# The Determinants of Appraisal-Based Capitalization Rates

by

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## I. Introduction

In traded securities markets, the single most revealing statistic about how an asset is viewed is the ratio of price to earnings (PE). In efficient markets, with high liquidity, PE ratios are felt to perfectly reflect the asset's earnings growth opportunities, as well as the risk and uncertainty about those earning outcomes. Higher PE's signal greater expected growth and less uncertainty, while lower PE's imply the reverse. Of course, average PE ratios over time should also reflect the opportunity cost of risk-free government yields.

In real estate, the analogy to an asset's PE is the capitalization rate, or the ratio of current net operating income to valuation.[2] Since most real estate is privately owned and individual property assets are only occasionally traded, there has always been considerable interest over the question of whether real estate capitalization rates act like stock PE's. The question gains added interest from the fact that there is little data on actual property value transactions and so most real estate valuations are obtained by periodic appraisals. Do these appraisals generate valuation estimates that move with the opportunity cost of capital and that reflect realistic expectations about future income growth and risk?

To study this question, we examine *average* capitalization rates over 16 years and across 14 metropolitan markets. We do this for four property types, obtaining consistent results that exhibit interesting differences. Our data source is well known, the shared property performance database of the National Council of Real Estate Investment Fiduciaries (NCREIF). Despite the widespread availability of this data, our study is the first to systematically examine NCREIF capitalization rates at the local level. Econometrically, our approach is also different from other studies, because we use a panel-based model, rather than just time series.[3] The addition of cross-section variation to time series gives greater data richness and yields quite robust statistical results.

Our conclusions are quite strong. Capitalization rates extracted from the NCREIF database move exactly as PE ratios do, *but only if appraisers form expectations about future income growth by looking myopically backward and not forward*. Despite the fact the real estate markets are widely felt to be mean-reverting, the NCREIF capitalization rates move contrary to this.[4] Past income growth seems to be extrapolated forward. When the market is at historically high levels, capitalization rates are low rather than being high in anticipation of the mean reversion. An additional and more practical conclusion from our analysis is that the statistical results are quite strong suggesting that it is possible to generate reliable forecasts of (appraisal-based) capitalization rates (conditioned on forecasts of market rents and interest rates).

The paper is structured as follows. The second section reviews previous research on capitalization rates, while the third section outlines the modeling framework. The fourth section discusses the data and estimation technique while the fifth section presents the empirical results. The conclusion summarizes the findings and discusses directions for further research.

## II. Previous Research

Real estate capitalization rates have been the focus of a growing body of empirical research. One segment of this literature covers studies that have examined and demonstrated the role of aggregate capital market and public policy factors (such as interest rates, expected inflation and changes in the tax code) in shaping the time-series movements in aggregate capitalization rates (Fisher, Lentz and Stern, 1984; Nourse, 1987; Froland, 1987; Evans, 1990; Ambrose and Nourse, 1993; Jud and Winkler, 1995).

A second segment of the existing literature involves studies that have explored cross-section variations in capitalization rates. For example, several papers have studied variations in capitalization rates (or required returns) across broad property types (Ambrose and Nourse, 1993; Dokko, Edelstein, Pomer and Urdang, 1991). A few other studies have attempted to explore spatial differences in capitalization rates, across either broadly defined regions or sub-markets within a given metropolitan area (Sirmans, Sirmans and Beasly, 1986; Saderion, Smith and Smith, 1994; Grissom, Hartzell and Liu, 1987; Hartzell, Hekman and Miles, 1987).

Despite the widespread view both within the industry and the academic community that real estate markets are naturally segmented by metropolitan area, very few studies have focused on metropolitan-specific capitalization rates. Only the research by Sivitanidou and Sivitanides (1997; 1999), using a panel approach, demonstrated the important role that local market conditions play in determining differences in capitalization rates both across metropolitan areas and through time.

Most of the previous studies have relied on data from the American Council of Life Insurance (ACLI) or the National Real Estate Index (NREI). Two recent studies, Fisher (2000) and Chandrashekaran and Young (2000), were the first to use capitalization rate estimates drawn from the database compiled by NCREIF. This carefully constructed database has not been used before to analyze capitalization rates and, as Chandrashekaran and Young (2000) point out, does not suffer from some of the reporting shortcomings that the other two databases may. These papers, however, focus on national capitalization rates for the different property types as opposed to market-specific capitalization rates.

