Valuing Land and Improvements in Thin Markets: Does the Frequency of Sales Cause Property Tax Inequities?

Rachel N. Weber and Daniel P. McMillen

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Abstract

Few studies have attempted to explain the well-documented tendency for lower-priced properties to receive higher assessment. We argue that the absence of market information and the assessor's desire to avoid appeals may decrease assessment uniformity for both high- and low-valued properties in areas with few sales. Using data on assessments and sales prices for Chicago from 2001 through 2003, we construct an instrument for sales price that allows us to avoid the misspecification problems that may have led prior studies to overstate the presence of regressivity. Moreover, a novel multinomial logit analysis reveals that assessment ratios are more closely clustered near the middle of the distribution in areas where accuracy is easier to achieve and the probability of appeals is greater. We conclude that thin markets suffer from a higher degree of assessment variability where both extremely high and extremely low assessments are more common.

About the Authors

Rachel N. Weber is an Associate Professor in the Urban Planning and Policy Program at the University of Illinois at Chicago. She is the author of numerous articles and reports in the fields of public finance and economic development, including her book, *Swords into Dow Shares: Governing the Decline of the Military-Industrial Complex* (2000). Her current area of expertise is in evaluating the design and effectiveness of financial incentives for urban redevelopment, particularly the municipal use of Tax Increment Financing (TIF). Dr. Weber received her master's degree and doctorate in City and Regional Planning from Cornell University and bachelor's degree from Brown University. Dr. Weber can be reached at 412 South Peoria MC 348, University of Illinois at Chicago, Chicago, IL 60607; telephone: (312) 355-0307; fax: (312) 413-2314; email: rachelw@uic.edu.

Daniel P. McMillen is a Professor in the Department of Economics at the University of Illinois at Chicago. He also is a visiting fellow at the Lincoln Institute of Land Policy and a consultant at the Federal Reserve Bank of Chicago. He served as the Director of the Center for Urban Real Estate at UIC from 1999-2005, and has been a member of the economics departments at the University of Oregon, Santa Clara University, and Tulane University. Professor McMillen received his Ph.D. in Economics from Northwestern University in 1987. His publications have appeared in such academic journals as the *Journal of Urban Economics*, *Regional Science and Urban Economics*, the *Review of Economics and Statistics*, *Real Estate Economics*, and the *Journal of Business and Economic Statistics*. He serves on the editorial boards of the *Journal of Urban Economics*, *Real Estate Economics*, *Growth and Change*, *Journal of Housing Economics*, *Journal of Real Estate Literature*, the *Journal of Economic Geography*, and the *Journal of Regional Science*. Dr. McMillen can be reached at 601 South Morgan MC144 University of Illinois at Chicago, Chicago, IL 60607; telephone: (312) 413-2100; fax: 312-996-3344; email: mcmillen@uic.edu.

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Introduction

Despite a voluminous literature, interest in the issue of property tax equity remains strong. Research has explored whether the property tax burden is shared fairly by taxpayers within and among assessment districts or different price strata of sales (i.e., horizontal and vertical equity). If the property tax is applied uniformly across income strata, the ratio of assessed values to estimated market values should be the same across a range of housing values. The tax can be considered "regressive" if lower-valued houses are assessed at a higher proportion of their market value, or "progressive" if higher-valued homes are taxed more favorably. During a decade of steadily increasing tax bills, the incidence of this important tax has significant implications for homeowners' standard of living.

While most empirical studies have found evidence of an inverse relationship between assessment ratios and sales prices (i.e., regressivity), few have sufficiently explained this finding. Are assessors acting inappropriately, discriminating against lower-income households in favor of more potentially more powerful and vocal property owners? Without a convincing explanation of regressivity, the basis for corrective action is limited.

We propose that assessors have access to a greater quantity of more accurate information about property values in those markets that are more active, i.e., that have more comparable sales. Because property owners in active markets also have access to this information, they may be more prone to appealing their tax bills if they perceive them to be above the norm for the area. As such, assessments may be less variable in these "high information environments". In a slow market with few sales, relevant information cannot be incorporated quickly into either a property's market price or, by association, its assessed valuation. Therefore, assessments of land and improvements in thin markets may vary significantly for nearly identical properties and may well be biased systematically for both high- and low-value properties.

Methodologically, tests for value-related inequities have suffered from biases associated with sample selection, simultaneity, and measurement error. We take advantage of the timing of the assessment cycle to construct an instrument for sales price that allows us to avoid such problems. Moreover, the standard regression specification used to detect non-uniformity imposes an inflexible structure on the data by requiring that lower-priced homes always be associated with either lower or higher assessment ratios. In contrast, we adopt a multinomial logit model to capture a potentially non-monotonic relationship between assessment ratio and explanatory variables, such as sales density. Such a model explains the probability that assessment ratios fall within different segments of their distribution.

Our research examines the residential property market within one large assessment region: the city of Chicago, in which tax rates on housing vary not because of institutional differences between different property tax jurisdictions but because assessment ratios are unequal. The principal dataset for this research includes sales and assessed valuations for small (six units or fewer), residentially zoned properties within Chicago during the period from 2001 to 2003. We conduct conventional assessment ratio analysis on this data and then introduce the instrumented variable, predicted sales price, to determine if these results are biased. We also estimate the level of the assessment ratio of as a function of sales density and relevant explanatory variables that reflect neighborhood, locational, and site-specific information. Finally, we conduct a multinomial logit analysis to measure the relationship between sales price, sales density, and assessment ratios.

Consistent with results from previous studies, our analysis suggests that high-value properties tend to have lower assessment ratios. However, the degree of regressivity is much lower when our instrumental variable is substituted for sales prices, and our multinomial logit model incorporating sales frequencies suggests that this monotonic relationship is over-simplified. In fact, a more active market is associated with less variability for both high- and low-value properties: on average, more sales in an area lead to a lower probability of being in either tail of the distribution of assessment ratio. Conversely, less active markets suffer from a higher degree of assessment variability where both extremely high and extremely low assessments are more common. This lack of predictability, we speculate, could have an adverse effect on future (re)development efforts in markets that are less active.

Explaining Inequities in Property Taxation

Although the bulk of assessment ratio studies have found evidence of regressivity in the distribution of property taxes, scholars have been unable to identify the root cause of inequities in property tax systems, particularly the degree to which the administrative capacities of assessment professionals are at fault (Oldman and Aaron, 1965). Findings of vertical tax inequity may be due to the frequency of assessment coupled with the rate of change in the underlying property values (Mikesell 1980). Ideally, assessment dates should be as close to sales dates as possible. The less frequent the reassessment, the less likely values are to reflect to market changes and current values. Declining areas would receive higher assessments, and appreciating areas would be underassessed.

Some attribute the lack of uniformity to variability in assessor characteristics, such as whether the assessing official is elected or appointed, employed full- or part-time, or familiar with sophisticated appraisal and mapping techniques (Bowman and Mikesell, 1978; Bowman and Butcher, 1986; Cornia and Walters 2005). These institutional dimensions of assessment practice are relevant because they may protect or reduce an assessor's capacity for subjective judgment, i.e., the assessor's ability to "grant *ad hoc* property tax relief to shield those they think would be unduly burdened from the full brunt of the tax" (Bowman and Mikesell 1978, 139).

Findings of regressivity may reflect an assessor's deference to high-income or politically connected residents. For example, in Chicago, Berry and Bednarz (1975) found higher-income neighborhoods, particularly those near the Daley family stronghold of Bridgeport, to be underassessed -- implying some political impropriety. In other instances, it may be low-income and elderly property owners who benefit from an assessor's capacity for subjective judgment.

We propose that the lack of assessment uniformity observed in many municipalities stems not from some nefarious manipulation on the part of the assessor, but from the manner in which market value information is revealed within the assessment process and from fundamental flaws in the methodologies used to detect property tax inequities in the first place. Residential assessments are most commonly based on comparable sales.[1] While the sales comparison approach works well in markets with many transactions of similar homes, it can provide seriously misleading estimates of market value for a more idiosyncratic home with few good comparable sales. Ironically, finding comparable sales can be particularly troublesome in large cities because many areas are characterized by rental buildings that trade infrequently, and by older, unique homes that have few counterparts. Moreover, many areas have a large stock of substandard housing that seldom trades. Thin markets – areas with few sales – compromise assessors' ability to set market values while more active markets provide assessors with more information.

