Office Capitalization Rates: Real Estate and Capital Market Influences

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Abstract
Focusing on the office capitalization rate, the central objective of this article is to shed light on two sets of issues that have not yet been fully researched. The first involves the importance of local-fixed and time-variant components of the office capitalization rate, and the significance of persistence in its time trends. The second centers on the relative importance of local office markets and the national capital market in shaping the various components of the office capitalization rate. Extensive econometric analysis of capitalization-rate series employed to address these issues highlights the existence of both local fixed and time-variant effects, while indicating differential persistence of time trends across markets. Moreover, such analysis uncovers the pivotal role of specific local office-market traits and the lesser role of national capital-market features in determining office capitalization-rate variations. Such findings on the role of local influences may provide a richer foundation for asset valuation and investment practices.

Key Words: office capitalization rates, office real estate markets, office asset markets

Exemplifying the link between the office space and asset markets, the office capitalization rate has been exhibiting nontrivial interarea and discernible intertemporal variations in recent years.[1] Despite the insights into how markets interact and function that can be gained from a better understanding of these variations, existing research has largely been one-sided (DiPasquale and Wheaton, 1992; Fisher, 1992). On the one hand, a substantial body of analytical work has explored in detail the role the national capital market plays in influencing capitalization-rate movements (e.g., Fisher, Lentz, and Stern, 1984; Hartzell, Hekman, and Miles, 1987; Ambrose and Nourse, 1993; Jud and Winkler, 1995). On the other hand, limited research, producing mixed results, has been devoted to the analysis of the role local office markets may play in shaping the office capitalization rate (Ambrose and Nourse, 1993; Jud and Winkler, 1995).[2]

Motivated by the paucity of relevant empirical work, this artilce builds on a simplified, short-run model of office asset markets to explore in an integrated fashion both the *components* and the *determinants* of the office capitalization rate. To this end, a series of semiannual, transaction-based capitalization rates for seventeen metropolitan markets during 1985 to 1995 is used to address two sets of research questions:

1. Does the office capitalization rate incorporate both local-fixed and time-variant components? Are area-specific time paths discernible, or does the time path of office capitalization rates only mirror common national trends? Furthermore, do location-specific time paths exhibit differential persistence, if any, in light of (unanticipated) exogenous shocks on asset markets?[3]
2. If the capitalization rate incorporates local-fixed and time-variant components, what are their underlying determinants? What is the relative magnitude of influences, if any, exerted on the capitalization rate by fixed or time-variant features of local office markets and time-variant features of the national capital market?

Empirical analysis of the research questions posed above may serve a dual purpose. *First*, by shedding light on the link between local office space and asset markets and the degree of asset-market inefficiency (potentially mirrored in the persistence of capitalization-rate time trends), such analysis may help bridge the gap between theoretical discussions and empirical research on issues of intense academic interest (Grissom, Hartzell, and Liu, 1987; Phillips 1988; Case and Shiller, 1990; 1991; Fisher 1992). *Second*, by elucidating the components and determinants of the office capitalization rate across various markets, this analysis may provide a richer foundation for asset valuation and investment practices (Brueggeman and Fisher 1993).

Taken together, the findings of this study highlight aspects of office space and asset market links. More specifically, they uncover the existence of local-fixed and both area-specific and time-variant components of the office capitalization rate and point to differential persistence across markets in its time trends, signifying perhaps differing degrees of local asset market inefficiency. Furthermore, they highlight the pivotal role of local office markets and the lesser role of the national capital market in shaping the capitalization rate, presumably through their influence on investor risk perceptions and income-growth expectations. Despite evidence for contemporaneous correlation of shocks across markets that points to some degree of market integration, these findings are consistent with the argument that the office asset market is segmented to a substantial degree along metropolitan boundaries. As such, they may not only lend support to asset valuation and investment practices that incorporate location considerations, but may also help refine such efforts.

The remainder of this paper is organized as follows. Section 1 outlines a simple short-run model of the office asset market that sets the platform for addressing the central questions of this study. Section 2 draws on this framework to discuss potential components and determinants of the office capitalization rate. Section 3 describes the office capitalization-rate series analyzed in subsequent sections of the article. Sections 4 and 5 present the respective empirical model variants used to explore the components and determinants of the office capitalization rate and discuss the empirical results. Lastly, section 6 summarizes the conclusions of the study and offers interpretive comments.

1. The Modeling Framework

The office capitalization rate can be explored through a simple model of office asset markets that is similar in spirit to those underlying studies of unemployment rates, vacancy rates, and price appreciation (e.g., Marston, 1985; Voith and Crone ,1988; Gyourko and Voith, 1992). Such model builds on two key premises that define the organizing blocks of this section: *first*, there exists an equilibrium capitalization rate that mirrors the marginal investor's minimum required return; and, *second*, the prevailing capitalization rate may deviate from this equilibrium level due to asset-market inefficiencies that may hamper swift responses to exogenous shocks.

