosenthal (1994), for example, find that the income elasticity of demand is higher for investment real estate than for housing consumption.

of the range given by Mayo (1981), and ϵ equal to 1.1, slightly above the estimate of McMillen (1990). In a later section we will discuss and explore the possibilities of using higher values of η in recent years.

Scale constant, σ . If ϵ is equal to 1.0, and we define monetary units such that aggregate income, y , is equal to 1.0, then from Equation (6), σ would be equal to the fraction of total income that is spent on real estate services. This ratio should be close to the ratio between the total value of real estate and total wealth, including human capital. Real estate has been estimated to be approximately 39% of nonhuman capital wealth in the United States (Ibbotson Associates 1991), and human capital has been estimated to be equal to 80% of all wealth (Becker 1993). These two estimates suggest that real estate comprises approximately 7.8% of all wealth, so σ is assumed to be equal to 0.078.

Parameters of the Production Function

Capital intensity, λ . The elasticity of production of real estate services with respect to capital intensity, λ , will reflect the declining marginal productivity of large buildings. For example, among other disadvantages, tall buildings must devote a larger fraction of their total area to elevators than short buildings. A 100-story building must devote approximately 30% of the total floor space of the building to elevators, loading lobbies, and machinery (Fortune 1998, p. 66). λ equal to 0.92 would mean that a 100-story building was 70% as efficient as a single-story building. Taller buildings are also more expensive to construct per square foot than shorter buildings.⁵ We assume that λ is equal to 0.85. This value takes account of the loss of building efficiency and the added cost of tall buildings.

Shape of the bid-rent curve, ϕ . The shape of the bid-rent curve is determined by the parameter ϕ . If ϕ is close to zero, then land in the city center would be close in value to land in the distant suburbs. A higher value of ϕ would mean a steeper slope of the bid-rent function. Mills (1969) estimates this parameter to be approximately 0.21 for Chicago, and we assume that ϕ is equal to this value. ϕ might have changed over time, but the final results do not appear to be sensitive to changes in ϕ .

City size and land productivity, γ , α and β . The relationship between land productivity and city size is given by γ . A possible estimate of γ can be obtained

⁵ Clark and Kingston (1930) show that construction costs per square foot of a 75-story building are approximately 19% higher than those of an 8-story building, and this cost difference does not appear to have changed significantly (Council on Tall Buildings 1981).

by regressing total rent (land and building) per unit of area on city size. The log of office rent regressed on the log of population for a sample of U.S. cities yields a coefficient of 0.32.

To estimate α and β , we take the log of Equation (9) to obtain a linear relationship between the log of population of cities and the log of their rank. Data were obtained for each census from 1920 to 2000 for the 100 largest cities in the United States, and linear regressions were run for each set of census data. Linear interpolation was used to obtain estimates of α and β for years between census measurements. Population was normalized so that the year 2000 population of the largest city was equal to one. The estimates obtained were similar to those that have been obtained elsewhere (Rosen and Resnick 1980).

Other Variables

Construction costs, c. Since y is set equal to one, then c , the other parameter that is expressed in monetary units, must be a fraction of aggregate income. Distance is measured in miles, so c will be equal to building construction cost per square mile divided by aggregate income. If building costs are currently \$75 per square foot, then c will be equal to 0.0002 (\$75 multiplied by 5,280 squared divided by \$10.5 trillion). Past building costs were estimated by deflating the current cost with the real construction cost index of the Engineering News-Record (<http://www.enr.com>).

Depreciation, δ . Depreciation is represented by δ and is assumed to be straight-line. A 40-year useful life of buildings would therefore imply a value of δ of 0.025.