A small number of sales in a given neighborhood will generate poor estimates of the corresponding population parameter and could compromise the quality of the denominator in the assessment ratio, biasing it toward 0 (i.e., attenuation bias). When sample sizes are small, assessors may try to increase the sample by including more questionable sales, imputing value based on sales in other neighborhoods that are not truly comparable, or making other such adjustments. The more adjustments assessors make, the more potentially subjective and random the estimation of market value becomes. Variation in information across neighborhoods may cause the same priced property to be assessed at different rates (i.e., horizontal inequity).

While variation in sales frequency might explain a general lack of assessment uniformity, it does not, on its own, explain the tendency for regressivity. A strong and positive correlation between transaction activity and sales prices could potentially explain prior findings of higher assessments for low-value homes. Indeed, one would expect to find less demand for housing in areas with lower sales prices because of lower incomes, lower owner-occupancy rates, and potentially higher operating and transaction costs. However, sales prices may also be negatively correlated with the supply and availability of housing. For example, areas with high-value homes frequently use tactics such as restrictive zoning to maintain lower densities. Houses in these areas may also be customized in such a way that they have as great a likelihood of being inaccurately appraised as the kinds of severely deteriorated house one finds in very low-income areas. In other words, the limited comparability of marginal properties, those at both the extreme bottom and

[1] Sales transactions form the basis for market value estimates in 37 states (the others tend to rely on some measure of replacement cost; see DeBoer, 1996).

top of the sales price distribution, may lead to assessment inaccuracies at both ends of the assessment ratio distribution.

Other factors may help explain value-related inequities. Although property owners are likely to be uninformed about their assessment ratios or those of their neighbors, property taxes are highly visible and assessed on what is typically a household's largest asset (Wassmer 1993). More active markets provide a greater wealth and potentially more accurate information not only to the assessor but also to local property owners. As both knowledge about market values and effective tax rates increase, the likelihood of property tax appeals also increases (Bowman and Mikesell 1978). While appeals are easier to win on the basis of inaccurate recording of structural characteristics than for simple over-assessment, still, the cost of appeals in a large assessment region ensures that the assessor will try to avoid antagonizing property owners. The frequency of appeals will be lower if assessments are roughly equal for comparable properties in an active market. They will also be lower if effective assessment rates are below statutory rates. For example, it is difficult to win an appeal with the argument that your 14% assessment ratio is higher than your neighbor's 10%, when both are below a statutory rate of 16%.

This line of reasoning suggests that the threat of appeals will lead to a distribution of assessment ratios that is centered on a lower assessment rate than the statutorily required one. The distribution can be expected to have a low variance in areas with enough sales to produce more accurate information, and the distribution is likely to be skewed so that few properties there are assessed higher than the statutory rate. These predictions are based on two reasonable assumptions. First, we are assuming that assessors strive for accurate assessments, where "accurate" is define as similar assessments for comparable properties. While serving the objective of reducing the number of appeals, accuracy also leads to a low variance in the assessment ratio distribution. Second, we are assuming that assessments are purposely targeted at a rate lower than the statutory one, thereby moving the entire distribution of assessment ratios to the left.[2] A low average assessment rate should reduce the number of appeals.

Assessment Ratio Studies

The other reason for prior findings of regressivity may be related to the methodologies deployed to measure tax uniformity. The tendency for higher-priced properties to receive lower assessment ratios has been documented by such authors as Baar (1982), Bell (1984), Black (1977), Cheng (1974), Clapp (1990), Cornia and Slade (2005), Engle (1975), Haurin (1989), Ihlanfeldt (1982), Paglin and Fogarty (1982), and Sirmans, Diskin and Friday (1995). Previous research on this topic has consisted primarily of straightforward ratio studies, the ratio being that of assessed values to estimated market values. The prototypical ratio study uses one of the two following equations to test whether higher-priced homes receive lower assessment rates:

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[2] There may be some constraints on how much the average assessment rate can be reduced. Most state governments conduct assessment ratio studies of every county or municipality, and there is some political pressure to have average ratios that are not too far from the statutory rate.

$$A / P = \alpha_0 + \alpha_1 P + u \quad (1)$$

$$\ln P = \beta_0 + \beta_1 \ln A + u \quad (2)$$

where *A* represents assessed value and *P* is sales price.[3] The typical finding from these is that $\alpha_1 < 0$ or $\beta_1 > 1$. Either result implies that higher-priced homes receive lower assessment ratios.

Equations (1) and (2) impose a restrictive structure on the data. Under either specification, higher-priced sales are always associated with either lower or higher assessment ratios. In contrast, our assumption is that the objective of the assessor is to produce *accurate* assessments. Assessment ratios will be close to the target value in locations where prices are readily predictable. Unusually high or low ratios are more likely to occur in areas with few comparable sales.

One way to account for predication accuracy is to directly introduce a measure of predictability. We maintain the reasonable assumption that prices are easier to predict in areas with many sales. Letting S represent the number of sales in a given geography (e.g., census tract), the logical starting point for the analysis is a straightforward extension of equation (1):

$$A / P = \alpha_0 + \alpha_1 P + \alpha_2 S + u \quad (3)$$

Equation (3) again imposes a monotonic relationship between the explanatory variables and the assessment ratio. The equation also illustrates a potential weakness in the standard regression specification to measure vertical equity. If the number of sales helps to explain assessment ratios, and *S* is correlated with sales prices, then the estimated value of α_1 will be biased. For example, suppose that assessment ratios are lower in areas where prices are relatively unpredictable (so that *S* is small), and that high-priced homes tend to be concentrated in areas with low sales. Then $\alpha_2 < 0$ while *P* and *S* are negatively correlated, implying a positive bias in the estimate of α_1, which is precisely the result found in traditional assessment studies. Of course, it is also possible that low sales lead to high ratios on average or that it is low-priced homes that are concentrated in areas with low sales. Under any assumption, the correlation between prices and the number of sales will tend to cause biases in traditional assessment ratio studies.

Apart from this missing variable bias, the traditional equations are misspecified because they assume that the explanatory variables have a simple monotonic relationship with assessment ratios. We have argued that assessors hope to eliminate variability and have assessment ratios clustered around a target value. If this assumption is true, then higher values of *S* should eliminate both high and low values of *A*/*P*. This non-monotonic relationship cannot be represented adequately by simple estimating equations.

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[3] Although other variants exist and these equations are often supplemented with additional explanatory variables, equations (1) and (2) are sufficient to illustrate our proposed methodology.

In contrast, we propose a multinomial logit model to account for a non-monotonic relationship between the assessment ratio and the explanatory variables. To implement this model, we first sort the assessment ratios from lowest to highest (after trimming the top and bottom 1% of the ratios). The indicator variable for the logit model, I, takes on one of three values depending on the location of the observation in the assessment ratio distribution. We define the base category, I=0, as the middle 25%-75% of the assessment ratio distribution. We define I=1 when the ratio falls in the lowest 25% of the distribution, and I=2 for observations in the top 25% of the distribution. The model estimates the probability that the assessment ratio falls in either the top or the bottom of the distribution, relative to the probability of being in the middle.

The logit model generalizes the traditional approach by allowing for complex relationships among the variables. If assessments are regressive and higher sales prices lead to lower assessment rates, then we expect to find the coefficient on P to be positive in the I=1 category and negative in the I=2 category: higher prices increase the probability that assessment ratios are in the lowest quarter of the distribution and decrease the probability that they are in the highest quarter, relative to being in the middle half. Alternatively, the model also can accommodate an association between sales prices and assessment accuracy. For example, suppose that high-priced homes are relatively difficult to assess accurately. If both unusually high and low assessment ratios become more likely when sales prices increase, then we may find that the estimated coefficients on P are positive in both the I=1 and I=2 categories: higher prices increase the probability of being in the tails of the distribution.