Against this background the current study uses capitalization rates from this newly expanded NCREIF database and applies a panel approach to study how capitalization rates vary across markets as well as through time. The results show that local market factors are extremely important in explaining capitalization rate variations.

## III. Modeling Framework

In traded securities markets, prices are widely felt to adjust quite rapidly to changes in information or market conditions. In private markets, however, the lack of liquidity and the use of appraisal pricing means that measured capitalization rates will exhibit smooth persistence and adjust much more gradually over time to the revelation of new information. Some of this "smoothing" is due to institutional factors (Geltner, 1991), but it also reflects fundamental appraisal behavior (Hendershott and Kane, 1995). To capture both effects, we model capitalization rates as an adjustment process around equilibrium values. The use of adjustment processes in studying persistence in real estate markets is well documented and widely applicable (Grenadier, 1995; Voith and Crone, 1988; Wheaton, 1998).

### *Equilibrium Capitalization Rates*

In a short-run, partial-equilibrium model of real estate asset pricing, rents and other market conditions are treated as exogenous.[5] Since we are using panel data, we refer to a metropolitan market with the subscript *j*, while time is denoted with *t*. The equilibrium capitalization rate, $C^e_{jt}$, is traditionally defined simply as the ratio of net operating income (NOI), $Y_{jt}$, to the equilibrium asset price, $P^e_{jt}$:

$$C^e_{jt} = \frac{Y_{jt}}{P^e_{jt}} \qquad (1)$$

The equilibrium asset price, $P^e_{jt}$, is determined in the asset market through the interplay of (existing) asset supply by property owners and asset demand by investors so that excess returns are arbitraged away and the marginal investor only earns a required risk adjusted rate of return, $d_{jt}$. Stated differently, for a given stream of cash flow, $CF_{jt}$, equilibrium prices $P^e_{jt}$ should exactly equal the present value of expected cash flows discounted at $d_{jt}$. This is shown by (2), where the discounting has been divided into two separate components over the property's life of $n$ periods:

$$P^e_{jt} = \sum_{t=1}^{T}\left[\frac{CF_{jt}}{(1+d_{jt})}\right] + \sum_{T+1}^{n}\left[\frac{CF_{jt}}{(1+d_{jt})}\right] \qquad (2)$$

The first term is the present value of annual cash flows, $CF_{jt}$, expected to be received during the holding period of $T$ years. The second is the present value of cash-flows over the remaining life of the property, $n$-$T$, representing the property's resale price at time $T$.[6] While capitalization rates are always defined with reference to NOI, asset prices are based on delivered dividend income or cash flow. We assume that true cash flow, $CF_{jt}$ is a constant percentage, $\beta$, of NOI, $Y_{jt.}$ Furthermore, we assume that both of these grow at the annual rate $g_{jt}$ . With these two assumptions, we convert (2) to (3).

$$P_{jt}^{e} = \beta Y_{jt}\left[\sum_{t=1}^{n}\left[\frac{(1+g_{jt})}{(1+d_{jt})}\right]\right] \tag{3}$$

When (3) is inserted into (1), we have $Y_{jt}$ in both the numerator and denominator, and the two cancel. This leaves the equilibrium cap rate as a function solely of the expected growth rate of income ($g_{jt}$) and the risk-adjusted discount rate ($d_{jt}$ ).[7]

$$C_{jt}^{e} = \frac{Y_{jt}}{\beta Y_{jt}\left[\sum_{t=1}^{n}\left[\frac{(1+g_{jt})}{(1+d_{jt})}\right]\right]} = C(d_{jt}, g_{jt}) \tag{4}$$

*The Rate of Appraisal Adjustment.*

As discussed previously, our analysis of NCREIF data suggests considerable persistence over time. Furthermore, it seems theoretically reasonable to expect that private-market appraisals have a natural resistance to change. Hence we model movements in observed capitalization rates as adjustments around the equilibrium rate.[8] Within such an adjustment-model framework, the actual movement in capitalization rates, in response to changes in discount rates or expected growth, will be only a fraction of how much those changes have altered the equilibrium rate from the current capitalization rate. This fraction is represented by the *adjustment coefficient*, $\gamma$ (Pindyck and Rubinfeldt, 1991). This adjustment process when applied to capitalization rates can be represented as follows:

$$C_{jt} - C_{j,t-1} = \gamma \left( C^{e}_{jt} - C_{j,t-1} \right) \qquad (5)$$

Combining (5) with (4) and solving with respect to $C_{jt}$ yields (6), which postulates that current observed capitalization rates are function of the implicit or desired capitalization rate and the previous year's observed capitalization rate:

$$C_{jt} = \gamma C^{e}_{jt} \left( d_{jt}, g_{jt} \right) + \left( 1 - \gamma \right) C_{j,t-1} \qquad (6)$$

The above formulation sets the stage for the specification of an empirical model that explains movements and differences in observed capitalization rates.

