The center restored: Chicago's residential price gradient reemerges

Daniel P. McMillen

Introduction and summary

Income growth and the development of new methods of transportation have made the decentralization of American cities a long-standing and ongoing process. Higher income raises the demand for land and housing, which typically are less expensive farther from the city center. The development of horse car lines, subways and elevated train lines, and most importantly, the automobile and highway system facilitated the growth of more remote locations by making long commutes feasible. The trend toward residential decentralization is reinforced by employment decentralization. Suburban locations offer firms low land costs, ready access to interstate highways, and the availability of a skilled labor force of nearby residents.

In many metropolitan areas, the traditional city center retains a strong job core in spite of the trend toward decentralization. Central business districts tend to specialize in high-skill, high-wage service jobs. Such jobs attract young professionals who enjoy city living and do not want to incur the long commute required from the suburbs. Re-gentrification of neighborhoods near the city center may take place as older housing is converted to modern condos and apartments to serve these households. The subsequent rise in housing prices provides cities with much-needed new revenue from property taxes.

In this article, I document the restoration of Chicago's city center from 1983 to 1998. Using a sample of single-family homes that each sold at least twice during the sample period, I find that prices rose far more rapidly near the city center than at the edge of the Chicago city limits. In the early 1980s, house prices increased with distance from the city center. In contrast, house prices *declined* by nearly 8 percent with each additional mile from the city center by the end of the 1990s.

The rapid growth of house prices in the city center has costs as well as benefits. Existing residents may find themselves forced to move when they can no longer afford what now are prime locations, and those who remain may not like the new character of the neighborhood. New residents may demand better provision of costly services, such as schools and police protection. Secondary effects will occur in other neighborhoods as displaced former residents move elsewhere. Nevertheless, the overall effect of a resurgent central city housing market is likely to be positive. Increased property tax revenues can more than pay for the new services, generating a surplus than can be used elsewhere in the city. New households attract stores and restaurants that in turn attract more residents. Just as urban decay can generate a flight to the suburbs, urban revitalization can generate additional growth that benefits the entire city.

Historical trends in Chicago

Chicago was a highly centralized city at the beginning of the twentieth century. Figure 1 shows that the City of Chicago then accounted for 81.5 percent of the population of the six-county region that today defines the Chicago metropolitan area.[1] Chicago's population peaked at 3.6 million in 1950, when it accounted for 69.9 percent of the metropolitan area's residents. The city's population then fell steadily up until 1990, while the rest of Cook County and the five collar counties grew rapidly. In 1998, Chicago's 2,802,079 residents accounted for 36.0 percent of the metropolitan area's residents, while the rest of Cook County and the collar counties accounted for 30.7

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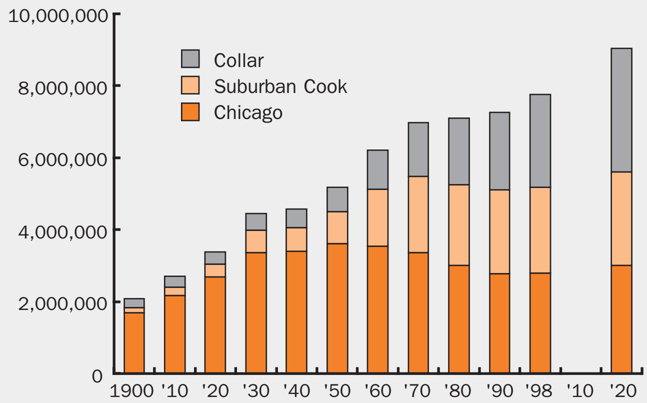
FIGURE 1

Chicago regional population
1990–2020



Source: Northeastern Illinois Planning Commission.

percent and 33.2 percent, respectively. However, the 1990s saw a reversal of the City of Chicago's 40-year decline in population, as its population increased by 18,353, or 0.6 percent. The Northeastern Illinois Planning Commission expects the trend to continue, with Chicago's population rising to 3,007,025 in 2020.