The logit model also allows us to test whether the tendency toward regressivity disappears once we control for the number of sales. As argued above, the logit model implies regressivity if the coefficients on P are positive in the I=1 category and negative in the I=2 category. We expect prices to be easier to predict in census tracts with more sales, so that the estimated coefficients on S are negative in both the I=1 and I=2 categories, i.e., there is less chance of being in either tail of the distribution. If P and S are correlated, it is possible that the pattern of the coefficients on P changes when S is included as an explanatory variable.

Property Taxation in Chicago

The Illinois constitution requires all properties to be assessed at 33% of market value while imposing a common tax rate for all properties in a taxing district. However, Chicago and Cook County are so large that the constitution implicitly grants exceptions to them. Although tax rates cannot vary by property type within a taxing district, any county with more than 250,000 residents is allowed to adopt a classification system. Of the state's 102 counties, only nine currently meet this population requirement, and six of these counties are in the Chicago metropolitan area. Only Cook County, with 5,376,741 residents in 2000, has elected to maintain a classification system. The tax system favors residential properties. Whereas commercial and manufacturing properties are supposed to be assessed at 38% and 36% of market value, respectively, residential properties with six units or fewer are supposed to be assessed at 16% of market value. In practice, assessment ratios fall below these statutory rates, particularly for residential properties.[4]

The state constitution assigns the primary responsibility for property assessments to the township. However, all assessments in Cook County are conducted by the Cook County Assessor's Office, whose director is elected to a four-year term. The county, the second largest assessment district in the United States, is divided into triads, with properties in each triad re-assessed every three years. The city of Chicago, with 2,896,016 residents in 2000, is one triad. Current assessments in Chicago were officially put in place on January 1, 2003, replacing the assessments from January 2000. Despite the official date, assessments typically are announced with a lag of approximately a year and a half. Thus, the 2003 assessments were not actually announced until the summer of 2004. This long lag allows the Assessor's Office to use sales from 2003 to help determine assessments for that year. Our conversations with representatives of the Assessor's Office suggest that assessments for 2003 would be calculated using sales from 2001, 2002, and 2003.

The Assessor's Office uses sales price regressions to assess residential properties with six units or fewer. Separate regressions are estimated for each of 129 neighborhoods defined for Chicago. The neighborhood definitions are reviewed periodically by field appraisers and each property is photographed in order to ensure that assessments are accurate. Significant residuals are flagged and reviewed.

With slightly more than a million small residential properties in the city of Chicago, most neighborhoods have enough sales to produce reasonably accurate assessments. However, the diversity of the housing stock in this large city makes assessments inherently difficult, and transactions vary with factors related to both housing demand and supply. Figure 1 maps sales of smaller residential properties that took place between 1992 and 2003 divided by the total number of such properties in each census tract.[5] High concentrations of rental housing, low levels of household income, and large numbers of low quality housing result in a small share of properties transacted in many neighborhoods on the city's south and west sides. On the other hand, tracts along the perimeter of Lake Michigan also exhibit low sales frequencies, in this case because of the paucity of smaller, single-family homes.

Data

Our dataset includes all sales of residential properties with seven or less units in the city of Chicago from 2001 to 2003. The data were provided by the Illinois Department of Revenue (IDOR), which is responsible for conducting assessment ratio studies for all Illinois townships and counties and for collecting the property transfer declaration forms

[4] The Illinois constitution does not allow the highest assessment rate to be more than 2.5 times the rate for the lowest rate. In Cook County, the highest rate is for commercial and the lowest is for residential, which produces a ratio of .38/.16, or 2.375. It is not certain whether effective tax rates meet the constitutional requirement since the degree of under-assessment appears to be lower for commercial properties than for residential.

[5] Census tracts are a smaller unit of analysis than the neighborhood overlay used by the County Assessor.

that must be filed when a property changes ownership. The IDOR eliminates non-arm's length sales and any sales with unusual financing. The remaining sales include a small number of extremely large and suspiciously small prices. To eliminate the effects of these unrepresentative observations without biasing the results, we symmetrically trim the lowest 1% and highest 1% of the sales prices from the sample. The final dataset of sales prices includes 53,418 observations.

The three year window of sales corresponds to the timing used by the Cook County Assessor's Office for the 2003 assessment cycle. As noted previously, although every property in the City of Chicago was re-assessed during 2004, the official assessment date is January 1, 2003. We merged our sales dataset with the complete assessment file for Chicago for 2003. The assessment file includes 416,535 single-family homes with six units for fewer. The merged dataset includes assessments for 2003 and detailed structural characteristics for all properties.[6] In addition, the sub-sample of sales includes assessments at the time of sale. These assessments date from January 1, 2000. We use the Chicago CPI from the Bureau of Labor Statistics to express all assessments and sales prices in 2003 dollars.

The typical assessment ratio study includes sales prices and assessments only for the set of properties that have sold. Using our dataset, the typical study would include the 53,418 that have sold, and each sale would be matched with the assessment at the time of sale. Since sales take place between 2001 and 2003 and assessments date from January 1, 2000, the sales and assessment dates do not match. This mismatch would typically be handled by deflating prices to a common date.

This procedure is subject to four problems. First, the CPI is only an approximation of the actual inflation rate for residential properties. If home prices are rising more rapidly than the CPI, assessment ratios will appear to be falling over time even if assessments were near the target value at the start of the assessment cycle. The second problem is related to the first: the typical procedure does not take into account the timing of the assessment cycle. In Chicago, the assessor uses sales prices from 2001-2003 to put assessments in place for the beginning of 2003. The goal presumably is to have an accurate assessment as of January 1, 2003; it certainly is no fault of the assessor if assessment ratios fall as prices subsequently rise in subsequent years.

The third problem with the standard approach as implemented using equation (1) is that sales price appears on both sides of the equation. If P is measured with error, there will be attenuation bias that tends to bias estimates of α_1 downward, i.e., toward regressivity. This problem has been recognized in the literature. For example, Clapp (1990) constructs an instrumental variable for P using sample means for ranges of the sales price distribution. The final problem is one of sample selection: are the properties that have sold representative of the overall sample (Gatzlaff and Haurin 1997)? Homes with low assessment may be more (or less) likely to sell, and this tendency may be more

[6] The IDOR sales file also includes data on other classes of properties, including commercial, industrial, and large residential units. However, we only have complete assessment data on Class 2 properties, i.e., residential units with six units or fewer.

pronounced at high sales prices where the gain to a low assessment is higher. In this case, true assessment ratios will be understated, and ratio studies will be biased toward a finding of regressivity.

Our dataset allows us to control for these sources of bias because we have data on the full assessment file for 2003, and our sales dataset is precisely the information that is used by the Assessor's Office to assess residential properties. In principle, we can replicate the full assessment process by estimating a sales price for every property as of January 1, 2003. We then can compare *predicted* sales prices to actual assessments to determine whether assessments are regressive. It may turn out in subsequent years that sales price rise rapidly so that assessment ratios fall, or that the properties that sell produce results suggesting regressivity. But the goal of the Assessor's Office is presumably to produce accurate assessments for *all* properties at one date.

We estimate separate regressions for each of the 129 neighborhoods indicated on the assessment file. The sample includes properties that sold during 2001-2003. The dependent variable is the sales price. Explanatory variables include structural characteristics and the date of sale by quarter. The data set is geocoded, allowing us to measure distance to the traditional city center at the intersection of State and Madison streets, along with distance to Lake Michigan, the nearest stop on the elevated train ("el") line, and the distance to the nearest rail line. Chicago is still a highly centralized city (McMillen 2003), so we expect that people are willing to pay more for residences closer to the city center. Proximity to Lake Michigan can be expected to raise property values because the lake is lined with parks and it has a moderating influence on the climate. The el is an important means of commuting within the city, and we expect home prices to be higher near stations. However, the noise associated with proximity to a rail line – whether on the el, a suburban commuter, or freight line – will tend to lower property values.

Once we have predictions of sales prices for the entire sample, we can reproduce a standard assessment ratio study using the information that is actually available to the assessor. The procedure avoids problems with using an incorrect price deflator because the regression allows us to date all variables as of January 2003. By using sales from 2001-2003 to estimate property values and comparing them to assessments for 2003, our procedure directly reproduces the timing of assessment cycle in Chicago. Our estimated sales price serves as an instrument for P, eliminating the bias associated with measurement error while, by using data on all assessments, the procedure also avoids the problem of sample selection bias.