## IV. The Determinants of Risk and Growth Expectations.

Building on the modeling framework just outlined two sets of influences on capitalization rates can be identified: discount rate influences that reflect both market risk and the opportunity cost of capital ($d_{jt}$), and factors that shape income growth expectations on the part of real estate investors ($g_{jt}$). Each deserves considerable discussion.

*Risk-Adjusted Discount Rate.*

According to conventional finance theory the nominal discount rate has two central components: the risk-free rate, and a risk component that varies depending on the specific investment and its industry or market environment. Risk-free rate influences can be captured through movements in the T-Bill rate, which by conventional wisdom is considered a risk-free investment. Since real estate competes with other investment vehicles for capital, increases in achievable risk-free rates should motivate investors in risky assets, such as real estate, to require higher returns. While this effect is always found in stock and bond pricing, whether it exists in appraisals remains to be seen.

To capture the risk-free opportunity cost of capital we used the 10-year treasury rate, [$TBILL_t$]. We experimented with different treasury rates, such as, the 3-year, the 5-year, the 7-year and 10-year rate. The 10-year rate worked better and it is consistent with the conventional view of real estate as a long-term investment vehicle.

The second component of the discount rate is idiosyncratic risk specific to the investment being considered. This component is most likely to vary across metropolitan real estate markets. Risk perceptions should be shaped by the long-term structural traits of metropolitan markets, such as, size of the market, employment composition, or the historic volatility of the local economy and real estate market. For example, smaller markets may be considered as more risky from a liquidity point of view, because of thinner property demand. Smaller markets also have less capacity to absorb new development projects of a given scale. Sectoral employment structure should also affect investor risk perceptions, as markets with a more diversified economic base are widely considered to be less volatile

It should be noted that a number of variables were tested in an attempt to capture some of these *fixed-effect* influences on investor risk perceptions.[9] Such variables included the average stock size and the standard deviation of office employment growth over the period 1980-1999. The standard deviation of the growth rate in property rents also was tested as a measure of risk. While some of these measures were statistically significant, collectively they did not work anywhere near as well as the inclusion of metropolitan-level fixed-effect dummy variables [$D_j$ ].[10] Since fixed effects are normally part of a panel analysis, including them was almost a requirement. Once included in the analysis, adding any other variables that exhibited only cross-section variation would be redundant. Thus, as we examine the results, the fixed effects will be interpreted largely as reflecting market-specific differences in perceived risk.

*Expectations of Income Growth.*

The second set of influences on capitalization rates has to do with factors driving expectations about income growth. In real estate, the leasing structure of properties leads to a significant lag between market changes in rent and the movement of property income.[11] To examine the future of property income, investors typically form expectations about market rents, rather than examining actual asset income. Thus, virtually any measure of expected income growth is based largely on expectations of where market rents are headed. Since in our analysis interest rate is measured nominally, the relevant rental growth rate examined is also nominal. We decided to split expectations of nominal rent growth into two components: growth due to expected economy-wide inflation and expected *real* rent growth.

Two alternative measures were used as proxies for expected economy-wide inflation [$INFL_t$]. The first was the spread between the short-term and long-term Treasury rates and the second was a simple extrapolation of past changes in the general Consumer Price Index (CPI) [Judd and Winkler, 1995; Sivitanidou and Sivitanides, 1999]. Lagged CPI inflation worked clearly better as proxy of expected inflation. This factor should have a negative impact on capitalization rates, as expectations of higher inflation and, hence, higher nominal rent growth, would motivate investors to accept a lower income return when acquiring a property.

In trying to determine the expected rate of growth of real market rents, it is important to develop some idea of how market rents move through time. There is a literature which clearly suggests that real estate markets are not random walks, and that prices or rents are mean-reverting, stationary series (Wheaton, 1998).[12] This generates considerable predictability over time (Case, 1989). In series of this type, there are two simple rules for *rational* prediction.

