An Integrated Approach to the Evaluation of Commercial Real Estate

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Abstract. **Hedonic estimation techniques have been applied to real estate markets for more than twenty years, but the literature is dominated by analyses of the single-family residential market. This paper focuses upon hedonic analysis as applied to commercial real estate when information is known about complex characteristics *and* net operating income. The model presented incorporates traditional hedonic specifications and rate of return analysis.**

The empirical illustration focuses upon the apartment market in Houston, Texas during the 1980s. It is found that the apartment complex price function displays the same type of nonlinearities often found in the single-family market and that apartment market cap rates vary substantially over time and across project types. This suggests that analysts of commercial real estate should be wary of applying simple price per square foot rules or common cap rates across all property types and across all locations.

Introduction

The difficulties associated with the evaluation of commercial real estate are widely recognized and documented.[1] These difficulties occur in estimating market price trends, the value of individual properties, or the marginal value of property characteristics. As a result, there often exists a large variance in valuations of commercial real estate markets and of particular properties in those markets.

While commercial real estate markets are noted for product heterogeneity, it is the "thinness of the market" that distinguishes them from the single-family residential market. In a large metropolitan area such as Houston, Texas, it is not atypical to have 20,000 to 30,000 sales of single-family houses in any given year, while at the same time having a few hundred sales of any type of commercial property.[2] Thus, it is difficult for analysts to easily procure market transactions of commercial real estate which are similar in age, size, location, etc.[3] Furthermore, monitoring overall market trends in commercial real estate can be extremely difficult compared to the single-family market where the large number of transactions improves the statistical properties of yearly or even monthly "market averages".

On the other hand, while the evaluation of commercial properties is hampered by the scarcity of market transactions, it is greatly aided by the availability of data on rental income. Rental income reveals information about consumer or business preferences for the unique characteristics package provided by any particular

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property. Through rental income, analysts are provided explicit measures of the "market value" of the real estate bundle provided. Hence, it is a key to the capital price valuation of commercial real estate assets. While rental income is the ultimate source of commercial property value, the relationship between rental income and property value is not a simple one. Analysts debate over the appropriate definition of income and over the appropriate algorithm to convert income into value.[4]

Appraisers typically apply three methodologies for evaluation: the market, income, and replacement cost approaches. Supposedly, each approach is conducted independently and then integrated or reconciled into a single estimate of value. The question posed in this paper is whether the application of the statistical techniques known as hedonic analysis can contribute to this process and to the integration and reconciliation of these three approaches to value.

The specific purpose of this study is to present a framework for statistical analysis that ameliorates the often confusing imbroglio surrounding the evaluation of commercial property. The framework simultaneously integrates the three standard forms of valuation by combining traditional hedonic analysis with rate of return analysis. This approach is applied to pooled cross-section/time series data for the apartment market in Houston, Texas during the decade of the 1980s. Issues of evaluating market trends as well as individual properties are addressed. The results of the research have important implications to such empirical questions as the nonlinearity of the price function and the variability of cap rates.

While earlier research discussed in the next section has used hedonic analyses to evaluate commercial property, the methodology presented here differs in terms of the specification of the hedonic function, particularly as it relates to all three approaches to estimating value. Furthermore, in contrast with previous studies, a large sample is used to test the models. While this paper focuses upon the apartment market, the techniques presented are anticipated to be applicable to any commercial sector of the real estate market.

Review of the Literature

Hedonic estimation typically applies standard ordinary least squares regression analysis to the study of multidimensional commodities. Initially, the application of hedonic techniques focused upon market trends or differentials. The path-breaking work of Grilliches (1961) estimated quality-adjusted price indices for automobiles. Applications to real estate emerged in the 1960s as analysts sought to explain differences in residential values over time or across locations. The work of Rosen (1974) provides the best theoretical basis of hedonic analysis applicable to real estate and is responsible for the development of what Smith (1991) refers to as the third-generation hedonic literature of the late 1970s and 1980s.

Hedonic estimation in the housing market not only provides analyses of market trends and property values, but also of characteristic marginal values. Marginal values of structural characteristics (such as square feet of living area or number of baths) and marginal values of neighborhood characteristics (such as distance to CBD or demographic make-up of neighborhoods) have been estimated in a broad array of articles on the single-family housing market.[5]

There is also a relatively extensive hedonic literature on rental rates in the multifamily market. Past studies that have used the hedonic approach have emphasized tenant demands for amenities (Smith and Kroll, 1989), household willingness to pay for unit characteristics (Gross, 1988), external factors and services that affect rents (Sirmans, Sirmans and Benjamin, 1989), the relationship between rents and length of residency (Goodman and Kawai, 1985), and the impact of rent control (Marks, 1983). Other studies have used the hedonic approach to demarcate segmented rental markets based upon the characteristics of occupants and or upon location (Smith and Kroll, 1989; Guntermann and Norrbin, 1987).