Traditional Assessment Ratio Analysis of Chicago

Table 1 presents traditional measures of assessment accuracy for the sample of observations that sold between 2001 and 2003. The average real price rises from $194,303 in 2001 to $228,424 in 2003. The implied average annual appreciation rate of 8.4% is much higher than the 1.7% inflation rate implied by the Chicago area's CPI. Median sales prices, which rise from $160,158 in 2001 to $198,254 in 2003, are much higher than average prices. At 11.3%, the average annual appreciation rate is even higher for the median price than for the average. The mean assessment is approximately \$16,000 and the median is about \$13,000 for all three years. Average and median assessments do not change much over time because they are stuck at 2000 levels; they are not constant because the sample composition changes.

Table 1 shows that the average assessment ratio falls from 9.6% in 2001 to 8.9% and 7.9% in 2002 and 2003, while comparable values for the median ratio are 8.5%, 7.8%, and 7.1%. We also use two methods recommended by the International Association of Assessing Officers (IAAO, 1999) for evaluating assessment ratio accuracy. The IAAO calls the *coefficient of dispersion* "the most generally useful measure of variability." It measures the average percentage deviation of the assessment ratios from the median ratio, and is defined as $\frac{100}{n}\sum_{i=1}^{n}\frac{|R_i - R_m|}{R_m}$, where R_i is the assessment ratio for observation *i* and R_m is the median ratio. The coefficients of dispersion range from 29%-32% in Table 1, or approximately double the IAAO's recommended limit of 15% for older residential properties. Thus, Chicago's assessments are more variable for this sample of sales than is considered acceptable by the IAAO.

The second measure of assessment ratio accuracy, the *price-related differential* (PRD), takes into account the tendency for high-priced properties to receive lower assessment rates. It is simply the ratio of the simple mean to the value-weighted mean.[7] When PRD > 1, the simple mean is higher than the weighted mean in which assessment ratios drawn from higher-priced properties receive more weight. Thus, PRD > 1 implies regressivity. The PRD's range from 1.134 to 1.166 in Table 1, and both values are well in excess of the IAAO's upper limit of 1.03. Together, these results imply that Chicago's assessments are highly variable and regressive. Estimates of equation (1) also imply regressivity. Table 2 presents the results of regressions of assessment ratios on sales prices. The estimates imply that assessment ratios decline significantly with sales prices.[8]

Predicted Sales Prices

A traditional analysis of assessment ratios indicates that Chicago's assessments are highly variable and regressive. We now want to determine whether (1) these results are biased by using actual sales prices in the denominator of the assessment ratio, and (2) the results are influenced by the number of comparable sales that are available for the assessments. To construct our instrument for sales, we estimate separate regressions for each of the 129 neighborhoods delineated for Chicago by the Cook County Assessor's

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[7] The value-weighed mean is defined as $\frac{\sum P_i R_i}{\sum P_i}$, where *P* is the sales price.

[8] Although they are not presented here since our focus is directly on assessment ratios, estimates of equation (2) imply the same regressive relationship between. The estimated values of β_2 are 1.0897, 1.0894, and 1.0678 for 2001-2003, with standard errors of 0.0023, 0.0020, and 0.0044. Each of the estimated values is significantly different from unity.

Office. Since the results are far too numerous to present here, we show the results for the pooled sample. We do not actually use the regression for the pooled sample in making any predictions. However, the results show the structure of the regression we do adopt.

The descriptive statistics for the regression are shown in Table 3, and the regression results are shown in Table 4. The base regression includes a variety of structural characteristics, the quarter of sale (with 2003:1 as the base), several locational measures, and indicators of the number of units in the building. Although the R^2 for the base regression is only 0.352, remember that the regression shown in Table 4 does not include any neighborhood indicators. Our predictions are based on 129 separate regressions, with R^2s ranging from 0.174 to 0.934 with an average of 0.578. Chicago includes a wide variety of houses, of many different vintages and vastly different conditions. It is not surprising that prices are somewhat difficult to predict even with an ample set of structural variables. The task faced by the Assessor's Office is a difficult one, and this difficulty of predicting sales prices is one of the factors leading to variability in assessment ratio.

One of the advantages of using the predicted prices in the assessment ratio analysis is that we can directly predict the price as of the time when the assessments are put in place. By setting all of the time variables to zero, we are predicting prices as of the first quarter of 2003. Furthermore, we are able to predict sales prices for every observation in the data set, including properties that do not sell during this time. Thus, the assessment ratio study is no longer subject to bias caused by analyzing only those properties that actually sell.

The advantages of the timing convention for the predictions are shown in Figure 2 and 3. These figures present kernel density estimates for each year's sales.[9] The kernel density estimator is analogous to estimates obtained assuming a normal distribution, but it does not impose stringent assumptions on the form of distribution. In particular, the estimated distribution can be skewed, asymmetric, and so on. Figure 2 shows that the estimated distribution for the sample of sales is centered on the sample median of 0.085 in 2001, the year after the assessments for this sample were officially put in place. Over the next two years, assessments do not increase but sales prices rise faster than the rate of inflation. Thus, the distribution is moving to the left; when assessment ratios are evaluated using sales from after the assessment date, average and median ratios appear to decline over time.

Figure 3 shows what happens when the predicted sales prices for 2003 are substituted for actual prices in this sample of sales. We now are closely matching the procedure used by

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[9] We use a Gaussian kernel: $f(R) = \frac{1}{hn}\sum_{i=1}^{n}\phi\left(\frac{R_i - R}{h}\right)$, where R is the target ratio, h is the bandwidth, and ϕ is the standard normal density function. We use the rule-of-thumb bandwidth recommended by Silverman (1986), $h = 1.06n^{-1/5}\sqrt{\text{var}(R)}$. We vary the target ratios from .01 to .20 in increments of .001. Excellent reviews of nonparametric estimation are presented in Härdle and Linton (1994), Pagan and Ullah (1999), and Yatchew (1998).

the assessor: given prices predicted for 2003 using sales from 2001-2003, what is the implied assessment ratio for the assessments put in place in January 2003? The estimates are shown for each year's sales, along with the complete set of properties – every residential property with six units or fewer in Chicago. The estimated distributions are now centered on about 0.10 for sales from all three years, and they are virtually indistinguishable from one another. They also are virtually indistinguishable from the results for all properties, including those that did not sell. This result suggests that using predicted prices in place of actual prices eliminates the selection bias associated with confining the analysis to the subset of properties that sold.

Table 5 replicates the traditional assessment ratio analysis of Table 1 using predicted sales prices in place of actual prices. Although predicted prices are available for all properties, we focus on sales so that the results are directly comparable across the two tables.[10] Note that by using predicted sales prices for 2003:1, the average and median prices no longer vary substantially across years. As a result, the mean assessment rate does not decline over time, instead remaining nearly constant at 9.3%-9.4%. The median is much closer to the mean (9.2% in all years) than in Table 1. With a range of 16.721-16.983, the coefficient dispersion is nearly half the level indicated in Table 1. However, this tendency toward lower variation is in part an artifact of using regressions to estimates sales prices. By construction, predicted prices are not as variable as actual prices, so assessment ratios are likely to be less variable also. The low value for the price related differential, however, is not an artifact of the regression procedure. The values range from 1.014 in 2001 to 1.020 in 2003, indicating at most a modest tendency toward regressivity.

The assessment ratio regressions reported in Table 6 also suggest that the instrument for sales price significantly reduces the apparent tendency toward regressivity. We combine years in the regressions because the results do not vary substantially over time. The first column of results in Table 6 uses a single regression to reproduce the results from Table 2. The regression indicates significant regressivity in the sales sample. The regression indicates that assessment ratios decline over time when actual prices form the denominator: relative to 2003, ratios are estimated to be 1.32 percentage points higher in 2001 and 0.74 percentage points higher in 2002. These results confirm the finding from simple descriptive statistics that using assessments from 2000 as the basis for ratios in the succeeding three years leads to declining assessment ratios as prices rise faster than the CPI.