The distribution of population is also changing within the City of Chicago. Figure 2 shows the growth rates in population between 1990 and 2000 across the 77 community areas that comprise the city. Community areas on the Far South Side lost population over the decade. In contrast, the city center grew rapidly. The Loop added 4,434 residents, which is a growth rate of 37.1 percent. The Near North Side grew from a population of 62,842 to 72,811, or 15.9 percent. The Near South Side had a growth rate of 39.3 percent, adding 2,681 residents over the decade. The growth near the city center is significant because it reverses many years of decline, and it has occurred in some of the most expensive areas of the city.

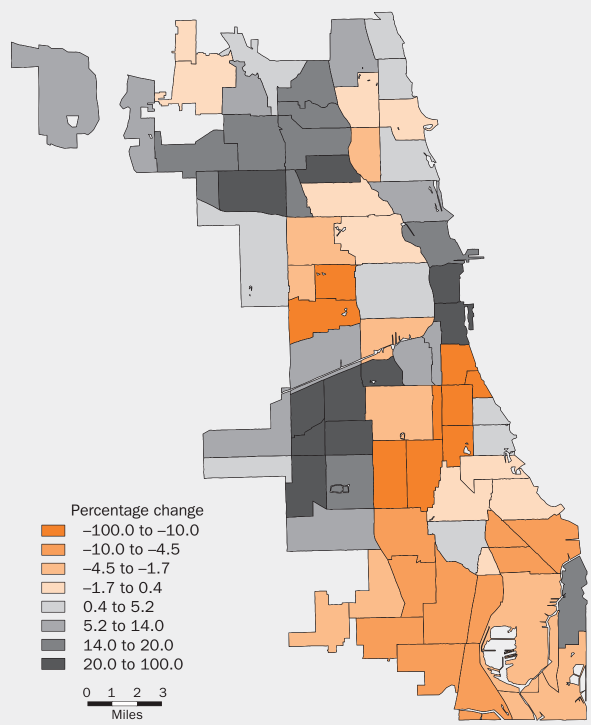
Data

To analyze trends in housing prices in the City of Chicago, I use a data set that includes all transactions of single-family homes that sold at least twice during the period from January 1, 1983, to December 31, 1998. The data are obtained from tax records and reflect actual transaction prices. In order to construct an index that controls for housing quality, I restrict the sample to repeat sales. When houses are not remodeled between sales, the average change in prices provides an estimate of a constant-quality house price index. Observations are not included in the final sample if the building size, lot size, or the number of stories changes between sales dates. I also discarded a small number of observations without addresses or sales dates. The final sample includes 52,972 transactions.

The Chicago metropolitan area is somewhat unusual in that very little information is available on house sales other than price and location. Although the City of Chicago collects information on lot size, building area, age, and the number of stories, no information is available on such common variables as the number of rooms or the presence of air

FIGURE 2

Chicago community area population change
1990–2000



Source: U.S. Census of Population and Housing, 2000.

TABLE 1

Descriptive statistics, house sales

	0–18 miles	0–6 miles	6–9 miles	9–12 miles	12–18 miles
Sales price	106.983	136.343	97.411	109.558	95.785
($1,000)	(105.901)	(191.882)	(55.544)	(109.216)	(61.940)
Log sales price	11.404	11.404	11.363	11.487	11.290
	(0.582)	(0.859)	(0.510)	(0.487)	(0.621)
Distance from CBD	8.759	4.718	7.678	10.229	13.296
(miles)	(2.561)	(1.019)	(0.793)	(0.801)	(0.955)
Lot size	4,158.77	3,345.72	3,958.15	4,469.70	4,963.86
(square feet)	(1,500.40)	(1,698.24)	(901.86)	(1,546.43)	(2,061.32)
Building area	1,208.37	1,276.34	1,205.27	1,189.92	1,189.40
(square feet)	(658.51)	(674.09)	(395.94)	(915.16)	(382.15)
Age (years in tens)	6.121	8.807	6.519	4.811	5.290
	(2.326)	(2.192)	(1.864)	(1.767)	(2.100)
More than one story (%)	16.58	21.66	13.92	17.51	16.75
Number of observations	52,972	7,572	21,248	18,264	5,888

Notes: Means are followed by standard deviations in parentheses for the continuous variables. CBD is central business district.