The application of hedonic estimation to explain the variability of apartment complex prices is much less extensive. Kang and Reichert (1988) analyzed 281 sales of small complexes in the Los Angeles area. Their two-part presentation examined sales prices as a function of physical, locational and "financial" variables. They found that, while well-defined physical and locational variables are useful in predicting price, the addition of gross or net operating income (NOI) improves the accuracy of the "forecast". They also concluded that "a simple overall capitalization ratio can be quite satisfactory" in evaluating properties within a single market.

Other more standard applications of the hedonic approach include the works of Gipe (1976), Shenkel (1975), and Bernes and Mitchell (1990) who used multiple regression analysis of property values on structural and neighborhood characteristics with sample sizes of 134, 54, and 16 complexes respectively.

Bible, Phillips and Whales (1987) examined sales of apartment complexes from 1982–85 by modeling price as a function of only gross income and age. That study experimented with a variety of alternative nonlinear specifications.

A related literature focuses upon the analysis of cap rates. This literature is also relatively sparse.[6] Part of the cap rate debate involves the determination of the rate itself and the source of information which analysts should use. Some argue that cap rates should be obtained from other asset markets and as such, will vary in harmony with yields in those markets. Steele (1989) has shown that national interest rates affect real estate cap rates; Evans (1990) examines the relationship between cap rates and business cycles; and Nourse (1987) and Rose and O'Neil (1988) have demonstrated that tax laws affect cap rates.

Others suggest that since cap rates reveal the rate of return to a specific asset, the unique rate can only be obtained from data on the particular market in question. This approach is challenged, however, by the research of Cohen (1979) that documents arguments against market-extracted cap rates. While Sirmans, Sirmans and Beasley (1986) accept market-extracted cap rates, they emphasize the variability of these rates. In the latter study, 137 sales of small complexes in Chicago were analyzed with a typical multiple regression approach. Cap rates were found to vary across submarkets, leading the authors to conclude that it "is incorrect to use market extracted overall rates, without adjustments."

The research reported in this paper contrasts with the existing literature in terms of both data and analytic approach. The data includes transaction prices over a span of ten years for nearly 500 complexes with more than 80 units each. The data includes structural, locational and financial data. The temporal span of the data between 1978 and 1988 includes a period of substantial changes in market interest rates, rental market performance, and relevant tax laws. The generalized model developed here incorporates traditional hedonic analysis and rate of return analysis within a cross-section/times series framework.

Empirical Models of Property Evaluation

Each of the three traditional approaches to real estate valuation presents its own set of difficulties, but done independently, each provides a "consistency check" on the others. Typically, analysts attempt to reconcile any differences with professional judgment. Statistical analyses focus upon a single methodology. For example, traditional hedonic analysis is merely a sophisticated application of the market or "comp" approach.

The Market Approach

The market approach depends upon access to observable market prices for similar products. But, the thinness of the commercial real estate market makes such comparisons difficult because of product heterogeneity. Furthermore, historical sales of identical properties is generally nonexistent.

Comparable sales of relatively similar properties require implicit adjustments for varying characteristics. The most common adjustment involves the date of sale. Historic prices must be adjusted to the present, requiring knowledge of market trends. In addition, adjustments are usually required to compare prices for properties of somewhat different characteristics. This requires knowledge of *the marginal value* of characteristics such as age, size, security, location, etc. Usually such adjustments are based upon professional judgment, though recent use of hedonic analyses has provided some objective statistical information to the estimation of adjustment factors.

The Income Approach

In the apartment market, differences in complexes offering alternative characteristic bundles can be observed from the underlying rental market. That is, differences in rental rates provide information on household valuations of characteristic packages. Detailed information regarding the physical dimensions of the amenity package provided by a complex may not be needed if rental information is available.[7] Thus, the income approach is not merely another way to evaluate property, but a way to ameliorate the difficulties associated with complex heterogeneity.