The second column of results in Table 6 uses the predicted sales price in place of the actual price in the assessment ratio regressions. The sample is still restricted to the subset of properties that sold for 2001-2003. Replacing actual sales prices with an instrumental variable significantly reduces the degree of regressivity implied by the regression as the magnitude of the coefficient falls from -0.1133 to -0.0223. Similarly, the estimated coefficient of -0.0183 in the final regression indicates only modest regressivity when the

[10] The samples are slightly different because the trimming differs. Whereas the lowest and highest 1% of the actual sales ratios are trimmed from the sample in Table 1, the lowest and highest 1% of the *predicted* sales ratios are trimmed from Table 5.

sample includes all residential properties with six units or fewer. These results suggest using lagged sales prices as both the denominator for the assessment ratio and as an explanatory variable significantly overstates the degree of regressivity. Sample selection appears to be less of an issue as the coefficient on the predicted sales prices does not change much when we add properties that did not sell to the regression.

In Table 7, we add the number of sales in the census tract to the regression.[11] Whereas the coefficient on this variable is significantly negative in the regression using actual sales prices, it is both small and statistically insignificant when the predicted price is substituted for the actual price for the sample of sales. The coefficient is statistically significant but very small in the final regression, which includes all properties. Adding sales frequency to the regression does not affect the implication of regressivity substantially; the coefficients on sales price, whether actual or predicted, are approximately the same in both Tables 6 and 7. The reason for this lack of change is that prices and the number of sales are not highly correlated; the correlation is 0.196 across the full sample of sales.

Multinomial Logit Results

The regression results up to this point all still impose a monotonic relationship between the assessment ratio and the explanatory variables. In this section, we relax this assumption using a multinomial logit model. The base category (I=0) is the middle half of the assessment ratio distribution. The other two categories are the lowest 25% and highest 25% of the distribution. These categories are indicated by I=1 and I=2, respectively.

The multinomial logit results presented in Table 8 are comparable to the assessment ratio regressions shown in Table 6. As was the case in Table 6, the multinomial logit model indicates that assessments are regressive. The positive coefficients on price in the top panel indicate that higher prices increase the probability that the assessment ratio will be in the lowest 25% of the distribution. The negative coefficients on price in the lower panel indicate that higher prices decrease the probability that the assessment ratio will be in the highest 25% of the distribution. Thus, the effect of sales price is similar to that implied by a simple regression: higher prices lead to lower assessment ratios. The estimated coefficients are much lower when predicted prices replace actual prices. This finding, too, is consistent with the results of Table 6. Both the simple regressions and the multinomial logit models suggest that assessments are regressive, but the degree of regressivity is much lower when an instrumental variable is used in place of actual sales prices.

[11] To construct this variable, we first match each property with the census tract in which it is located. We then use the sample of sales to calculate the number of sales of residential properties with six or fewer units that sold between 2001 and 2003. The average number of sales is 126.964, with a standard deviation of 89.798 and a range of 0-483. Of the 878 census tracts in the sample, 44 had no sales of small residential properties.

Table 9 shows the results when sales frequency is added as an explanatory variable to the multinomial logit model. As predicted, this variable does not have a simple monotonic relationship with the assessment ratio. In all three estimated models, greater sales frequency leads to a lower probability of being in both the I=1 and I=2 categories. This pattern means that having more sales makes both extremes of the distribution less likely: with more sales, assessment ratios are more likely to cluster in the center of the distribution. This result provides strong evidence that our prediction of assessor behavior holds. Having more sales both makes it easier to conduct accurate assessments and creates an incentive for assessors to rein in variability for fear of tax payer appeals. As result, the distribution of assessment ratios is more closely clustered around the center.

Adding the sales frequency variable to the logit model reduces but does not eliminate the finding of regressivity. The first column of results shows that higher prices increase the probability of having an assessment ratio in the bottom of the distribution while decreasing the probability of being in the top of the distribution. In the second column, which uses predicted prices for the sample of properties that have sold, the patterns change: higher prices continue to decrease the probability of being in the top quarter of the distribution, but they also decrease the probability of being in the bottom quarter. In other words, high prices act much like sales frequency by increasing the probability of being in the middle of the distribution. However, the results again indicate regressivity when the model is applied to the entire sample of properties, including those that have not sold.

Conclusion

By including the number of sales in a census tract as an explanatory variable for assessment ratios in our multinomial logit analysis, we tested the notion that a greater number of sales will improve assessment accuracy. This variable is highly significant, and the effect is as predicted: a greater number of sales decreases the probability of being in either tail of the distribution. Thus, both extremely high and extremely low assessments are more likely in these locations, and owners there face greater uncertainty regarding property tax burdens.

Overall, the results strongly suggest that thin markets make estimating property values difficult. When a property is located in an area with few comparable sales, the assessor has less information upon which to base assessments. In contrast, thick markets with ample sales are associated with more accurate assessments, both because of the availability of more data and the potential for more appeals. In active markets, information about market values and effective tax rates is likely to circulate among property owners. If property owners perceive themselves to be singled out for higher assessments, they will challenge their bills. Assessors can avoid these expensive appeals by both assessing below the statutory rate and by clustering assessment ratios near the center of the distribution, particularly in areas with more sales.

Our paper contributes to the literature by proposing the use of a multinomial logit model to analyze assessment ratios. The logit model avoids the serious misspecification inherent in the standard regression specification. Assessment accuracy may be related to price if, for example, high-priced properties are easier to assess. In this event, findings of regressivity are questionable as higher prices may reduce the probability of being in either extreme of the distribution. In contrast, the standard approach imposes a simple relationship in which higher prices increase the probability of being only in the lower end of distribution of assessment ratios.

Our analysis also demonstrates that previous findings of vertical tax inequity may be due, in part, to measurement and specification error. In this study, we have taken advantage of the timing of the assessment cycle in Chicago to construct a high-quality instrument for sales price that allows us to avoid several problems that plague standard assessment ratio studies. First, the sales price regression makes it possible to value all variables in 2003 dollars without relying on a CPI that is inaccurate since it is only an approximation to the actual inflation rate for residential properties. Second, by using the information that is actually available to the assessor to estimate price, we avoid penalizing the assessor for failing to predict the path of *future* prices. The goal presumably is to produce accurate assessments at the time the assessments are put in place; using sales prices from three years later to evaluate the assessment performance imposes a moving standard. The third advantage of our instrument is that it avoids biases associated with simultaneity and measurement error that are caused by having price in both the denominator of the dependent variables (the assessment ratio) and the explanatory variables (sales price). Finally, using an instrument for sales price allows us to conduct the assessment study using all properties rather than just the ones that sell, a feature that helps reduce sample selection bias that come about when the sample of sales is different from the overall sample of properties.

The instrument has important effects in the assessment ratio study. The standard model implies that assessments are highly regressive, with assessment ratios declining significantly with sales price. This result does not disappear after replacing the actual sales price with its predicted value; indeed the assessment performance of smaller residential properties is not uniform in Chicago. However, the degree of regressivity is reduced dramatically, with the magnitude of the coefficient falling by a factor of five or more. This conclusion holds whether we apply our model to the all properties or only the subset that sold.

The findings from this study should not discount the importance of regressivity as a cause for policy concern. Although we suggest that the methodologies traditionally adopted may overstate the degree of property tax inequity, even a small amount of non-uniformity may “covertly distribute (either by design or accidentally) arbitrarily high portions of governmental costs to certain properties” (Bowman and Mikesell 1978, 137). Moreover, if assessments are either extremely high or low in low-sales environments, this lack of predictability could have a suppressing effect on future development in locations with initially few sales. While less of a problem in those thin markets where supply is intentionally curbed (i.e., higher-income areas), those markets that are less active because of low incomes and greater perceived development risks stand to be made worse off.

Unfortunately, our findings suggest that one of causes of this variation is one over which individual assessors have little control, namely the relatively sparse number of comparable sales in certain markets. As a corrective action, assessors may want to consider supplementing their samples with individual appraisals (Malme 1991; Youngman 1994), particularly in thin markets with low sales prices. Texas and Washington, for example, require random appraisals on unsold properties. Other statistical adjustments, such as the use of equalization factors, may be necessary to correct for systematic bias in the short run (Birch, Sunderman and Hamilton 1990). Our study suggests that while a radical overhaul of their property tax system may not be in order, assessors should seek to increase assessment uniformity in thin markets.