1.1 Equilibrium Capitalization Rate

Consider a short-run, partial equilibrium model of a representative office asset market j, assuming that office rents and other features of the space market (such as office stock) are exogenous. Exemplifying the link between the asset and space markets, the equilibrium capitalization rate in asset market j at time t, C^e_{jt}, is simply the ratio of a *given* net operating income (NOI), Y_{jt}, largely driven by office (space) rents, over the equilibrium asset price, P^e_{jt}.

$$C^e_{jt} = \frac{Y_{jt}}{P^e_{jt}} \tag{1}$$

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 his or her minimum required rate of return, d_{jt}.[4] Stated differently, for a given Y_{jt}, P^e_{jt} should exactly equal the present value of expected cash flows discounted at d_{jt}. This is shown by (2), where cash flows represent the sum of two components:

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

The first is the present value of annual cash flows, CF_{jt}, expected to be received during the holding period of T years, assumed (for simplicity) to be exogenous and time- and space-invariant. The second is the present value of cash flows over the remaining useful life of the property, $n\text{-}T$, representing the property's resale price at time T.[5] Assuming that CF_{jt} is a constant percentage, b, of Y_{jt} and that the latter grows annually at an *exogenous* average rate, g_{jt}, (2) is rewritten as in (3):

$$P^e_{jt} = b\,Y_{jt} \left[\sum_{t=1}^{n} \left[\frac{(1+g_{jt})^t}{(1+d_{jt})^t} \right] \right] \quad (3)$$

Inserting (3) into (1) yields (4), depicting the equilibrium capitalization rate in terms of two sets of exogenous determinants: the discount rate, d_{jt}, and the expected income growth rate, g_{jt}.[6]

$$C^e_{jt} = \frac{Y_{jt}}{b\,Y_{jt} \left[\sum_{t=1}^{n} \left[\frac{(1+g_{jt})^t}{(1+d_{jt})^t} \right] \right]} = C(d_{jt},\ g_{jt}) \quad (4)$$

1.2. Deviations from Equilibrium Capitalization Rate

Drawing on the model just outlined, (unanticipated) changes in exogenous factors shaping the discount rate, d, or income growth expectations, g, will dictate asset price and, hence, capitalization- rate adjustments toward new equilibrium states. Elicited through asset-demand and capital-flow shifts, such asset-price and capitalization-rate adjustments may be sluggish due to numerous asset- market inefficiencies: high transaction and adjustment costs; lengthy institutional decision-making processes that may prevent investor entry, or exit; and informational inefficiencies hampering the buyer-seller matching process, especially in heterogeneous markets (Arnott, 1989; Wheaton and Torto, 1994).[7] Within this setting, the following formulation of the prevailing capitalization rate is pertinent:

$$C_{jt} = C^e_{jt} + e_{jt} \quad (5)$$

Such formulation advances the idea that the capitalization rate prevailing in market j at time t includes an equilibrium component, C^e_{jt}, dictated by prevailing market realities, and a disequilibrium deviation, e_{jt}. Given slow adjustments of C_{jt} toward C^e_{jt}, only a fraction, $1\text{-}r$, of such deviation can each period be eliminated through asset-price movements. Stated differently, a fraction r of such deviation in period t must persist into the next. Thus, an AR(1) autocorrelated error structure is adopted, where e_{jt} is allowed to exhibit differential persistence, r_j, across markets, presumably due to local market idiosyncrasies. This error structure is shown in (6), where u_{jt} represents independent random shocks:

$$e_{jt} = r_j e_{jt-1} + u_{jt}, \tag{6}$$

Combining now (6) with (5) and (4) yields the following formulation of prevailing capitalization rates that sets the stage for the discussion in the remaining sections of the article.

$$C_{jt} = C^e_{jt}(d, g) + r_j e_{jt-1} + u_{jt} \tag{7}$$

2. Office Capitalization Rates: Components and Determinants

As already mentioned in section 1, office capitalization rates may largely be driven by the risk-adjusted required (total) return, or discount rate, and income-growth expectations. Each of these factors may be influenced by local-fixed traits of office markets that may also be responsible for the spatial variability of the persistence, if any, of capitalization-rate trends; time-variant office-market traits; and time-variant features of the national capital market.[8] Local office-market and national capital-market features exemplifying such effects are discussed below.

2.1. Discount Rate: Components and Determinants

Risk-related factors affecting the discount rate, *d*, representing the marginal investor's required rate of (total) return, are first considered.

2.1.1. Local-Fixed Office-Market Effects

Time-invariant local factors determining the discount rate include those factors only slowly changing through time and likely to shape *location-specific* risk premia.[9] These may include such local office-market traits potentially affecting liquidity and business risks, as sheer market size and market heterogeneity or diversity. Market size may matter, as investments in smaller markets may be deemed less liquid and, hence, more risky. Market heterogeneity or diversity may also matter, but its exact influence may depend on its nature. More heterogeneous and diverse markets in terms of location or inventory composition, for example, may be thinner and may be characterized by greater information or search costs, longer buyer or seller search, more burdensome buyer-seller matching process and, hence, higher risk. In contrast, those markets characterized by a more diversified sectoral mix or a sectoral mix favoring tenants that are deemed more stable (such as government) may be associated with perceptions of greater stability and, hence, lower risk.