Two versions of the income approach are common: present discounted valuation (PDV) and direct capitalization (DC). PDV estimates the present discounted value of expected future cash flows and thus, requires projections of property income in future years. On the other hand, direct capitalization (DC) relates value to a single (usually the present) year's cash flow (NOI) by using a capitalization (cap) rate.[8]

The PDV and DC are equivalent if current income were expected to be constant in perpetuity. This is more probable in real dollar terms. Thus, in calculating PDV and

DC, a real discount rate should be used. Of course, the appeal of DC is that variations in the real income of the property over time need not be forecast. However, if future real income is expected to differ from present levels, the cap rates used for DC will vary from the discount rate used for PDV.

A major problem with the income approach is the determination of the appropriate discount or cap rate. Slight changes in the discount rate used can substantially alter the estimated value of commercial property, yet it is known that market yields vary substantially over time and across asset types.

If all apartment complexes were identical, then the task of determining the current cap rate inferred by the market itself would be much easier. But, if slight asset heterogeneity in the bond market creates substantial variation in yields, the extent of complex heterogeneity in the apartment market is likely to generate enormous fluctuations in observed cap rates.

The Cost Approach

The cost approach is founded upon the principle of substitution and long-run equilibrium. No rational economic agent would pay more for an existing asset than the amount for which a new asset could be produced (its current replacement costs). Furthermore, prices temporarily above replacement costs would induce new supply that would eventually reduce prices back to replacement cost levels. Prices below replacement costs halt new construction until stock demand and supply once again achieve long-run, steady-state equilibrium.

The primary challenge of the cost approach is making the appropriate adjustment for external depreciation. This, along with adjustments for physical deterioration due to age or for functional obsolescence associated with a particular attribute such as master-metered electricity, form the triad for depreciation adjustments.

However, the cost approach begs the question regarding value during times of market disequilibrium. For example, at times of excess supply, prices will be less than replacement costs. Furthermore, the ratio of market price to replacement costs is not likely to be constant across all property types. Thus, simple "rule of thumb" average adjustments for market condition are not viable. In those circumstances, the cost approach is not usable without independent information obtained from either the market or income approach.

Hedonic Specifications and the Three Approaches to Valuation

The statistical analog to the traditional approaches to property valuation can be summarized by the following hedonic specifications. Consider first a standard exponential specification of property values typical of many hedonic estimations.

$$P = A_0 * e^{\beta Z}, \tag{1}$$

where Z is a vector of property and locational characteristics, Z_i, including, in pooled time series/cross-section data, variables designating the date of sale.

The exponential specification satisfies theoretical priors on fixed characteristics such as location variables (for example, distance to the CBD) and allows for interaction effects between characteristics. That is, the marginal price of additional square feet is dependent upon the age of the complex, etc. The inclusion of higher order values of the Z can further account for nonlinearities. There is substantial empirical evidence to the "goodness of fit" of the exponential specification with higher order transformations.

Marginal values ($P_i = \delta P / \delta Z_i$) of this hedonic specification (and hence the adjustment factors in property valuation) are

$$P_i = \beta_i * P(Z)\,, \tag{1'}$$

for any particular complex with a characteristics bundle, Z. In addition, note that $\hat{P}$ for $AGE = 0$ provides an estimate of replacement costs for markets in long-run equilibrium and the market value of new complexes during times of disequilibrium.

The simple income approach can be characterized by a simple multiplicative specification:

$$P = A_0 * NOI^{\gamma}\,, \tag{2}$$

where NOI is the current net operating income of each property and where the implied cap rate (R) is

$$R = NOI/P = A_0^{-1} * NOI^{(1-\gamma)}\,. \tag{2'}$$

Only when $\gamma = 1$ will the cap rate be constant ($R = A_0^{-1}$). Where $\gamma > 1$ (< 1), the cap rate will decline (increase) with project size.

However, it may be the case that cap rates also vary across time and/or across complex types. This will occur if investor expectations regarding real rental rates in the future vary over time or between different types of property.[9] Expectations of greater market improvements will lower cap rates. Changes in the expected return of alternative assets or in the tax treatment of real estate will also be expected to affect cap rates. If this is the case, equation (2) can be rewritten as follows:

$$P = A_0 * e^{\beta Z} * NOI^{\gamma}\,. \tag{3}$$

Note that equation (3) appears as a hybrid of equations (1) and (2), a type of hedonic equation that includes information on net operating income as well as property characteristics. Marginal values, however, do not correspond to normal hedonic shadow prices. Instead, they indicate the relationship between characteristics and cap rates:

$$R = NOI/P = A_0^{-1} * e^{-\beta Z} * NOI^{(1-\gamma)}\,. \tag{3'}$$

In this case, R is constant only if the $\beta_i = 0$ for all i and if $\gamma = 1$. Variations in R across property characteristics, location, and time would indicate variation in investor expectations of future market conditions. Thus, a positive coefficient on square feet indicates that cap rates are smaller for larger units, suggesting that investors expect greater market improvement for larger properties.