References

Baar, K., “Property Tax Assessment Discrimination against Low Income Neighborhoods,” *Property Tax Journal* 1 (1982), 1-50.

Berry, B. and Bednarz, R. “A Hedonic Model of Prices and Assessments for Single Family Homes: Does the Assessor Follow the Market or the Market Follow the Assessor?” *Land Economics* 51 (1975), 22-40.

Bell, E., “Administrative Inequity and Property Assessment: The Case for the Traditional Approach,” *Property Tax Journal* 3 (1984), 123-131.

Black, D., “Property Tax Incidence: The Excise-Tax Effect and Assessment Practices,” *National Tax Journal* 30 (1977), 429-434.

Birch, J., M. Sunderman and T. Hamilton, "Adjusting for Vertical Inequity in Property Assessment," *Property Tax Journal* 9(1990): 197 - 211.

Bowman, J. and W. Butcher, “Institutional Remedies and the Uniform Assessment of Property: An Update and Extension,” *National Tax Journal* 39 (1986), 157-169.

Bowman, J. and J. Mikesell, “Uniform Assessment of Property: Returns from Institutional Remedies,” *National Tax Journal* 31 (1978), 137-153.

Cheng, P., “Property Taxation, Assessment Performance and Its Measurement,” *Public Finance* 29 (1974), 268-284.

Clapp, J., “A New Test for Equitable Real Estate Tax Assessment,” *Journal of Real Estate Finance and Economics* 3 (1990), 233-249.

Cornia, G. and B. Slade, “Property Taxation of Multifamily Housing: An Empirical Analysis of Vertical and Horizontal Equity,” *Journal of Real Estate Research* 27 (2005), 17-46.

Cornia, G. and L. Walters, “Full Disclosure: Unanticipated Improvements in Property Tax Uniformity,” *Public Budgeting and Finance* Summer (2005), 106-123.

Engle, R., “De Facto Discrimination in Residential Assessments: Boston,” *National Tax Journal* 28 (1975), 445-451.

Fisher, J., D. Gatzlaff, D. Geltner, and D. Haurin, “An Analysis of the Determinants of Transaction Frequency of Institutional Commercial Real Estate Investment Property,” *Real Estate Economics* 32 (2004), 239-264.

Gatzlaff, D. and D. Haurin, "Sample selection bias and repeat-sales index estimates," *Journal of Real Estate Finance and Economics* 14 (1997), 33-50.

Härdle, W. and O. Linton, "Applied Nonparametric Methods," *Handbook of Econometrics, Vol. 4*, edited by R. Engle and D. McFadden, Elsevier, New York (1994).

Haurin, Donald R., "An Empirical Analysis of Property Tax Equity", *Property Tax Journal* 7 (1988), 5-18.

Ihlanfeldt, K., "Property Tax Incidence on Owner-Occupied Housing: Evidence from the Annual Housing Survey," *National Tax Journal* 35 (1982), 89-97.

International Association of Assessing Officers, "Standard on Ratio Studies," *Assessment Journal* 6 (1999), 23-64.

Janssen, C. and Soderberg, B. "Estimating Market Prices and Assessed Values for Income Properties" *Urban Studies* 36 (1999), 359-376.

Malme, J. *Policies and Practices That Promote Assessment Equity: Case Studies of Alternative Models*, Cambridge, MA: Lincoln Institute of Land Policy (1991).

McDonald, J., "The Incidence of the Property Tax on Commercial Real Estate: The Case of Downtown Chicago," National Tax Journal 46 (1993), 109-120.

McMillen, D., "The Return of Centralization to Chicago: Using Repeat Sales to Identify Changes in House Price Distance Gradients," *Regional Science and Urban Economics* 33 (2003), 287-304.

Mikesell, J., *Fiscal Administration: Analysis and Applications for the Public Sector*, Pacific Grove, CA: Brooks/Cole (1991).

Mikesell, J. "Property Tax Reassessment Cycles: Significance for Uniformity and Effective Rates" *Public Finance Quarterly* 8 (1980), 23-38.

Oldman, O. and H. Aaron, "Assessment-Sales Ratios under the Boston Property Tax," *National Tax Journal* 18 (1965), 37-45.

Pagan, A. and A. Ullah, *Nonparametric Econometrics*, Cambridge University Press, New York, 1999.

Paglin, M. and M. Fogarty, "Equity and the Property Tax: A New Conceptual Focus," *National Tax Journal* 24 (1972), 557-565.

Silverman, B., *Density Estimation for Statistics and Data Analysis*, Chapman and Hall, New York (1986).

Sirmans, G., B. Diskin and H. Friday, "Vertical Inequity in the Taxation of Real Property," *National Tax Journal* 49 (1995), 71-84.

Wassmer, R. "Property Taxation, Property Base, and Property Value: An Empirical Test of the 'New View'," *National Tax Journal* 46 (2003), 135-59.

Yatchew, A., "Nonparametric Regression Techniques in Economics," *Journal of Economic Literature* 36 (1998), 669-721.

Youngman, J., *Legal Issues in Property Valuation and Taxation: Cases and Materials*. Chicago: The International Association of Assessing Officers (1994).

Table 1
Assessment Ratios Using Actual Sales Prices

	2001	2002	2003
Mean sales price	194303 (139044)	203386 (144278)	228424 (150387)
Median sales price	160158	168276	198254
Mean assessment	16089 (10149)	15552 (9845)	15905 (9855)
Median assessment	13433	12905	13305
Mean assessment ratio	0.096 (0.043)	0.089 (0.041)	0.079 (0.034)
Median assessment ratio	0.085	0.078	0.071
Coefficient of dispersion	30.810	32.095	28.984
Price-related differential	1.160	1.166	1.134
Number of sales	14792	16952	21674

Note. Sales prices and assessments are measured in 2003 dollars. Standard deviations are in parentheses. The highest 1% and lowest 1% of sales prices and assessment ratios are not included.

Table 2
Assessment Ratio Regressions

	2001	2002	2003
Constant	0.1219 (224.8693)	0.1143 (234.3539)	0.1004 (259.670)
Sales Price ($millions)	-0.1332 (57.6736)	-0.1238 (63.2984)	-0.0941 (66.5274)
R^2	0.1888	0.1912	15905
Number of sales	14792	16952	21674

Note. The dependent variable is the ratio of sales price to the assessed value. Absolute t-values are in parentheses. Prices are in 2003 dollars.

Table 3
Descriptive Statistics for Sales Price Regressions

Variable	Mean	Std. Dev.	Minimum	Maximum
Price	209893	147742	13800	960000
Building area (s.f.)	1757	1116	400	20000
Land Area (s.f.)	3861	1314	43	32450
Distance from city center (miles)	8.0820	2.9249	0.7888	16.7440
Distance from nearest El stop (miles)	1.3041	1.0453	0.0087	6.0524
Within ½ mile of Lake Michigan	0.0123	0.1101	0	1
Within ½ mile of a rail line	0.2330	0.4228	0	1
2-unit building	0.1450	0.3521	0	1
3-unit building	0.0566	0.2311	0	1
4-unit building	0.0209	0.1429	0	1
5-unit building	0.0039	0.0621	0	1
6-unit building	0.0132	0.1143	0	1
Number of commercial units in building	0.0207	0.1574	0	3
Number of rooms	7.3100	4.0956	2	54
Number of bedrooms	3.6651	1.8742	1	24
Basement	0.7581	0.4282	0	1
Central air conditioning	0.1647	0.3710	0	1
Fireplace	0.1173	0.4297	0	9
Attic	0.3743	0.4839	0	1
Attic is finished	0.1298	0.3360	0	1
Brick	0.6079	0.4882	0	1
Basement is finished	0.2210	0.4149	0	1
Number of bathrooms	1.7666	0.9687	1	13
One-car garage	0.2652	0.4415	0	1
Two-car garage (or more)	0.4546	0.4979	0	1
Porch	0.2650	0.4413	0	1
Age	75.2984	27.7118	0	173
2001:1 sale	0.0510	0.2201	0	1
2001:2 sale	0.0713	0.2573	0	1
2001:3 sale	0.0773	0.2671	0	1
2001:4 sale	0.0788	0.2694	0	1
2002:1 sale	0.0626	0.2422	0	1
2002:2 sale	0.0795	0.2705	0	1
2002:3 sale	0.0822	0.2746	0	1
2002:4 sale	0.0932	0.2907	0	1
2003:2 sale	0.1170	0.3215	0	1
2003:3 sale	0.1262	0.3321	0	1
2003:4 sale	0.0760	0.2651	0	1

Note. The sample includes 54510 sales of residential buildings with 6 units or less. The highest 1% and lowest 1% of sales prices are not included.