conditioning.[2] Table 1 presents descriptive statistics for the available variables. Over the full sample, sales prices average $106,983 over 1983–98. Average prices are much higher for houses near the city center: The average price for houses located within six miles of the city center is $136,343, compared with $95,785 for houses located more than 12 miles from the center. Lot sizes are smaller near the city center, with average lots of 3,345.72 square feet within six miles of the center versus 4,963.86 square feet in the most distant areas of the city. Building areas do not differ much across locations, but the housing stock is much older on average near the city center (88 years, compared with 61 years for all houses in the sample). The traditional center of Chicago is the intersection of State and Madison streets in the Loop. For the sample of house sales, distances range from 0.27 to 16.73 miles, with an average of 8.76 miles.

Estimated house price indexes

Figure 3, panel A plots the averages of the natural logarithms of house sales prices, calculated separately for each quarter from 1983 to 1998. I calculated separate price indexes for four intervals of distance from the Chicago city center, 0–6 miles, 6–9 miles, 9–12 miles, and 12–18 miles. During the early 1980s, average house prices were much lower for the 0-6 mile interval than for any other interval. Though average prices rose over time for all distance intervals, the rate of appreciation was much more rapid in the interval closest to the city center. By the end of the 1990s, average prices were much higher in the area surrounding the city center than in any of the other intervals.

Although figure 3, panel A shows a clear tendency toward the return of Chicago's center, simple averages are not the best way to construct price indexes. The composition of house sales may change systematically over the business cycle and by location. For instance, it is possible that only expensive homes remain in demand near the city center when the economy slows, which would tend to overstate the rate of price appreciation near the city center during economic downturns. Such changes in housing composition violate the spirit of a house price index, which is supposed to represent the rate of price appreciation for homes whose quality is not changing over time. A better measure then is a constant-quality price index.

Constant-quality price indexes

Two econometric methods are commonly used to construct constant-quality price indexes. The *hedonic* approach is based on a straightforward regression of house sales prices on housing characteristics, which include location and the date of sale in addition to standard house features such as living area. The hedonic price index is simply the set of predicted house prices for a house with given characteristics, constructed at varying target dates.[3] The other common method for constructing constant-quality price indexes is the *repeat sales* method.[4] The repeat sales approach is less vulnerable to missing variable bias than the hedonic approach because it estimates the rate of price appreciation from houses that sell at least twice during a sample period. If houses have not been remodeled between sales, then the change in prices across sales dates provides a measure of the rate of appreciation that is not contaminated by the effects of unobserved housing characteristics. Details on these estimation procedures are provided in the appendix.

By confining the sample to houses that sell at least twice during the sample period, the repeat sales estimator ignores the information provided by homes that sell only once. In addition to this potential inefficiency, the repeat sales estimator may be subject to sample selection bias if the sample of repeat sales homes differs systematically from the overall housing market. These problems are not likely to be serious in our sample, which covers a long period. In an active housing market, the set of houses that sell at least twice over 16 years is not likely to differ much from the overall stock of houses in the city.

Figure 3, panel B shows price indexes constructed by the hedonic method for various distance intervals. The representative house is 60 years old, has a single story, 1,200 square feet of living space, and a 4,200 square foot lot. The results are quite similar to the simple averages shown in panel A. Prices start out lowest in the interval closest to the city center, but this area has the most rapid rate of price appreciation over time, so that it has the highest prices at the end of the 1990s. Prices appreciated least rapidly in the most distant region, which is 12–18 miles from the city center. For the full sample of 0–18 miles, figure 3, panel C compares the price indexes calculated using the hedonic and repeat sales approaches. The indexes are similar, although the repeat sales estimator shows a slightly lower overall rate of price appreciation.