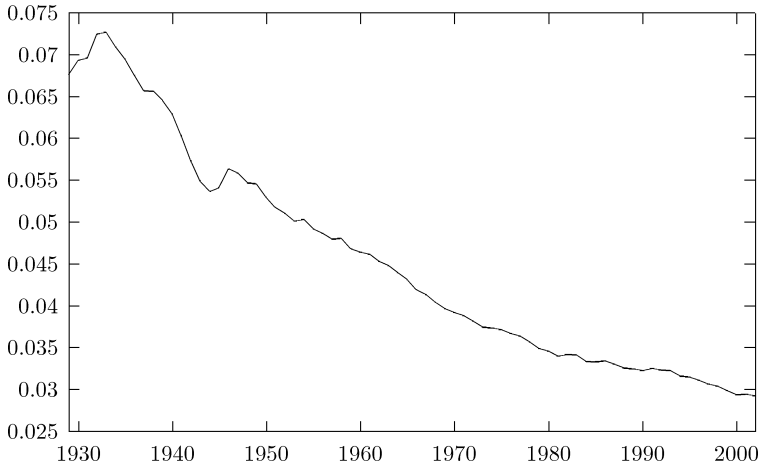
Interest rates, i . i , is taken from Moody's Baa corporate bond yields.

Aggregate income, y . Aggregate income is estimated by using real GDP, normalized so that year 2002 GDP is equal to 1.0.

Results

Constant income elasticity of demand. The estimated values of the parameters described above were substituted into Equation (11) for each year from 1929 to 2002 and are displayed in Figure 3. The pattern of the estimated share of rent in national income is remarkably similar to the pattern of the ratio of Rental Income of Persons to national income shown in Figure 1. The share of rent increases as aggregate income falls during the early years of the Great Depression, falls sharply during the 1930s, and then falls gradually until the present. One difference between the two figures is that in Figure 1, the share of

Figure 3 ■ Model estimate of ratio of total rent to aggregate income, 1929–2002, constant income elasticity of demand.



rent increases during the 1990s, but it continues to fall in Figure 3. The level of rent as a share of national income is higher than Rental Income of Persons, but this is consistent with our earlier discussion, which explained that Rental Income of Persons understates true land rent.

The model results do not have a pattern similar to that shown in Figure 2. It is possible that this is due to the treatment of agricultural land rents. Agricultural land rents are not included in Rental Income of Persons, and they are also not included in the model, since land values are assumed to derive only from capital investment and proximity to large cities, not agricultural productivity. The aggregate land values included in the data shown in Figure 2 do include agricultural land.

Numerical estimates of the derivative of the share of land rent with respect to aggregate income are positive using the assumed parameter values. In other words, higher income leads to a lower share of rent in national income. The sign of this derivative, however, is sensitive to the assumed value of η . In the next section we take a closer look at possible values of η .

Variable income elasticity of demand. Rental Income of Persons as a ratio of national income increased during the 1990s. In this section, we investigate whether reasonable values of the model parameters can reproduce this increase. Since η , the income elasticity of demand, is an important parameter in the model

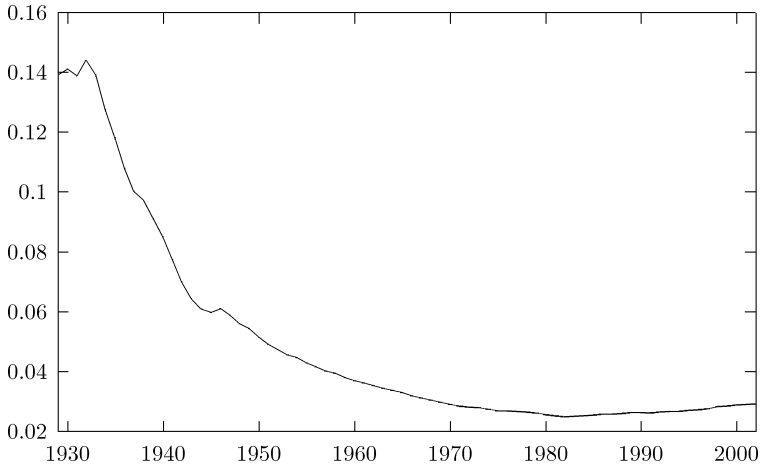
and its value as estimated in the literature is uncertain, it seems to be a good candidate for experimentation.