Analysts interested in traditional marginal values of property characteristics and in overall market trends would use equation (1). Analysts interested in the evaluation of individual properties would use equation (3). While equation (3) incorporates the full set of information available to analysts, since *NOI* is determined by market trends, this equation could not be used to create a price index for apartment complexes without generating first an index of net operating income over time.

Empirical Results

The Data

The data used to estimate equations (1) through (3) consists of 500 observations of market transactions of large, two-story garden apartment complexes in Houston, Texas. Each complex in the data set has at least eighty units and offers the same basic amenity package, including pool and laundry facilities. While the set of complexes represent a relatively homogeneous pool of apartment properties, they vary in terms of size, age and location.

Sales in the data set occurred between the years 1978 and 1988.[10] The Appendix lists and describes the variables used in the empirical analysis along with their corresponding sample means. Note that sales are relatively evenly distributed throughout the ten-year period. Structural variables include total square feet, complex age and a dummy variable equal to 1 when tenants pay for their own electricity based upon individually metered units. Locational variables include a series of demographic variables describing the census tract containing each property along with the distance in miles each property is from Houston's central business district (CBD). Year of sale is accounted for by a vector of dummy variables for each individual year. The year 1979 was taken as the control period.

Several alternative definitions of net operating income (*NOI*) were included in the data set. The variable used in this analysis is *stabilized net operating income*, defined as the net income that would have been earned in the year the property sold with that year's rental rates if the property were 95% occupied.[11] Thus, during the rather sharp slump in the apartment rental market in the mid-1980s, *stabilized net operating income* substantially exceeded *actual NOI* as occupancy rates for many projects fell below 70%.

Regression Results—The Standard Hedonic

The log transformation of equation (1) was estimated using OLS regression analysis and produced an excellent fit, with an R^2 of .91. The estimated variable coefficients along with corresponding t-statistics are provided as equation (1) in Exhibit 1. The structural variables explained much of the variance in property values and are, in general, statistically significant. Neighborhood variables, on the other hand, have overall lower t-statistics, though multicollinearity has probably artificially reduced

Exhibit 1
Estimated Coefficients*

Variable	Equation 1	Equation 2	Equation 3
SF	.981*e*-5 (23.8)		.776*e*-5 (16.5)
*SF*²	−1.058*e*-11 (13.5)		−8.159*e*-12 (10.3)
*SF*³	3.277*e*-18 (10.9)		2.519*e*-18 (8.58)
AGE	−.0361 (10.1)		−.0285 (8.0)
METER	.0665 (1.5)		.0708 (1.7)
CBD	−1.84*e*-4 (1.23)		−1.73*e*-4 (1.11)
*CBD*²	6.175*e*-8 (1.28)		4.957*e*-8 (1.02)
PHG	3.11*e*-3 (2.15)		1.32*e*-3 (.934)
PNE	4.23*e*-3 (2.466)		2.996*e*-3 (1.81)
MINC	−1.427*e*-6 (.42)		−5.704*e*-7 (.18)
PBP	−1.771*e*-2 (2.89)		−1.137*e*-2 (2.82)
TRANS	−3.577*e*-1 (6.78)		−2.951*e*-1 (5.67)
LN(*NOI*)		.7582 (27.97)	1.902*e*-1 (6.65)
*T*80	.0522 (.65)	.0407 (.317)	.1137 (1.41)
*T*81	.2041 (3.40)	.1723 (1.81)	.3071 (4.54)
*T*82	.4006 (6.62)	.1503 (1.65)	.3791 (6.31)
*T*83	.3760 (5.60)	.2335 (2.26)	.3507 (5.42)
*T*84	.2968 (4.83)	.4554 (4.93)	.3633 (6.07)

Exhibit 1 (continued)

Variable	Equation 1	Equation 2	Equation 3
*T*85	.1825 (2.97)	.4373 (4.73)	.2512 (4.20)
*T*86	−.0940 (1.43)	.2759 (2.69)	.0303 (.47)
*T*87	−.1414 (2.03)	.0656 (.61)	−.0412 (.61)
*T*88	−.1472 (2.04)	.1170 (1.09)	−.0247 (.35)
R-Square	.9095	.7517	.9256

**t*-statistics are provided in parentheses below each coefficient. With $N=500$, $t>1.96$ is indicative of statistical significance at a probability level of 97.5%. Remember, however, that these *t*-statistics are likely to be biased downward.