First, when the market is at or near historic highs there is an increased likelihood, as one goes further out, that they will turn down and mean revert. The opposite holds when near historic lows. A simple measure of where each market currently is "cyclically" would be the ratio of current real rent to its historical average [$RRENT_{j,t}$ ]. With rational expectations, forward-looking appraisers should anticipate lower subsequent income growth when the market is relatively high. This means that the measure [$RRENT_{j,t}$ ] should lead to higher capitalization rates. On the other hand, there is always the possibility that naïve expectations could prevail, in which case appraisers might assume that when the market is up, growth will continue even further. In this case higher relative real rents would lead to lower capitalization rates.

Second, in a mean-reverting series identical (high) rent levels can occur both prior to and after the high is reached. Similarly, identical (low) rent levels occur both before and after rents have reached a bottom. Holding the *level* of rents constant, the *change in rents* does indicate whether future rents will be higher or lower. Thus, rent differences do (positively) predict future rent growth, but this holds true only when rent levels are controlled for. In this study we use the change in real rents [$DRRENT_{j,t}$] as the measure of rent differences and we anticipate that it will be negatively related to capitalization rates. In other words, during periods of high rent growth we expect capitalization rates to be lower.

It is important to note that the change in rents might influence capitalization rates through a variety of expectation formations, besides those that are informed or rational. Appraisers, for example, might simply extrapolate current growth rates forward. Thus, a significant (negative) impact of current rent growth on capitalization rates is not a discriminating test of alternative expectation formations. The rent level variable has much more power in this regard.

Finally, the rent level and change variables have been measured relative to their historical averages. As such, their influence on capitalization rates should hold universally across markets. Thus, fixed-effect dummy variables are technically not needed to control for inter-market differences in historical average values of these variables. This makes it easier to interpret the estimated fixed-effect coefficients as measures of perceived investor risk. It is also important to realize that the interest rate used varies only by time, and of course the fixed effects are purely cross sectional. Thus, it is only the rent variables that will capture all the interaction effects that exist across both time and market. A summary of the variables used is presented in Table 1, along with their sources and the expected sign of impact.

## V. Data and Model Estimation

The basic data used to measure metropolitan-specific capitalization rates are drawn from the database compiled by NCREIF. The NCREIF database includes quarterly property-specific information on net operating income (NOI) and appraised values (or sales price for the few properties that are sold during the quarter) as reported by its members. These represent many of the nation's largest institutional investors. This property-specific information is aggregated by area to generate market-specific time-series data.

A major criticism of the NCREIF data is that they are mostly based on appraised values as opposed to transaction values. However, as Chandrashekaran and Young (2000) point out, as long as the definition of the data is consistent, any capitalization rate series calculated using the NCREIF value series could be reasonably representative of the true movements in these rates through time (if not levels).

Although, the NCREIF data series come in a quarterly form we use annual capitalization rate estimates to avoid the noise from seasonal appraisal patterns. In particular, the source of appraisals in the fourth quarter is different from that in the other three. Following Chandrashekaran and Young (2000) the annual capitalization rates have been calculated as the ratio of the NOI over the ending market value. Given the quarterly nature of the original data this calculation was completed in two steps. First, we used the quarterly data to calculate quarterly capitalization rates as the ratio of NOI over property value at the end of the quarter. Subsequently we calculated annual capitalization rates using a compounding formula.[13]

When annualized, the number of observations varies significantly by property type. For offices and industrial properties, there are 14 metropolitan areas and the data series goes back to 1984. For multi-housing and retail properties, on the other hand, there are only 9 MSAs and the data series goes back to 1990 and 1983, respectively.

Experimentation with different functional forms showed that a log-linear specification provides the more robust estimation results.[14] This specification is consistent with the non-linearity that is embedded in (4). In addition, a log-linear equation constrains the capitalization rate to be non-negative. Following this specification, and using the data in Table 1, equation (7) was separately estimated for each of the four property types in the NCREIF database.

$$Log(C_{j,t}) = a_0 + a_1 log(C_{j,t-1}) + a_2 RRENT_{j,t-2} + a_3 DRRENT_{j,t-1} + a_4 TBILL_{t-1} + a_5 INFL_{t-1} + a_6 D_j \quad (7)$$

The statistical specification described by (7) was estimated using the Time-Series Cross-Section (TSCS) model discussed by Greene (1993). This model corrects for cross-section correlation as well as for group-wise heteroskedasticity, which have been detected in the structure of the error term through appropriate LM tests.[15] The correction for cross-section correlation is especially important since the capital market is nationally integrated and thereby exercises common influences on all metropolitan markets. In the absence of such correction some independent variables may appear with the wrong sign. With this approach, the estimation results for office properties are presented in Table 2.