An interesting characteristic of the income elasticity of housing demand is that it appears to increase with income. Reid (1962, p. 231) noted that the income elasticity of demand for housing appeared to increase over time. Ihlanfeldt (1982) found that the elasticity for low-income households is between 0.14 and 0.62, and it is between 0.72 and 1.1 for high-income households. Hansen, Formby and Smith (1998) also find significant increases in income elasticity between low-income and high-income owners. Our approach is to assume a low value of η in 1929 and allow it to increase proportionately with income until it reaches a higher value at the end of the simulated period.

For a low value of η , we use 0.4, toward the lower end of the range of estimated values of η . The highest income elasticity of demand for housing that has been estimated is 2.0 (Reid 1962), but this estimate is suspect because of aggregation at the census tract level. Harmon (1988) concludes that the short-run income elasticity of housing demand is approximately 0.7, and the long-run elasticity is approximately 1.1. Follain and Jiminez (1985) report several studies that find high elasticities of demand for various measures of the quality of housing. Over time, it seems reasonable to expect that quality, as opposed to square footage and the number of rooms, has increased as a fraction of the price of housing, and that the income elasticity of demand is moving toward these higher values. Barnett and Noland (1981), for example, find an income elasticity of demand for quality of 2.32 for renters. As other types of real estate that have not been included in studies of income elasticity of demand, such as second and vacation homes, hotels, and retail property come to constitute a larger fraction of total expenditure over time, we would expect the income elasticity of demand for real estate to increase further.⁶

We use 1.5 as a high value of η . This is at the top of the range of previous estimates reported by Harmon (1988), and it seems reasonable, given the reasons to expect the elasticity of real estate as a whole to be higher than that of housing. Figure 4 shows the model's estimate of the share of rent in national income along with the ratio of Rental Income of Persons to national income. The model does show a slight increase in the share of rent in national income during the 1990s. Pushing the model further, if we allow η to gradually increase to 2.0, real aggregate income to continue to increase at a rate of 3.4% per year and real construction costs to continue to increase at a rate of 1.1% per year, rent as a

⁶ Increased demand for land as scenic and recreational areas, untouched wilderness or for biodiversity as aggregate income increases might also raise the overall value of η (see Bastian 2002).

Figure 4 ■ Model estimate of ratio of total rent to aggregate income, 1929–2002, variable income elasticity of demand.**Table 2 ■** Sensitivity analysis holding other variables at 1965 levels.

Variable	Max	75th	50th	25th	Min
c	0.0428241	0.0432389	0.0440292	0.0451891	0.0465296
α	0.0446712	0.0445004	0.0443067	0.0439897	0.0435314
β	0.0438907	0.0438996	0.0440347	0.0441648	0.0442138
y	0.030309	0.0370253	0.0440292	0.0547481	0.0747972
i	0.0407404	0.0424241	0.0431255	0.0440996	0.0450876

share of national income would rise to 29% in the year 2075 and 64% by the year 2100 according to the model. This estimate is very sensitive to the assumed values of η and ϵ . Lowering ϵ to 1.0 lowers the predicted share in 2100 to 31%, while allowing η to remain at 1.5 reduces the predicted share in 2100 to 13.0%.

Sensitivity Analysis

To determine which variables have the greatest influence on the estimated rent as a share of national income, each parameter was allowed to change within a certain range. The results shown are for the constant income elasticity of demand model. Table 2 shows the results over time of changing each of the variables that was allowed to change. One variable is changed in each row; the other variables are at their 1965 levels. The first column shows the resulting share of rent in national income if each variable is at its maximum over the 1929–2002 period. The second column sets each variable to the 75th percentile, while the

Table 3 ■ Sensitivity analysis holding other variables at 2002 levels.