Source: Authors

t-statistics.[12] The one neighborhood variable with a highly significant coefficient is *TRANS*, the 0–1 dummy variable indicating racial transition during the sample period. The coefficient indicates that complexes in neighborhoods experiencing racial transition are discounted by as much as 36%, suggesting a large degree of market uncertainty regarding this submarket.[13]

Estimated coefficients of the time dummies describe a pattern of substantial price appreciation in the early 1980s followed by a collapse of apartment complex prices in the mid-1980s.[14] The coefficients of the dummy variables indicate that by 1982 prices had risen by 40% over the 1979 base period, but by 1986 they had fallen below base period levels. Despite the fact that by 1988 the Houston area economy was growing again and occupancy and rental rates were increasing, prices of multifamily complexes continued to fall.[15]

Exhibit 4 (see page 163) summarizes the change in prices over the ten-year period in terms of average price per square foot as estimated by the hedonic equation. For the standard complex (with mean value characteristics), the base-year (1979) price per square foot was $20.89. By 1982 prices had increased to $31.18 per square foot. Most of the mid-1980s losses occurred by 1986, with prices having fallen to $19.02 per square foot.

The age coefficient shows a surprisingly large economic depreciation rate of 3.6% per year.[16] This may be due to the fact that the stock of apartments in Houston is relatively new. Over 50% were built after 1975. It is also the case that the real estate market debacle of the mid-1980s left most projects with substantial deferred maintenance which may have exaggerated the relationship between age and property values during this time period.

Exhibit 2
Marginal Impacts of Complex Characteristics

Variable	Cap Rates (%)	Price per Square Foot
CBD: per mile	+ .04	($.047)
SF: per 1000 sq ft	− .04	($.083)
AGE: per year	+ .22	($.585)
METER	− .55	$1.079
PHG: per 1% increase	− .01	$.051
PNE: per 1% increase	− .02	$.069
MINC: per $1000	− .004	$.023
PBP: per 1% increase	+ .13	($.287)
TRANS: if transition area	+2.31	($5.805)

Source: Authors

The statistical significance of second- and third-order terms of the square feet and distance variables, suggests that important nonlinearities exist in the apartment complex price function. This is consistent with many analyses of the single-family residential market.[17]

In order to more easily interpret the results, marginal values in terms of price per square foot are reported in Exhibit 2 (column 2) for each property characteristic (calculated for the mean bundle). For example, the presence of individually metered units adds $1.08 per square foot to the value of an apartment complex. This interesting result suggests that there is a sizable efficiency gain to the elimination of the moral hazard problem associated with master-metered rental units.

Exhibit 2 also indicates that complex prices decline by about 5 cents per square foot per mile from the CBD. This is a surprisingly low impact given the steep price gradient in the single-family market where prices decline by about 60 cents per square foot per mile.[18] This suggests that distance to the CBD is not as relevant for multifamily occupants as it is for owner-occupants.[19]

The extent of the nonlinearity of the price structure with regards to square feet is substantial. Each additional 1,000 square feet adds $.08 per square feet of value. Thus, a 300,000 square foot complex is estimated to be worth $4 per square foot more than a 250,000 square foot complex. This may be explained by economies of scale associated with the standard garden apartment complexes in the sample, but it is also likely that the large marginal impact of greater square feet is attributable to a correlation with excluded variables such as the extent of security and special amenities, such as fitness centers and multiple swimming pools.[20]

The Regression Results—The Simple Cap Rate Equation

The simple income or cap rate equation described in equation (2) was estimated with the same data set with less explanatory power: $R^2 = .752$. The coefficient of

LN(NOI) (γ in equation (2)) is .758. Statistically, it is significantly different from 1.00 at the .99% confidence level. Thus, cap rates are estimated to vary across projects of various sizes. The estimation of equation (2) also indicates that cap rates varied in Houston over time as well. Applying the formula in (2′), the cap rate for the base year is estimated as 8.69% for the standard (mean bundle) complex. By 1984, prices (holding *NOI* constant) were 45.5% higher. Thus, cap rates were 45.5% lower. This reduction in cap rates is associated with the collapse of the rental market in the mid-1980s that generated an environment where investors, expecting a recovery, anticipated substantially higher real dollar rental rates in the future.