The results in Table 2 are very consistent with the use of an adjustment process to gradually move capitalization rates towards a desired or equilibrium rate. The estimation yields a coefficient of adjustment of 0.52, which indicates that observed capitalization rates adjust towards the desired or equilibrium capitalization rate at a moderate pace.[16] In particular the estimated coefficient of adjustment suggests that about 52% of the deviation between the desired office capitalization rate and the observed capitalization rate is eliminated within one year.

Next, the estimation results suggest that appraisal-based valuations do move with the risk-free rate, as certainly would be the case for valuations in publicly-traded markets. We find that risk-free rate movements, as reflected in *TBILL,* have a statistically significant positive effect, as expected, indicating that real estate investors do require a higher return when the risk-free rate increases. The magnitude of this effect, however, is less than what one might expect from equation (4). There, if the interest rate rises by 100 basis points, one would expect a similar increase in the capitalization rate. The coefficient in Table 2 suggests that this interest rate rise would generate only about a 25 basis-point rise in the real estate capitalization rate.[17] Now of course, some of this might be explained if investors do not necessarily expect a yearly change in the government risk-free yield to become a permanent change in the cost of capital. Yet, clearly appraisals to not react as closely to risk-free rates as do (for example) bonds.

Focusing on the role of the metropolitan fixed effects, the dummy coefficients are both *individually* and *jointly* significant at high levels of confidence. The statistical significance of the dummy-variable coefficients indicates that there are fixed characteristics that support sustained differentials in capitalization rate levels across metropolitan markets. The significance of such local-fixed effects corroborates recent findings by Sivitanidou and Sivitanides (1999). The magnitude of these effects ranges from zero to almost 400 basis points across the markets included in the sample. These fixed-effect differentials suggest that Saint Louis is regarded as the most risky market, while Houston the least.

Turning now to the role of *time-and-market varying real estate variables*, one is first struck by the very high levels of significance exhibited by the variables *INFL*, *RRENT* and *DRRENT*. The second important conclusion about this group of variables is that they all work best when lagged by a year or two. The contemporaneous relationship is generally of the same sign, but not as significant statistically. This clearly shows that appraisal-based valuations react with a lag to current market conditions.

The magnitude of the effects also varies. If investors only cared about the expected growth rate in nominal rents, then the coefficients on *INFL* and *DRRENT* would be identical. Furthermore, according to equation (4), both of these coefficients should generate a percentage-for-percentage-point change in the capitalization rate. In Table 2, however, the coefficient on *INFL* is five times that of *DRRENT*, although both are significant at equivalent levels. Following the same procedure as in footnote 6, we find that an increase in expected economy-wide inflation of 1% annually lowers the capitalization rate by 46 basis points. A 1% increase in last year's rate of real office rental growth reduces the capitalization rate by only 9 basis points. The *INFL* effect is about half of what might be expected, while the *DRRENT* effect is very small, although still highly significant. Perhaps yearly rental growth rates are regarded as somewhat transitory by appraisers.

Turning to the impact of the variable *RRENT*, the results strongly suggest that investors indeed use a myopic (as opposed to a forward-looking) approach in forming their expectations of market movements. The relative level of the 2-period lagged real rent has a very significant *negative* impact on capitalization rates. It appears that during periods characterized by historically high real rents capitalization rates are lower, implying that investors have expectations of continued greater income growth in the future. The opposite holds as well: when the market is low, growth expectations are as well. If this variable is entered either contemporaneously or lagged further backward, it becomes much less significant. *There is simply little evidence that appraisal valuations recognize any degree of market mean-reversion*.

The magnitude of the *RRENT* variable is quite large. Historically, real office rents have varied between their highs and lows by about 50%. Again, using the procedure discussed in footnote 6, a 10% increase in real rent levels generates a drop in capitalization rates of 56 basis points. Thus, the typical market sample swing in office rents results in capitalization rates that move by slightly less than three full percentage points

## VI. Differences in Capitalization Rate Behavior across Property Types

In order to gauge behavioral and appraisal differences across property types we estimated empirical capitalization rate models not only for office but also for industrial, retail and multi-housing. In each case the model was identical to that estimated in Table 2, with all variables identically defined. Only the sample size varied, both in the number of years and markets. In all cases, the statistical significance of the results was roughly comparable to those reported in Table 2. Capitalization adjustment rates also closely varied around 50% annually, except for multi-housing, where full adjustment occurred within one year.