Variable	Max	75th	50th	25th	Min
c	0.0289643	0.0292449	0.0297794	0.0305639	0.0314706
α	0.0294855	0.0293727	0.0292449	0.0290356	0.0287331
β	0.0290312	0.0290371	0.0291264	0.0292125	0.0292449
y	0.0292449	0.0218569	0.0169873	0.0123726	0.00785797
i	0.0278314	0.0289815	0.0294607	0.0301262	0.0308011

Table 4 ■ Sensitivity analysis holding other variables at 1965 levels.

Variable	0.5	0.9	1.1	2.0
η	0.0638346	0.0466501	0.0398795	0.019692
ϵ	0.000146715	0.0149199	0.120527	343.566
ϕ	0.0440249	0.0432667	0.0430108	0.0422575
γ		0.0434892	0.0428131	0.0405744
δ	0.0438091	0.0432571	0.0430118	0.0420894
σ	0.0217881	0.0388794	0.0473786	0.0853852
λ		0.0671539	0.019671	

Table 5 ■ Sensitivity analysis holding other variables at 2002 levels.

Variable	0.5	0.9	1.1	2.0
η	0.0292449	0.0292449	0.0292449	0.0292449
ϵ	0.000131644	0.0106596	0.0776846	149.606
ϕ	0.0298502	0.0293361	0.0291626	0.0286518
γ		0.0294937	0.029032	0.027634
δ	0.0295634	0.0293051	0.0291862	0.0287176
σ	0.014773	0.0263614	0.0321241	0.0578937
λ		0.0497481	0.0133165	

next columns set each variable to the 50th percentile, the 25th percentile and the minimum value over the period. Table 3 shows the same results, but setting the unchanging variables equal to their 2002 values.

Holding other variables at 1965 and 2002 levels, only changes in y have a large impact on predicted rent as a share of national income.

Tables 4 and 5 show the results of allowing parameters that were not assumed to change over time to vary. In Table 4, parameters that change over time were set at their 1965 levels, and the fixed parameters are multiplied by 2, 1.1, 0.9 and 0.5.

Blank cells in the tables indicate that only complex solutions were available at these parameter values. The predicted value of the share of rent in national income is very sensitive to changes in ϵ , although the highest and lowest values used in the tables are implausible. Holding other variables constant at 2002 levels, η does not change the predicted share, but this is because y is set equal to one, and η enters into Equation (11) only as an exponent of y . In general, predicted rent as a share of national income is sensitive to the assumed value of η .

The values of the parameters σ and λ are not well known, and changes in their values that are well within the range of uncertainty can cause the predicted value of the share of rent to vary significantly. These two variables should clearly be the focus of future research. One approach would be to find better methods of estimating the values of these parameters; another would be to attempt to solve some of the problems with the Rental Income of Persons series, for example, by including net rent paid to partnerships and corporations, excluding return to capital, including imputed rent on owner-occupied government and commercial property and so forth. The parameters σ and λ could then be estimated by choosing the values which provide the best fit to this series.

Conclusion

Rental income as a fraction of aggregate income is difficult to measure empirically. Figures 1 and 2 present different measures of this fraction over past decades. Figure 3 shows the predicted share of rental income in aggregate income from a theoretical model of land rents. Figures 1 and 3 are remarkably similar, suggesting that the model may have some validity, and that the series Rental Income of Persons may be a reasonable indicator of trends in land rent.

Rent as a share of national income has declined significantly since 1929, and our model reproduces this decline using reasonable parameter values. Beginning around 1990, however, the data show a small increase in the share of rent in national income. If the income elasticity of demand for real estate has increased to the high end of the range of estimates in the literature, then our model can reproduce this increase. In this case, the model also suggests that this increase may continue as aggregate income increases and that owners of land would control a larger and larger share of total income. It is important to keep in mind that the increase suggested by the data and the model is slow, and it might take decades for the share of rent in national income to reach the levels of the early 1930s. In the long run, however, such a trend would be important. Under assumptions at the outer edge of plausibility, the model suggests that rents as a share of national income could reach very high levels by the year 2100.