By 1987, cap rates quickly returned to levels above 8%, despite the fact the real dollar rental rates were still substantially below replacement rents.[21] The timing of the sudden rise in cap rates beginning in 1986 provides some evidence that the Tax Reform Act of 1986 had a substantial impact upon apartment complex values.

The Regression Results—The Consolidated Equation

The estimation of equation (3) with the same data produced the best fit in terms of the proportion of the variance in complex prices explained: $R^2=.926$. The estimated coefficients accompanied by their *t*-statistics are provided in Exhibit 1.[22] The incremental R^2 and the *t*-statistic associated with *LN*(*NOI*) suggests that net operating income significantly contributes to the estimation of value, even after property characteristics are accounted for. Similarly, the characteristics variables help explain value over and above what can be explained by *NOI* alone. Furthermore, the statistical significance of the characteristics variables indicate that cap rates vary across different property types.[23] These results suggest that the estimation of cap rates without controlling for property characteristics could constitute serious equation misspecification.

Exhibit 2 (column 1) summarizes the marginal impact that changes in characteristic variable values have on market cap rates. For instance, cap rates rise .04% for every mile farther from the CBD. This suggests that investors expect greater market improvement for properties closer to the CBD. As reported in Exhibit 3, the base-year cap rate is 7.30% for properties six miles from the CBD and 7.63% for properties twenty miles from the CBD.

While distance only modestly affects cap rates, age is estimated to have a substantial impact. Each additional year of complex age adds .22% to the cap rate. In the base year, the market cap rates for new complexes averaged 6.02%, while cap rates for a fifteen-year old property averaged 9.23% (see Exhibit 3). This would suggest that investors either expected much greater rental gains for newer projects or that they considered apartment complex lives to be relatively short. This relationship of age to cap rates may also be attributable to similar reasons that explain the high estimated depreciation rate from equation (1).

Exhibit 3 summarizes the temporal pattern of cap rates for five property types. The lowest cap rates were for new complexes in 1984: $R=4.19\%$. The highest cap rates were for older complexes in 1987: $R=9.62\%$. This variability in actual market cap rates suggests that the application of a single-market extracted cap rate is likely to produce very poor estimates of value and that changes in cap rates over time are sufficient to warrant very careful monitoring each year.

Exhibit 3
Temporal Trends in Cap Rates
(by property characteristics)

Year	Standard (%)	CBD=6 (%)	CBD=20 (%)	AGE=0 (%)	AGE=15 (%)
1979	7.71	7.30	7.63	6.02	9.23
1980	6.68	6.52	6.81	5.37	8.24
1981	5.67	5.37	5.61	4.43	6.70
1982	5.27	5.00	5.22	4.12	6.32
1983	5.43	5.14	5.38	4.24	6.50
1984	5.36	5.08	5.31	4.19	6.42
1985	5.99	5.68	5.94	4.68	7.18
1986	7.48	7.09	7.41	5.84	8.95
1987	8.03	7.61	7.95	6.27	9.62
1988	7.90	7.49	7.82	6.17	9.46

Source: Authors

The empirical estimation of equation (3) also strongly suggests that the Tax Reform Act of 1986 had a significant impact upon property values. Throughout the first half of the 1980s cap rates fell rather dramatically as the rental market deteriorated. By the end of 1984 vacancy rates had risen to 18% and rental rates had fallen by 25%. In 1985, *NOI* for most projects was insufficient to cover debt service, leading to a barrage of foreclosures and bankruptcies. In some cases, actual *NOI* was reduced to less than $.25 per square foot.[24]

In 1986, the overall occupancy rate in the housing market began to improve. This occurred primarily because of a declining overall housing stock. During 1987 improvement in the rental market accelerated and by the end of the year prospects for future improvements were more widely anticipated. This should have reduced cap rates further. Instead cap rates rose sharply hitting ten-year highs in 1987.

Two phenomena were coincident to those rising cap rates: the Tax Reform Act of 1986 and the liquidation of properties by lending institutions—the FDIC (FEMA), and eventually the RTC. Either the Tax Reform Act was depressing the investor value of residential income properties or the disposition of REO (foreclosed real estate—owned by institutions) had depressed resale prices below long-run equilibrium levels.[25]

Conclusion

The estimation of both equations (1) and (3) proved to be useful in the evaluation of apartment market trends. Equation (1) is the standard hedonic equation corresponding to the market (comp) approach used by appraisers. The statistical fit is particularly encouraging. Nonlinearities are evident.