Estimated city-center gradients

Although dividing the sample into four distance intervals provides a useful illustration of the effects of distance from the city center on house-price appreciation rates, it is based on the unrealistic assumption that prices change discretely across intervals while remaining constant within them. A more conventional approach is to use distance from the city center as an

FIGURE 3

Chicago house price indexes

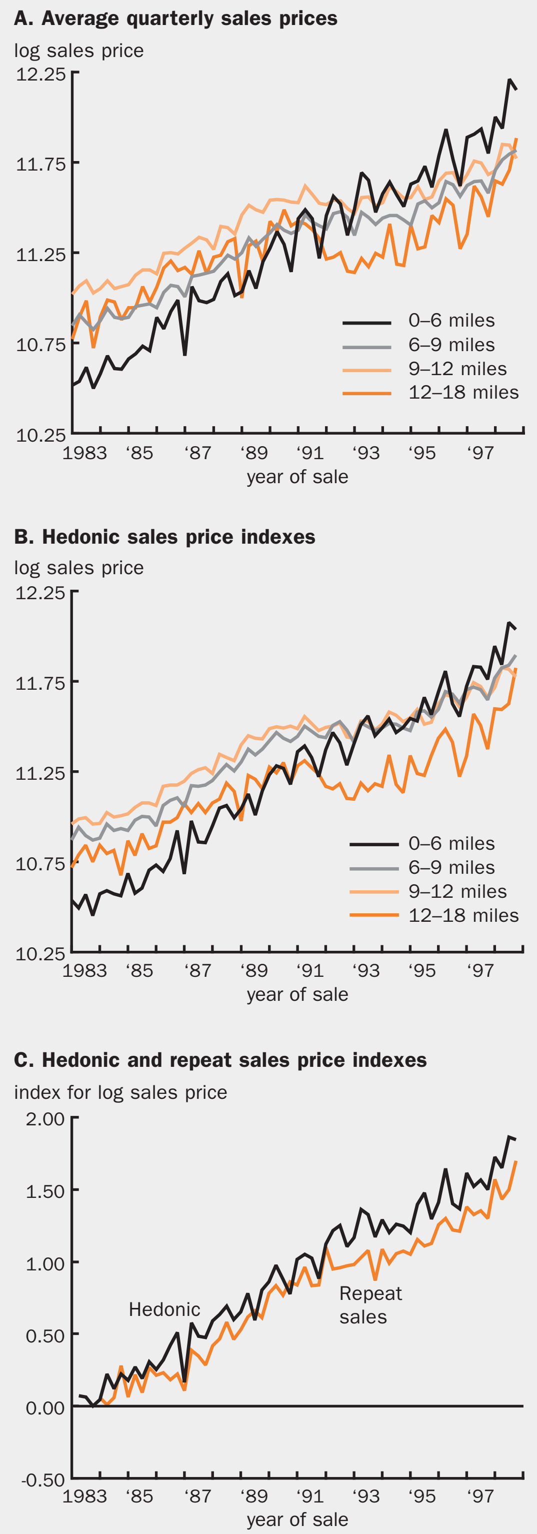
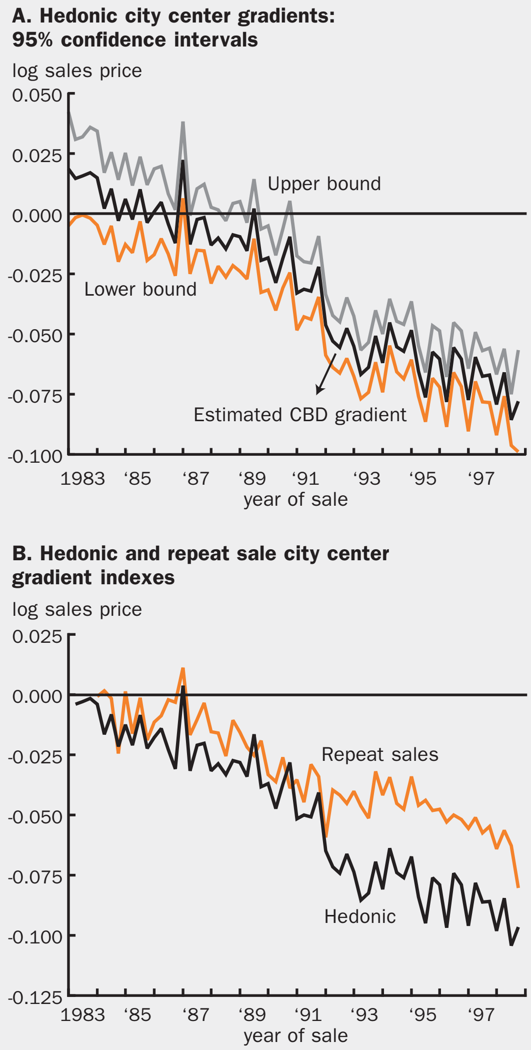


FIGURE 4

City center price gradients



Note: CBD is central business district.