Table 4
Sales Price Regression for Full Sample

Variable	Coefficient	Standard Error	T-Value
Constant	254266.4628	3923.5904	64.8045
Building area (s.f.)	37.3118	1.1506	32.4270
Land Area (s.f.)	9.9246	0.4524	21.9396
Distance from city center (miles)	-16011.6922	278.2300	-57.5484
Distance from nearest El stop (miles)	-52.9801	684.8297	-0.0774
Within ½ mile of Lake Michigan	43775.1939	4681.8393	9.3500
Within ½ mile of a rail line	-14413.5399	1220.2281	-11.8122
2-unit building	16625.2651	1757.2622	9.4609
3-unit building	25230.4777	3069.0843	8.2209
4-unit building	4342.6941	4820.9545	0.9008
5-unit building	-32704.0829	9448.7560	-3.4612
6-unit building	-89807.0017	7051.8748	-12.7352
Number of commercial units in building	-26270.8071	4884.8859	-5.3780
Number of rooms	1922.2085	395.9496	4.8547
Number of bedrooms	-9424.4411	718.2540	-13.1213
Basement	18853.1787	1544.8797	12.2037
Central air conditioning	69356.1003	1589.6465	43.6299
Fireplace	38017.4349	1283.1716	29.6277
Attic	179.3013	1362.1110	0.1316
Attic is finished	19325.9243	1780.1227	10.8565
Brick	-11305.9233	1293.4541	-8.7409
Basement is finished	-2255.9932	1340.8802	-1.6825
Number of bathrooms	19214.3132	1096.0735	17.5301
One-car garage	13468.7436	1418.0786	9.4979
Two-car garage (or more)	25023.2242	1285.8883	19.4599
Porch	13194.1552	1270.0814	10.3884
Age	-898.8222	24.5049	-36.6793
2001:1 sale	-40139.7850	2855.7298	-14.0559
2001:2 sale	-27062.4007	2590.1852	-10.4481
2001:3 sale	-23388.5004	2534.8379	-9.2268
2001:4 sale	-35499.9705	2522.5159	-14.0732
2002:1 sale	-26812.9844	2685.8986	-9.9829
2002:2 sale	-12250.3614	2516.0755	-4.8688
2002:3 sale	-8111.8817	2494.9891	-3.2513
2002:4 sale	-14856.0174	2418.5961	-6.1424
2003:2 sale	16240.2081	2297.9975	7.0671
2003:3 sale	20683.8025	2263.6554	9.1374
2003:4 sale	15344.6074	2545.4354	6.0283

Note. The regression has 54510 sales. The R^2 is 0.352.

Table 5
Assessment Ratios Using Predicted Sales Prices

	2001	2002	2003
Mean sales price	225752 (129240)	219217 (126958)	222460 (126612)
Median sales price	197550	189929	195983
Mean assessment	20889 (13259)	20120 (12713)	20462 (12438)
Median assessment	16958	16349	16764
Mean assessment ratio	0.094 (0.022)	0.093 (0.022)	0.094 (0.022)
Median assessment ratio	0.092	0.092	0.092
Coefficient of dispersion	16.876	16.983	16.721
Price-related differential	1.014	1.018	1.020
Number of sales	14855	16941	21610

Note. Sales prices and assessments are measured in 2003 dollars. Standard deviations are in parentheses. The highest 1% and lowest 1% of sales prices and predicted assessment ratios are not included.

Table 6
Base Assessment Ratio Regressions

	Actual Ratio	Predicted Ratio	Predicted Ratio
Sample	Sales	Sales	All observations
Constant	0.1048 (309.6996)	0.0988 (447.3823)	0.0984 (1407.6239)
Price ($millions)	-0.1133 (108.0740)		
Predicted price ($millions)		-0.0223 (30.2755)	-0.0183 (71.6575)
2001 sale	0.0132 (35.1057	0.0001 (0.4189)	-0.0004 (2.2366)
2002 sale	0.0074 (20.3270	-0.0004 (2.0049)	-0.0009 (5.3464)
2003 sale			-0.0005 (3.2113)
R^2	0.2060	0.0169	0.0125
Number of observations	53418	53406	408204

Note. Absolute t-values are in parentheses.

Table 7
Assessment Ratio Regressions Including Number of Sales by Census Tract

	Actual Ratio	Predicted Ratio	Predicted Ratio
Sample	Sales	Sales	All observations
Constant	0.1084 (250.8821)	0.0989 (350.1049)	0.0985 (1034.5035)
Price ($millions)	-0.1161 (108.7218)		
Predicted price ($millions)		-0.0225 (29.6496)	-0.0184 (70.1585)
2001 sale	0.0132 (34.9394)	0.0001 (0.4242)	-0.0004 (2.2147)
2002 sale	0.0073 (20.1350)	-0.0004 (2.0082)	-0.0009 (5.3331)
2003 sale			-0.0005 (3.1923)
Number of sales (thousands)	-0.0220 (13.1907)	-0.0009 (0.8318)	-0.0008 (1.9885)
R^2	0.2085	0.0170	0.0125
Number of observations	53418	53406	408204

Note. Absolute t-values are in parentheses.

Table 8
Base Logit Models

	Actual Ratio	Predicted Ratio	Predicted Ratio
Sample	Sales	Sales	All observations
I = 1 (Lowest 25% of the Assessment ratio Distribution)			
Price ($millions)	2.1644 (30.38)		
Predicted price ($millions)		0.5789 (7.35)	0.8284 (31.30)
2001 sale	-1.0679 (36.01)	0.0193 (0.74)	0.0248 (1.21)
2002 sale	-0.5539 (22.09)	0.0504 (2.01)	0.0585 (3.06)
2003 sale			0.0119 (0.70)
Constant	-0.8383 (35.29)	-0.8490 (34.12)	-0.8966 (116.89)
I = 2 (Highest 25% of the Assessment ratio Distribution)			
Price ($millions)	-16.0616 (85.23)		
Predicted price ($millions)		-2.1341 (22.54)	-1.6416 (50.98)
2001 sale	0.4937 (16.58)	0.0250 (0.96)	-0.0024 (0.12)
2002 sale	0.2176 (7.33)	0.0085 (0.34)	-0.0154 (0.79)
2003 sale			-0.0223 (1.29)
Constant	1.5255 (47.09)	-0.2516 (9.80)	-0.3317 (41.18)
Number of observations	53418	53406	408204

Note. The base category is the 25%-75% range of the assessment ratio distribution. Absolute z-values are in parentheses.

Table 9
Logit Models Including Number of Sales by Census Tract

	Actual Ratio	Predicted Ratio	Predicted Ratio
Sample	Sales	Sales	All observations
I = 1 (Lowest 25% of the Assessment ratio Distribution)			
Price ($millions)	1.6102 (21.91)		
Predicted price ($millions)		-0.1543 (1.89)	0.1404 (5.13)
2001 sale	-1.0964 (36.67)	-0.0262 (0.99)	0.0468 (2.26)
2002 sale	-0.5766 (22.78)	0.0477 (1.88)	0.0712 (3.68)
2003 sale			0.0273 (1.57)
Number of Sales (thousands)	-3.7932 (27.28)	-4.4559 (32.85)	-4.6640 (91.21)
Constant	-0.2078 (6.43)	-0.1128 (3.46)	-0.1609 (14.94)
I = 2 (Highest 25% of the Assessment ratio Distribution)			
Price ($millions)	-16.1549 (86.06)		
Predicted price ($millions)		-2.610 (27.06)	-2.0924 (63.69)
2001 sale	0.4833 (16.13)	0.0296 (1.12)	0.0138 (0.67)
2002 sale	0.2067 (6.93)	0.0068 (0.27)	-0.0054 (0.28)
2003 sale			-0.0106 (0.61)
Number of Sales (thousands)	-2.3339 (18.41)	-2.8398 (23.47)	-2.9613 (64.96)
Constant	1.8860 (50.80)	0.2362 (7.26)	0.1554 (14.37)
Number of observations	53418	53406	408204

Note. The base category is the 25%-75% range of the assessment ratio distribution. Absolute z-values are in parentheses.