In Ricardo's time, few luxury goods were available for most people. The opportunities to spend extra income were limited, so it was usually spent on additional food, clothing, or shelter. In other words, housing demand might have been somewhat income elastic. If the demand for housing was income elastic, then, according to our model, Ricardo's prediction that land rents would increase as a share of national income had some foundation. During the 19th and 20th centuries, the amount of luxury goods available to large numbers of people increased, and the income elasticities of demand for necessities like housing probably decreased. A low income elasticity of demand for real estate can explain the long decline of land rent as a share of national income during most of the 20th century. It seems possible that the nature of real estate is changing, so that more and more of the services real estate provides are luxuries with high income elasticities of demand. If this is true, then our model predicts that the share of land rent in national income will grow over time.

There are many potential implications of increased wealth for landowners. First is an increase in the concentration of national wealth. Assuming that landowners are already wealthier than the average American, if the wealth of landowners increases faster than that of the rest of the country, overall concentration of wealth will increase. The largest group of landowners, however, is homeowners. Since this is a very large group, the increase in wealth will be fairly widespread, but the wealth gap between homeowners and renters will increase.

A second implication is that investments in real estate may perform better than they have in the past. If rents increase faster than other income, we might expect real estate values to increase faster than other asset values. On the other hand, investors might have already predicted acceleration in real estate rents, and current asset prices might have already taken this into account. If this is the case, then current investors in real estate should not expect any higher returns than investors in any other asset.

A third implication regards the politics of real estate. During the 19th century, the predicted increase in rent was referred to as the "unearned increment." It was widely held that landowners produced nothing of value and simply profited from the work of others. Land taxes, regulation and land reform were advocated as a result of these beliefs. The decline in rent relative to the rest of the economy may have contributed to the weakening of movements to tax and regulate landowners. If rents increase in the future, these political movements might strengthen.

In developing countries the situation may be very different. Since these countries do not have the levels of income that are associated with high income elasticities of demand for real estate, they might see a long period of decline in land rents similar to that experienced by the United States.

The authors thank Robert Solow, Jim Clayton, Roberto Quercia, and the referees for many useful comments.

References

- Alperovich, G. 1984. The Size Distribution of Cities: On the Empirical Validity of the Rank-Size Rule. *Journal of Urban Economics* 16: 232–239.
- Barnett, C.L., and C. Noland. 1981. *The Demand for Housing Space and Quality*. Working paper. Rand Corporation: Santa Monica, CA.
- Bastian, C. 2002. Environmental Amenities and Agricultural Land Values: A Hedonic Model Using Geographic Information Systems Data. *Ecological Economics* 40: 337–349.
- Becker, G. 1993. *Human Capital: A Theoretical and Empirical Analysis, With Special Reference to Education*. University of Chicago Press: Chicago.
- Burns, L. and L. Grebler. 1976. Resources Allocation to Housing Investment: A Comparative International Study. *Economic Development and Cultural Change* 25(1): 95–121.
- Clark, W. and J. Kingston. 1930. *The Skyscraper*. American Institute of Steel Construction: New York.
- Council on Tall Buildings, Committee 39. 1981. Direct Cost of Tall Buildings. *Monograph on Planning and Design of Tall Buildings*, PC, 298–315. American Society of Civil Engineers: Bethlehem, PA.
- Deane, P. 1962. *British Economic Growth, 1688–1959; Trends and Structure*. Cambridge University Press: Cambridge, England.
- Energy Information Administration. 2002. *1999 Commercial Buildings Energy Consumption Survey*. Department of Energy: Washington, DC.
- Feldstein, M. 1981. Inflation, Tax Rules and the Accumulation of Residential and Non-residential Capital. Working Paper No. 753. National Bureau of Economic Research: Cambridge, MA.
- Follain, J. and E. Jimenez. 1985. Estimating the Demand for Housing Characteristics. *Regional Science and Urban Economics* 15: 77–107.
- Fortune, J. 1998. Revolutionary Lift Designs for Mega-High-Rise-Buildings. *Elevator World*, May, 66.
- Goldsmith, R. 1962. *The National Wealth of the United States in the Postwar Period*. Princeton University Press: Princeton, NJ.
- Hansen, J., J. Formby and W. Smith. 1998. Estimating the Income Elasticity of Demand for Housing: A Comparison of Traditional and Lorenz-Concentration Curve Methodologies. *Journal of Housing Economics* 7, 328–342.
- Harmon, O. 1988. The Income Elasticity of Demand for Single-Family Owner-Occupied Housing: An Empirical Reconciliation. *Journal of Urban Economics* 24: 173–185.
- Hayami, Y. and V. Ruttan. 1971. *Agricultural Development*. Baltimore: Johns Hopkins University Press.
- Hendershott, P. 1982. Government Policies on the Allocation of Capital between Residential and Industrial Uses. National Bureau of Economic Research Working Paper No. 1036.
- Hendershott, P. and S. Hu. 1980. Government-Induced Biases in the Allocation of the Stock of Fixed Capital in the United States. *Capital Efficiency and Growth*. Ballinger: Cambridge, MA.
- Hendershott, P. and J. Shilling. 1982. Capital Allocation and the Tax Reform Act of 1981. *Public Finance Quarterly* 10(a): 242–273.