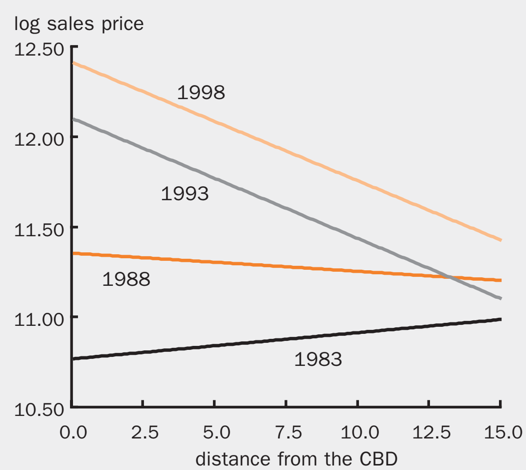
explanatory variable in the hedonic price function. The coefficient for this variable—the "city-center gradient"—represents the rate at which prices change with each additional mile of distance from the city center. The distance variable can also be interacted with the explanatory variables for the repeat sales model to form an index of time-varying city-center gradients.

The estimated hedonic city-center gradients and the associated 95 percent confidence intervals are presented in figure 4, panel A. The figure clearly illustrates the return of centralization to the City of Chicago. In the early 1980s, house prices *increased* with distance from the city center by a rate of about 2 percent per mile. The gradient fell throughout the 1980s and had become significantly negative by the beginning of the 1990s. By 1998, house prices are estimated to decline by more than 7 percent with each mile of distance from the city center. Figure 4, panel B presents the estimated index of repeat sales city-center gradients, along with the implied hedonic index, which is calculated by subtracting the estimated first-quarter gradient from the hedonic index. The repeat sales index shows a less rapid decline in the gradient because missing variables that help produce the sharp rise in house prices near the city center are correlated with distance to the city center, leading to a downward bias in the hedonic gradient term. Nonetheless, the repeat sales index also shows a significant decline in the gradient over time as areas near the city center regain their popularity and increase sharply in price.

Figure 5 provides an alternative view of the sequence of events. The hedonic estimates are used to generate predictions for four dates—the second quarters of 1983, 1988, 1993, and 1998—at varying distances from the city center. The representative home again is 60 years old, with a single story, 1,200 square feet of living space, and a 4,200 square foot lot. In 1983, house prices rose with distance from the center. House prices are not affected significantly by distance from the center in 1988. By 1993, prices are much higher near the center than in distant locations. Prices simply appreciate in all locations between 1993 and 1998, maintaining the city center premium. Over the full 1983–98 period, prices do not increase significantly in the most distant locations, whereas they rise dramatically in the city center.

FIGURE 5

Shift over time in the sales price functions



Note: CBD is central business district.

Census tracts

Confining the effects of location to discrete intervals or a single variable representing distance from the city center may obscure variation in appreciation rates across small geographic areas. Prices may move together in some city neighborhoods while they diverge greatly in others. It is difficult to estimate accurate price indexes for small tracts because some areas occasionally have only a few sales. However, McMillen and Dombrow (2001) show that price indexes can be estimated accurately for small samples when prices change smoothly over time. They use a Fourier expansion to estimate the time trend in house prices.

In the remainder of this section, I use McMillen and Dombrow's approach to estimate the rate of increase in house prices from 1990 to 1996 for 851 census tracts in the City of Chicago. I use a nonparametric estimator that uses the standard repeat sales estimator as its base. The estimator places more weight on nearby observations when constructing an estimate for a given geographic location. The target geographic locations are the midpoints of the 851 census tracts that are represented in the sample of repeat sales. All observations are used in constructing the estimated price appreciation rate for a census tract, but the estimator places more weight on house sales from the target tract.