Figure 1
1992-2003 Sales as Percentage of Total Units by Chicago Census Tract

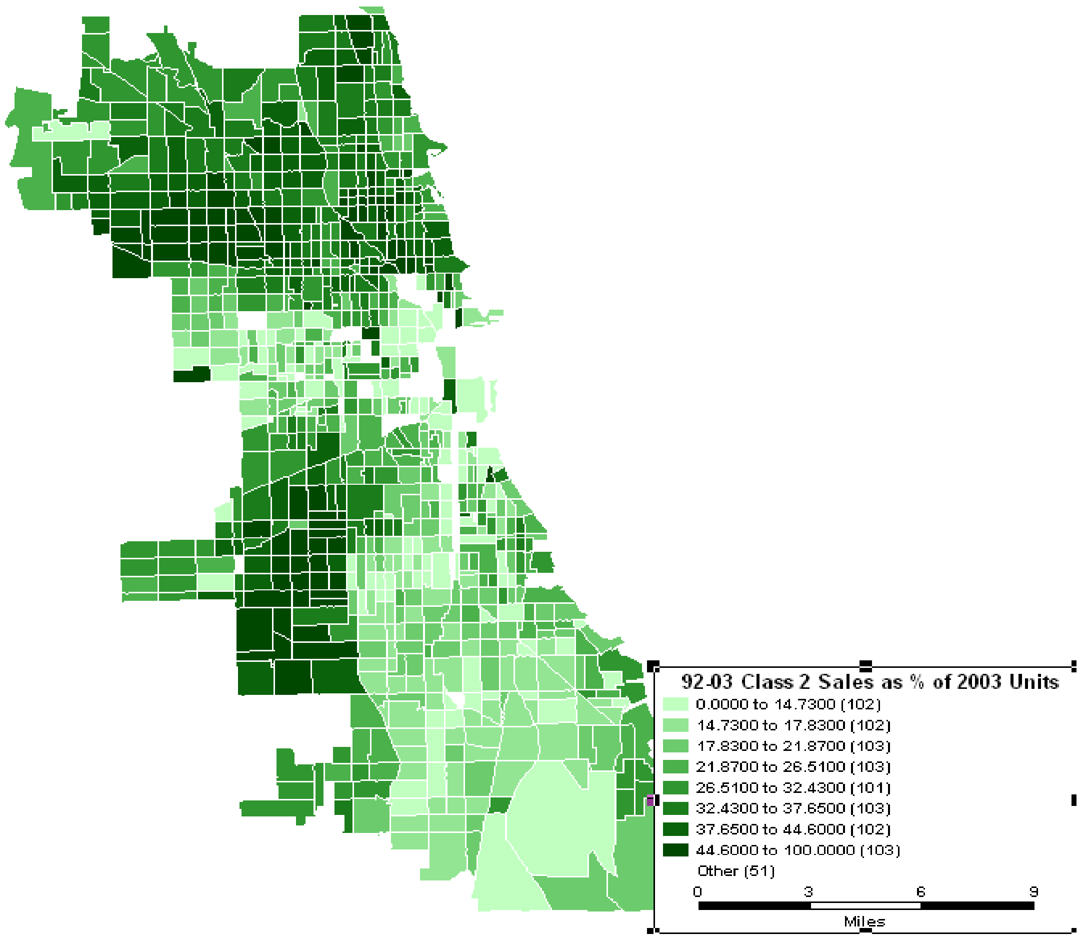

Figure 2
Kernel Density Estimates for Traded Properties – Actual Sales Prices

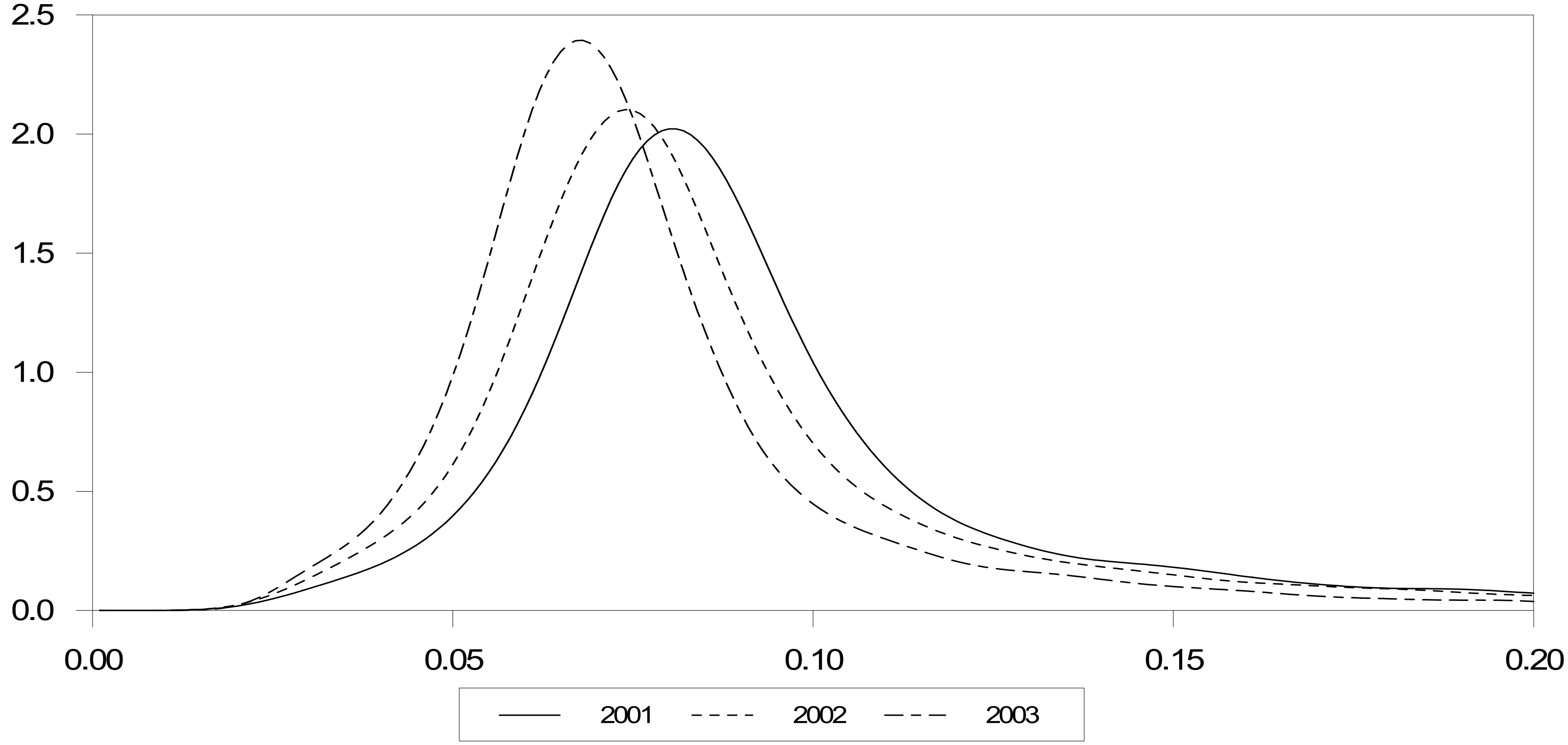

Figure 3
Kernel Density Estimates for Traded Properties – Predicted Sales Prices