Using the estimated parameters for each property type's equation, we follow the procedure in footnote 6, and examine the effect of hypothetical increases in each of the independent variables on that property type's capitalization rate. The results of this analysis are presented in Figure 1.

These calculations reveal a broad similarity in the effect of the factors discussed earlier. For example, as Figure 1 indicates, a 1% increase in the inflation rate will cause a 40 basis-point decrease in multi-housing capitalization rates, a 54 basis-point decrease in retail capitalization rates, but only a 20 basis-point decrease in industrial cap rates. These are in comparison to the 46 basis-point drop for office. Some of these differences might be explainable by differences in how each property type's income stream responds to changes in market rental growth. For example, the income stream of industrial properties might well be the least exposed to market changes because industrial leases roll relatively more infrequently than other commercial uses. It could also mean that investors place always a high risk premium when buying industrial properties with little regard to what is happening in the local market, because they are the least familiar with this product type. These explanations receive some support when the differences in the impact of *DRRENT* are examined. Again, industrial properties respond the least to differences in real rental growth.

Our analysis points to a bigger difference in the sensitivity of capitalization rates to changes in rent levels, particularly between multi-housing and retail. A 10% increase in the real rent level will push multi-housing capitalization rates down by 87 basis points but retail capitalization rates only by 14 basis points. Office and industrial capitalization rates respond in between, with 56 and 58 basis point changes respectively. A possible explanation for the unusually large (small) impact on multi-housing (retail) properties again focuses on the role of leases in buffering property income from market rent movements. In retail properties, who the tenant is often is as important as the movement in market rents. By contrast, with annual leases and little or no tenant discrimination, multi-housing income streams move very closely with market rents.

## VII. Conclusions

The findings of this paper point to three major conclusions. First, capitalization rate levels exhibit persistent differences across markets as a result of variations in fixed market characteristics that influence investor perceptions of risk and/or income growth expectations.

Second, movements in market-specific capitalization rates strongly incorporate components that are shaped by the behavior of the local market and, more specifically, by the time path of rental growth and rent levels relative to their historical averages. The nature of these relationships suggests that appraisal-based valuation is more "backward" than "forward" looking.

Third, movements in market-specific capitalization rates also incorporate common national influences: from the capital market in the form of interest rates and from the economy in the form of expected general price inflation.

Overall, the results of this study indicate that movements in market-specific capitalization rates have strong predictable components that allow the development of econometric forecasts (contingent on forecasts of critical local market indicators along with forecasts of interest rates and inflation).

Further research could address the issues of variation of capitalization rates across sub-markets within the same metropolitan area, or alternatively, between suburban versus downtown locations. Additionally, the sources of the sluggish adjustment in capitalization rates across and within metropolitan markets need to be empirically investigated. Such a task requires modeling of market-specific asset prices and analysis of the extent to which they respond to changes in market fundamentals. Examination of these issues would further advance our understanding of the idiosyncrasies of appraisal-based asset pricing in private markets.

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**Table 1. Variable Definitions and Expected Effects**

| Variable Name | Variable Definition | Source | Expected Sign |
|---|---|---|---|
| *LCAP* [1] | Logarithm of the annual capitalization rate calculated as the ratio of the NOI over the ending value[2] | NCREIF | |
| *RRENT* | Metropolitan-specific real rent index created by dividing each year's real rent by the 1980-1999 average real rent | Torto Wheaton Research | (-/+) |
| *DRRENT* | Annual percent change in the metropolitan-specific real rent index described above | Torto Wheaton Research | (-/+) |
| *TBILL* | 10-year Treasury rate | Federal Reserve Bulletin | (+) |
| *INFL* | Annual percent change in CPI | Federal Reserve Bulletin | (-/+) |
| *D* | Fixed effect for each market | | (-/+) |

[1] This variable is used as dependent variable. Its first lag, however, is used also in the right hand side of the statistical equation.

[2] This was calculated from quarterly data. In order to derive annual capitalization rates the quarterly estimates were compounded to annual. See equation (7) in text.