The estimated price appreciation rates are illustrated in figure 6. As with previous results, the results in figure 6 show that housing prices grew much more rapidly near the city center than in more distant locations. Appreciation rates do not decline uniformly with distance, however. Growth rates do not decline as rapidly on the Near North Side as in locations that are comparable distances from the city center on the South and West sides of the city. The Far South Side has higher appreciation rates than comparable locations on the North Side. The Englewood area on the South Side is a pocket of no growth in the midst of moderate appreciation rates.

Calculating the appreciation rates for 1990–96 allows us to match the housing data with data from the 1990 U.S. Census of Population and Housing to explain differences in appreciation rates across census tracts. Table 2 presents the regression results, along with descriptive statistics for the explanatory variables. The regression results imply that growth rates decline by .401 percentage points with each additional mile from the city center. House-price growth rates increase by 0.0392 percentage points when the percentage of African-American residents in a tract rises by 10 percentage points. An increase in the percentage of Hispanic residents has a larger effect on growth rates: An increase of 10 percentage points in the number of Hispanic residents increases growth rates by 0.0876 percentage points.

Interestingly, Census tracts bordering Lake Michigan and tracts with high median incomes do not have higher appreciation rates than other tracts. Another striking result is that census tracts with high poverty rates and a lot of vacant housing in 1990 have high appreciation rates: Growth rates rise by 0.1052 percentage points when the percentage of households that are in poverty rises by 10 percentage points, and they rise by 0.1781 percentage points when there is a similar increase in the amount of vacant housing in the census tract. Census tracts with older housing do not have lower growth rates, but increasing the amount of housing that is owner occupied by 10 percentage points adds 0.1053 percentage points to appreciation rates.

FIGURE 6

Annual house price growth rates
1990–96

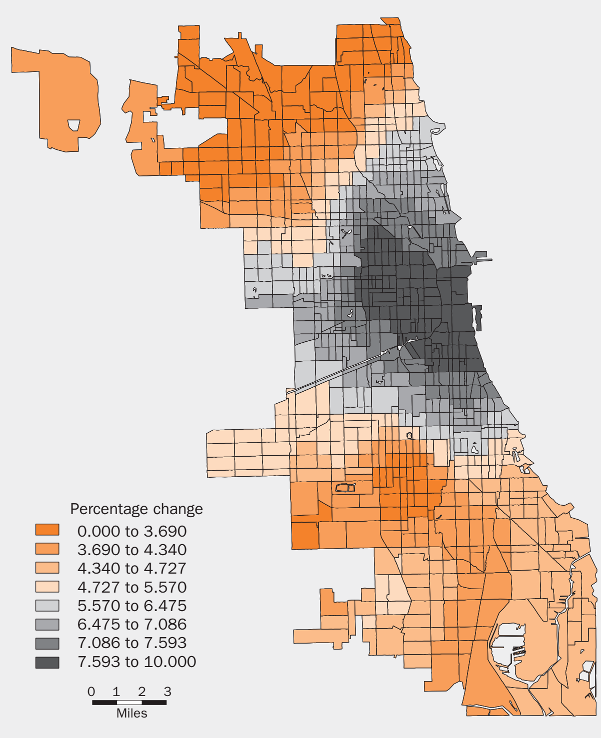


TABLE 2

House price growth rate regressions, census tracts

	Descriptive statistics		Regression	
	Mean	Standard	Coefficient	Standard error
Constant			7.389*	0.329
Distance from city center	6.370	3.091	–0.401*	0.014
Census tract borders lake	0.048	0.214	–0.118	0.152
African-American	0.424	0.444	0.392*	0.117
Hispanic	0.193	0.263	0.876*	0.175
High-school dropout	0.226	0.103	0.536	0.413
Completed college	0.116	0.142	1.289*	0.422
Median income ($10,000)	2.475	1.133	–0.005	0.060
Poverty	0.249	0.200	1.052*	0.284
Vacant	0.105	0.083	1.781*	0.465
Owner-occupied	0.366	0.244	1.053*	0.256
Median house age (years)	44.121	9.651	–0.014*	0.003

Notes: The dependent variable is the estimated average growth rate in house sales prices between 1990 and 1996. The mean of the dependent variable is 5.620 and the standard deviation is 1.574. There are 851 observations. The R^2 for the regression is 0.855. An asterisk indicates statistical significance at the 5 percent level.