Exhibit 4
Temporal Trends in Price per Square Foot
(by property characteristics)

Year	Standard ($)	CBD=6 ($)	CBD=20 ($)	AGE=0 ($)	AGE=15 ($)
1979	20.89	21.87	21.15	28.56	16.63
1980	22.01	23.04	22.28	30.09	17.52
1981	25.02	26.82	25.94	35.02	20.39
1982	31.18	32.65	31.57	42.63	24.82
1983	30.42	31.86	30.81	41.59	24.22
1984	28.11	29.43	28.46	38.43	22.37
1985	25.07	26.25	25.39	34.28	19.96
1986	19.02	19.91	19.25	26.00	15.15
1987	18.14	18.99	18.36	24.79	14.43
1988	18.03	18.88	18.26	24.65	14.35

Source: Authors

This equation is to be used to create price indices for apartment complexes such as those generated in Exhibit 4 in terms of price per square foot. Further refinement of this analysis could include expanded experimentation with alternative nonlinear specifications and separate subperiod regressions to allow for greater variability in the marginal value of characteristics over time.

Equation (3), on the other hand, appears to be a better "predictor" of value, and hence would be more appropriate for statistical evaluation. The advantage of equation (3) is that it simultaneously utilizes both characteristics and financial data. Indeed, the results suggest that, in evaluating individual properties, equation (1) alone (the market approach) is likely to be inadequate because of the lack of data that can explain subtle differences in complex "quality," and equation (2) (the income approach) is likely to be inadequate because of the failure to account for major differences in cap rates across alternative property types. Reconciling the two by some simple averaging will not solve the problem. Equation (3) jointly treats the data limitations problem by including *NOI* and the variable cap rate problem by including characteristic variables.

The empirical results for Houston show a remarkable change in values over time due to the glut of apartments constructed in the early 1980s, the slump in Houston's energy economy, the disposition of an enormous inventory of real estate by lending institutions and government agencies, and the Tax Reform Act of 1986.

The results also provide instructive insights regarding general appraisal practices. The results show that the use of a single cap rate is as inappropriate as the use of a single price per square foot. Variance in cap rates is not, however, purely random. Cap rates appear to systemically vary with respect to project size and age as well as location. This means that the income approach requires much more careful application than typically has been done in the past.

Appendix
Variable List

Variable	Definition	Mean
P	The total purchase price of an individual apartment complex	$2,934,999
NOI	The stabilized net operating income of each complex	$100,000
SF	The total square feet of each complex	210,916 sf
AGE	The age of the complex at the date of sale	8.67 yrs
METER	A dummy variable = 1 if complex has individual electricity meters	69.5%
CBD	The distance in miles from the complex to the Central Business District	12.60 m
PHG	Census tract data: Percent of high school graduates	81.1%
PNE	Census tract data: Percent non English speaking	17.1%
MINC	Census tract data: Median family income	$23,000
PBP	Census tract data: Percent below poverty level	5.35%
TRANS	Dummy variable = 1 for census tracts that underwent racial transition during the 1980s, from less than 20% minority to greater than 50% minority	10.8%
*T*80	Dummy variable = 1 if date of sale was 1980	3.3%
*T*81	Dummy variable = 1 if date of sale was 1981	8.4%
*T*82	Dummy variable = 1 if date of sale was 1982	11.1%
*T*83	Dummy variable = 1 if date of sale was 1983	7.7%
*T*84	Dummy variable = 1 if date of sale was 1984	14.6%
*T*85	Dummy variable = 1 if date of sale was 1985	14.4%
*T*86	Dummy variable = 1 if date of sale was 1986	11.9%
*T*87	Dummy variable = 1 if date of sale was 1987	10.4%
*T*88	Dummy variable = 1 if date of sale was 1988	9.8%

Source: Authors

Notes

[1]See Liu, Grissom and Hartzell (1990) for an interesting discussion of the problems of commercial real estate evaluation.

[2]See Smith and Forrest (1993) for historical market transaction data for Houston, Texas.