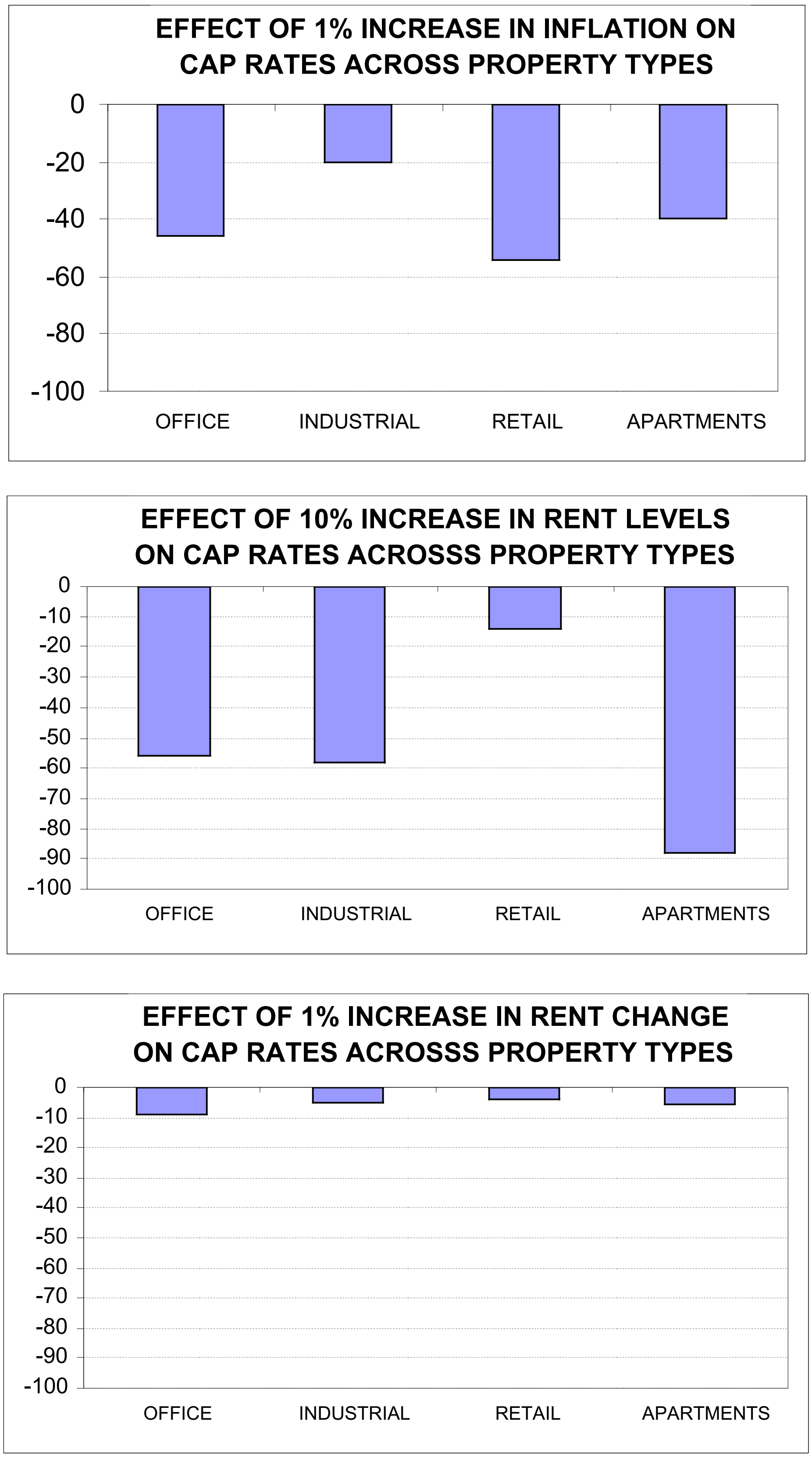
**Table 2. Office Capitalization Rate Results**

| Variable[1,2] | Coefficient (b) | z=b/s.e. |
|---|---|---|
| *LCAP (1)* | 0.4748 | 73.0 |
| *RRENT (2)* | -0.4221 | -74.4 |
| *DRRENT (1)* | -0.0070 | -83.3 |
| *TBILL (1)* | 0.0141 | 25.2 |
| *INFL (1)* | -0.0375 | -78.1 |
| *MSA1* | 0.0907 | 1.5 |
| *MSA2* | 0.1187 | 2.0 |
| *MSA3* | 0.1120 | 1.9 |
| *MSA4* | 0.0763 | 1.9 |
| *MSA5* | 0.0546 | 0.6 |
| *MSA7* | 0.0564 | 1.2 |
| *MSA8* | 0.1678 | 2.7 |
| *MSA9* | 0.1222 | 2.1 |
| *MSA10* | 0.1381 | 1.9 |
| *MSA11* | 0.1106 | 1.7 |
| *MSA12* | 0.1142 | 1.7 |
| *MSA13* | 0.2274 | 5.0 |
| *MSA14* | 0.1480 | 2.7 |
| Constant | 1.3792 | 23.4 |
| *Likelihood Ratio* | *298.59* | |
| *Log-likelihood Function* | *284.41* | |

[1] Numbers in parentheses adjacent to variable names denote the number of years each variable is lagged.