- Ibbotson Associates. 1991. *I/IDEAS, U.S. Capital Markets Module*. Ibbotson Associates: Chicago.
- Ihlanfeldt, K. 1982. Property Tax Incidence on Owner-Occupied Housing: Evidence from the Annual Housing Survey. *National Tax Journal*, 35: 84–97.
- Ioannides, Y. and S. Rosenthal. 1994. Estimating the Consumption and Investment Demands for Housing and Their Effect on Housing Tenure Status. *The Review of Economics and Statistics* 76: 127–141.
- Keiper, J., E. Kurnow, C. Clark and H. Segal. 1961. *Theory and Measurement of Rent*. Chilton: Philadelphia.
- Lindert, P. 1974. Land Scarcity and American Growth. *Journal of Economic History* 34: 851–884.
- Mayo, S. 1988. Theory and Estimation in the Economics of Housing Demand. *Journal of Urban Economics* 10: 95–116.
- McMillen, D. 1990. Consistent Estimation of the Urban Land Value Function. *Journal of Urban Economics* 27: 285–293.
- Mill, J. S. 1872. *Principles of Political Economy*. New York: Lee, Shepard and Dillingham (First edition 1848).
- Mills, E. 1969. The Value of Urban Land. *The Quality of the Urban Environment*. Resources for the Future: Washington, DC.
- . 1987. Has the United States Overinvested in Housing? *Journal of the American Real Estate and Urban Economics Association* 15(Spring): 601–616.
- Polinsky, A. M. 1977. The Demand for Housing: A Study in Specification and Grouping. *Econometrica* 45: 447–462.
- Reid, M. 1962. *Housing and Income*. The University of Chicago Press: Chicago.
- Ricardo, D. 1911. *The Principles of Political Economy and Taxation*. J.M. Dent and Sons, Ltd.: London (First edition 1817).
- Rosen, K. and M. Resnick. 1980. The Size Distribution of Cities: An Examination of the Pareto Law and Primacy. *Journal of Urban Economics* 98: 165–186.
- Schultz, T. 1953. The Declining Importance of Agricultural Land. *The Economic Organization of Agriculture*. McGraw-Hill: New York.
- Smith, B. and J. M. Campbell. 1978. Aggregation Bias and the Demand for Housing. *International Economic Review* 19: 495–505.
- Stigler, G. 1959. Bernard Shaw, Sidney Webb, and the Theory of Fabian Socialism. *Proceedings of the American Philosophical Society* CIII(June): 464–475.