Figure 6 and table 2 suggest that a process of gentrification is underway in the City of Chicago. Census tracts closer to the city center that had a higher percentage of vacant housing, high poverty rates, and high percentages of African-American or Hispanic households experienced higher appreciation in house prices than other locations in the 1990s. These census tracts are the same ones that the 2000 Census shows have had significant increases in population, and much of this population increase is accounted for by higher-income, white households. These areas are served by public transportation and are close to the center of Chicago's central business district. New, expensive housing is being built for young professionals who formerly were moving to the suburbs.

Conclusion

This article presents strong evidence of the return of centralization to the City of Chicago. Growth in suburban employment caused Chicago's central business district to decline in importance steadily until the 1980s. By 1990, the city center was enjoying renewed employment growth. Partly due to this growth, high-priced housing returned to locations near the city center. Although house prices increased slowly in census tracts near the city limits, prices rose very rapidly near the city center. By the end of the 1990s, the traditional negative house-price gradient had been restored. House values are estimated to decline by more than 8 percent with each mile of distance from the city center.

It is too early to judge whether this trend will continue. The majority of the Chicago metropolitan area's jobs are now in the suburbs. Furthermore, the city continues to suffer from poor schools and other social problems. But employment growth in the central business area, the presence of numerous million-dollar homes, the destruction or conversion of housing projects near the city center, and the growing importance of households with two central-city workers suggest strongly that the inner city is enjoying a resurgence.

APPENDIX: ESTIMATION PROCEDURES FOR CONSTANT-QUALITY PRICE INDEXES

Let V_{it} represent the sales price of house i at time t, and let $y_{it} = \log(V_{it})$. The following regression equation is the basis for the hedonic house price index:

$$1) \quad y_{it} = \delta_t + X_{it}\beta + u_{it}.$$

In equation 1, X_{it} is a vector of housing characteristics, u_{it} is an error term, and δ_t and β are parameters to be estimated. In our application, X_{it} includes the natural logarithms of lot size and building area, the age of the house, a dummy variable indicating that the house has more than one story, and distance from the city center. The estimates of δ_t are the coefficients for a series of dummy variables indicating the quarter during which a house is sold.

The estimated coefficient will be biased if unobserved housing characteristics are correlated with the error term. The repeat sales estimator avoids this bias by analyzing differences in sales prices of houses that sell at least twice during the sample period. If the coefficients for the housing characteristics do not change over time, the estimating equation for the repeat sales estimator is

$$2) \quad y_{it} - y_{is} = \delta_t - \delta_s + u_{it} - u_{is}.$$

In equation 2, s represents the date of a house's earlier sale. The base coefficient, δ_0, is normalized to zero because it is not identified.

McMillen and Dombrow (2001) generalize the standard repeat sales estimator by using a smooth continuous function $g(T)$ to represent the time trend in house prices, where T represents the date of sale. The estimator is written as:

$$3) \quad y_{it} - y_{is} = g(T_i) - g(T_i^s) + u_{it} - u_{is}.$$

In equation 3, T_i is the day of sale for house i and T_i^s is its previous sale date.

Following Gallant (1981, 1982), McMillen and Dombrow (2001) use a Fourier expansion to model $g(T_i)$ and $g(T_i^s)$. The first step in the Fourier expansion is to transform the time variable to lie between 0 and 2π. The transformed variables are $z_i = 2\pi T_i / \max(T)$ and $z_i^s = 2\pi T_i^s/\max(T)$. The Fourier expansions are $g(T_i) = \alpha_0 + \alpha_1 z_i + \alpha_2 z_i^2 + \Sigma_q(\lambda_q \sin(qz_i) + \gamma_q \cos(qz_i))$ and $g(T_i^s) = \alpha_0^s + \alpha_1^s z_i^s + \alpha_2^s z_i^{s2} + \Sigma_q(\lambda_q^s \sin(qz_i^s) + \gamma_q^s \cos(qz_i^s))$, where $q = 1, \ldots, Q$. The restriction that $g(T_i)$ and $g(T_i^s)$ are the same underlying function is imposed by setting $\alpha_1 = \alpha_1^s$, $\lambda_1 = \lambda_1^s$, and so on. These restrictions imply:

$$4) \quad y_{it} - y_{is} = \alpha_1(z_i - z_i^s) + \alpha_2(z_i^2 - z_i^{s2}) + \Sigma_q[\lambda_q(\sin(qz_i) - \sin(qz_i^s)) + \gamma_q(\cos(qz_i) - \cos(qz_i^s))] + u_{it} - u_{is}.$$