[2] The MSA dummies represent the following metropolitan areas in the order they are presented above: Atlanta, Boston, Chicago, Dallas, Denver, Los Angeles, Minneapolis, New York, Oakland, Orange County, Philadelphia, St. Louis, and Washington, DC. The default metropolitan area, *MSA6*, is Houston.

Figure 1. Differences in Capitalization Rate Behavior Across Property Types



[1] Correspondence should be addressed to Wheaton: E52-252B, MIT, Cambridge, Mass 02139, wheaton@mit.edu.
[2] The net operating income of a property is typically calculated as the difference between gross income and operating expenses.
[3] Panel-based models use pooled cross-section time-series data. For example in this study we use data for 14 metropolitan markets that span from 1984 to 1999. In this sense capitalization rates are allowed to vary across markets at the same point in time and through time within each market.
[4] Mean reversion refers to the tendency of certain random variables to remain at, or return over time to a long-run average level.
[5] An exogenous variable is one whose value is determined outside of the model or system under consideration.
[6] Note that this model does not explicitly account for debt financing and taxes, as relevant data are not available.
[7] See Clark (1996) for a present value model used to address the question of whether price appreciation expectations are correct. Also note that if the value, $P$, of a property is calculated as the present value of a *perpetual* income stream, $CF$, that is expected to grow at a constant rate $g$, then using a discount rate $d$, $P=CF/(d-g)$ (also see Brueggeman and Fisher, 1993).
[8] Granger and Newbold (1974) suggest that the proper way to "correct" a model for persistence and autocorrelation is to directly incorporate "adjustment" into the model.
[9] Fixed-effect influences refer to influences that vary across cross-section units, or markets in this analysis, but *not* through time.
[10] These are variables that take the value of 1 for observations that correspond to a given metropolitan area and 0 otherwise.
[11] This is the case because the rent paid by a tenant can not change before his/her lease expires. The term of commercial real estate leases spans typically several years.
[12] A variable is considered to follow a random walk if its changes are random and unpredictable. A variable is considered stationary if its mean and variance are constant through time and the covariance between two time periods depends only on their distance and not on the actual time period at which the covariance is calculated.
[13] When EV denotes the end of quarter value, the annual capitalization rate is:

$$C_{jt} = [1+(NOI_1/EV_1)]\,[1+(NOI_2/EV_2)]\,[1+(NOI_3/EV_3)]\,[1+(NOI_4/EV_4)] - 1$$

[14] In a log-linear specification only the dependent variable, and the lagged dependent variable, if present at the right hand side of the equation as is the case in this analysis, enter the model in a logarithmic form.
[15] Cross-section correlation is present when the disturbances are correlated across cross-section units. Heteroskedasticity is present when the disturbances do not all have the same variance. In the case of panel data cross-section correlation and group-wise heteroskedasticity can be detected through appropriate Langrange Multiplier (LM) statistics described by (i) and (ii), respectively:

$$T\sum_{j=2}^{n}\sum_{i=1}^{j-1} r_{ji}^2 \qquad \text{(i)}$$

$$\frac{T}{2}\sum_{j}\left[\frac{s_j^2}{s^2}-1\right]^2 \qquad \text{(ii)}$$

where $T$ is the number of time periods, $n$ the total number of cross-section units (markets in our case) included in the sample, $r_{ji}$ the $ji$th residual correlation coefficient, $s$ the restricted maximum likelihood estimator of common variance and $s_j$ the variance estimate for each group (market). Both statistics have chi-squared distribution with $n-1$ degrees of freedom.
[16] This is calculated as $1-a_1$, where $a_1$ is the coefficient of the lagged capitalization rate.
[17] This calculation first takes the *TBILL* coefficient and divides by .53 to get the long run impact of a 100 basis point change. The Exponential of this value is then multiplied by the pre-change capitalization rate (sample average of 8.0%) to get the eventual new resulting capitalization rate. The text reports the difference in these two values.