[3]That is, while commercial properties themselves may not be any more heterogenous than single-family homes, the pool of "comparable sales" are likely to be much more heterogenous.
[4]Most analysts use a form of stabilized income, income generated if the project were achieving normal occupancy levels. While there is some debate over the correct stabilization procedure, the greatest disagreement involves the determination of the appropriate discount or cap rate that capitalizes income into asset value.
[5]See Bailey, Muth and Nourse (1963); Ball (1973); Kain and Quigley (1970); Palmquist (1980); and Smith and Ohsfeldt (1980) as examples of a variety of different types of hedonic analyses applied to housing.
[6]For an excellent overview of this topic, see Hanford (1976).
[7]Under certain circumstances, discussed later in the text, rental income can fully account for all differences in price, requiring no additional information on structural or locational attributes.
[8]This is not to say that expectations of future cash flows are not important. Cap rates derived from market data implicitly incorporate market-wide perceptions regarding the future.
[9]For example, suppose investors expect greater appreciation for properties closer to the CBD. Then, rather than remaining constant for all locations, cap rates will increase with distance from the CBD. Cap rates might also vary with respect to property size or age.
[10]The data incorporates no repeat sales. Thus, each observation is associated with a different apartment complex.
[11]The analysis actually experimented with several alternative definitions of income. *Stabilized net operating income* for the year of sale was found to have the greatest predictive properties. This stabilized *NOI* is utilized because it reflects the likely long-term performance of this property.
[12]Multicollinearity is almost always a problem in hedonic analyses. Fortunately multicollinearity only affects the efficiency of estimated parameters. This efficiency problem translates into inflated standard errors and hence lower t-statistics.

A more serious problem is the potential correlation between included and excluded variables. This correlation does bias estimated parameters. Because there are so many variables that might affect property values for which the researcher cannot control, this problem is quite common with hedonic estimation. As a result, one must always be cautious of interpreting the estimated "shadow prices" of hedonic equations as purely isolated marginal values.
[13]There was a very high degree of collinearity between areas experiencing racial transition and the percent Black of each tract. Few modern garden apartment complexes exist in traditionally Black neighborhoods in Houston. Because the sample of properties was limited to the standard garden apartment complex typical of the period, it does not include a representative subsample of all minority areas.
[14]See Smith (1989) for details on the Houston recession and real estate bust of the mid-1980s.
[15]It should be noted that the coefficients of T87 and T88 are not statistically significant from one another.
[16]The depreciation rate estimated here incorporates all three forms of depreciation. The empirical specification results in constant depreciation elasticities. Subsample estimations seem to indicate that the depreciation rate varies across project characteristics. However, in many cases, these differences are not statistically significant.
[17]See Special Issue, *Journal of the American Real Estate and Urban Economics Association*, Fall 1991, for an excellent review of the single-family hedonic literature as it relates to price indices.
[18]See Smith and Ohsfeldt (1980).
[19]This finding is also bolstered by the fact that, using this data set, there was virtually no rental gradient found with respect to distance from the CBD. Multifamily complexes are typically clustered near work centers and renters typically locate in complexes near their work. Rent gradients do exist relative to immediate distance to these work centers, such as to the Texas Medical Center with an employment base of 50,000 jobs and the Galleria area with an

employment base of 70,000 jobs. Rent gradients are noticeable for about three miles from these centers. It would not be unreasonable to expect similar rent gradients from the CBD, except that unlike most other Houston area work centers, there are few garden apartments within a three-mile radius.

[20]Of course, this phenomenon is also a part of the economies of scale of large projects that can efficiently provide these additional amenities.

[21]Replacement rents are the long-run equilibrium rent levels required to warrant new construction, if for no reason but to replace that portion of the stock of housing retired each year. Standard asset pricing models predict that long-run rents must eventually return to those levels. If current rents are substantially below replacement rents, the market participants would have reason to expect rising real dollar rental rates in the future. As a result, cap rates would be lower than normal.

[22]The reader should remember that equations (1) and (3) cannot be directly compared. Equation (1) is essentially a price equation, while equation (3) is a "cap rate" equation.

[23]The t-statistic of 6.65 indicates that the additional explanatory power of adding log(NOI) to the estimating equation (equation (1)) is significantly greater than 0 at a confidence level in excess of 99%. A group F-test was similarly applied to evaluate the addition of characteristic variables to equation (2). The F-statistic of 50.8 also indicates that the collective explanatory impact of adding the Z was also significantly greater than 0. Thus, the predictive power of equation (3) is greater than either equation (1) with only characteristic variables or equation (2) with only *NOI*.

[24]For a few projects, actual *NOI* became negative. These became prime candidates for early retirement. In fact, between 1985 and 1988 more than 20,000 multifamily units were boarded up. None of the projects in the sample used in this report experienced negative *NOI*s.

[25]Further investigation is now underway to examine differences in the implicit cap rates associated with transactions in the late 1980s of foreclosed properties sold by private and government institutions.

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