By convention, the price index is normalized to zero in the first period. Imposing a similar constraint on the Fourier index implies $g(0) = 0$, which implies $\alpha_0 + \gamma_1 + \ldots + \gamma_Q = 0$. The estimated price index can then be constructed from ordinary least squares (OLS) estimates of equation 4 as $\alpha_1 z + \alpha_2 z^2 + \Sigma_q(\lambda_q \sin(qz) + \gamma_q(\cos(qz) - 1))$, where z is a set of target dates.

The standard repeat sales estimator and McMillen and Dombrow's extension rely on an assumption that a single regression is adequate for an entire city. Nonparametric estimation allows for local geographic variation in house price appreciation rates. The nonparametric estimator used here was proposed by Cleveland and Devlin (1988), and is referred to as *locally weighted regression* (LWR). In constructing an LWR estimate for a given location, more weight is placed on nearby house sales than on distant sales. Let d_i be the distance between observation i and the target location for the price index. LWR uses a window of nearby observations to estimate the regression: The nearest b observations are given weights that decline with distance, whereas more distant observations receive no weight. In the empirical application, I set b equal to 10 percent of the total sample size. Let $d(b)$ represent the distance of the most distant observation receiving weight in estimation. Following common practice, I use the tri-cube function:

$$5) \quad w_i = \left[1 - \left(\frac{d_i}{d(b)}\right)^3\right]^3 I\left(d_i \le d(b)\right),$$

where $I(\bullet)$ is an indicator function that equals one when the condition is true and zero otherwise. The weights fall smoothly from a maximum of one at the target location to zero at distance $d(b)$.

The LWR estimate at the target location is simply the predicted value from the weighted least squares regression. Letting y_i represent the dependent variable and x_i the vector of explanatory variables, the LWR prediction is:

$$6) \quad \hat{y}_i = x_i'\left(\sum_{i-1}^{n} w_i x_i x_i'\right)^{-1}\left(\sum_{i=1}^{n} w_i x_i y_i\right).$$

The target site can be any arbitrary location. Each site will have a unique set of coefficient estimates, which implies a complete price index for the repeat sales estimator. The estimator varies smoothly over space, so estimated price indexes will be similar for nearby sites. However, estimates can differ significantly across more distant locations.

The centers of 851 census tracts within the city limits of Chicago are the target points for estimation, leading to 851 separate weighted least squares regressions. I construct price index estimates for each census tract for each day between 1983 and 1998. To summarize the estimated price indexes, I calculate the estimated index for January 1, 1990, and January 1, 1996, and solve for the implied yearly growth rate in prices. The former date corresponds to the 1990 Census, while the latter date is chosen to reduce the potential sensitivity of the estimates to small numbers of observations at the end of the sample period.

NOTES

[1]The six counties in Illinois are Cook, DuPage, Lake, Kane, McHenry, and Will.

[2]The situation is worse in the suburbs, which do not collect information on lot size.

[3]Examples of the hedonic approach include Bryan and Colwell (1982), Kiel and Zabel (1997), Mark and Goldberg (1984), Palmquist (1980), and Thibodeau (1989).

[4]The repeat sales house price index was first proposed by Bailey, Muth, and Nourse (1963). Applications include Abraham and Schauman (1991), Case, Pollakowski, and Wachter (1997), Case and Quigley (1991), Case and Shiller (1987, 1989), Clapp and Giaccotto (1998), Follain and Calhoun (1997), Gatzlaff and Haurin (1997), Geltner and Goetzmann (2000), Goetzmann and Spiegel (1997), Hill, Knight, and Sirmans (1997), Kiel and Zabel (1997), McMillen and Dombrow (2001), and Stephens et al. (1995).

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