2.1.2. Time-Variant Local Office-Market and National Capital-Market Effects

Risk premia may be shaped by time-variant features of both the local office and national capital markets. Relevant time-variant real estate market traits may include those influencing business risks, such as level of short-run office space demand (such as net absorption), local office space market strength (such as vacancy rates), and the volatility of office demand base (Sivitanides and Sivitanidou, 1996). Relevant capital-market features may include returns on alternative investment vehicles as well as indicators of expected purchasing power risk. As these factors vary across markets or over time, risk premia and, consequently, the investors' required rate of return may vary accordingly.

2.2. Income-Growth Expectations: Components and Determinants

Income growth expectations, g, may similarly be shaped by variables that may be either time-invariant or time-variant.

2.2.1. Local-Fixed Office-Market Effects

Time-invariant effects may be associated with local office-market size, as investors may form expectations for faster rent growth in smaller markets.[10] Such expectations may originate in observed service industry growth patterns during the 1980s and early 1990s. Recent studies point out that substantial service-sector growth during the 1980 to 1995 period has been taking place in smaller metropolitan markets at the expense of larger, higher-cost centers of service activity (Regional Financial Associates, 1997). If investors expect faster service employment growth in smaller markets, they may also expect higher rental income growth in these markets.

2.2.2. Time-Variant Local Office-Market and National Capital-Market Effects

Investor income-growth expectations may predominantly be shaped by perceptions of local real estate market strength that may be driven by such critical indicators as past rental income growth, office vacancy, or absorption rates. However, shaped in the capital market, expected inflation may also be relevant if it is not fully incorporated into past income growth.

2.3. Location Effects on Persistence

Office-market features, such as market size and degree of spatial or tenant heterogeneity, may play a pivotal role in inducing differences across local office markets in the persistence or serial correlation, r_j, embedded in their capitalization-rate paths. As noted in section 1, such characteristics may influence the degree of a market's informational and other inefficiencies that may, in turn, determine how swiftly asset prices and, hence, capitalization rates respond to changes in market realities.

3. Office Capitalization Rates: 1985 to 1995

For the purpose of this analysis, average capitalization rates for seventeen office markets during 1985 to 1995 were obtained from the National Real Estate Index (NREI), a CB Richard Ellis publication. The NREI primarily reports data on transactions that involve about 150 of the nation's largest real estate buyers and sellers. The latter include pension plans, Real Estate Investment Trusts (REITs), banks, savings and loans associations, commercial brokerage companies, and investment program sponsors.

Based on arms-length transactions, the aforementioned area-specific capitalization rates reflect average ratios of actual NOI over the transaction price. The transaction-based prices entering the calculation of the capitalization rate circumvent problems of systematic biases associated with the use of appraised values.[11] Moreover, although these transaction-based prices are not quality-adjusted through hedonic techniques, they do control, to some extent, for quality, as they refer to properties that conform to certain norms. These properties, for example, are located in central business districts and represent modern (less than ten-year old), Class A high-rise structures (10 stories or more), with steel frame or other high-quality construction, and with a modern exterior finish and glass applications. Characterized by lease and vacancy rates that are not substantially different from their close substitutes within the same metropolis, these structures are considered to be rather representative of the market.

As the NREI data illustrate, the average office capitalization rates during the period of 1985 to 1995 exhibit interarea and intertemporal variations that are sufficiently large to induce nontrivial differences in sales price estimates developed on the basis of the direct-income capitalization approach (see Brueggeman and Fisher, 1993). The nature and extent of these variations is evident in figures 1 and 2. As indicated in figure 1, portraying the year-end 1995 average capitalization rates for the metropolitan office markets analyzed in this study, capitalization rates range from 7.1% in San Francisco to 9.8% in Houston, with a mean and standard deviation of 8.6% and 0.6%, respectively. Similar intermarket variations are observed in all other analysis years.

Figure 2 portrays the time path of the average office capitalization rate for the nation and for four "representative" metropolitan office markets: Los Angeles in the West, Boston in the East, Atlanta in the South, and Chicago in the Midwest. Two important messages are conveyed by this figure. First, intertemporal movements in office capitalization rates are non-negligible. Atlanta presents the smoothest path, with capitalization rates ranging from a low of 8.0% to a high of 8.9%. In contrast, Los Angeles exhibits a more volatile path, with capitalization rates ranging from a low of 6.6% in the second quarter of 1989 to a high of 8.7% in the second quarter of 1993. Second, the time paths of capitalization rates in the various markets do not exactly parallel each other, suggesting that local idiosyncratic influences may (in part) be underlying such movements.

4. Empirical Analysis I: Exploring the Components of the Office Capitalization Rate

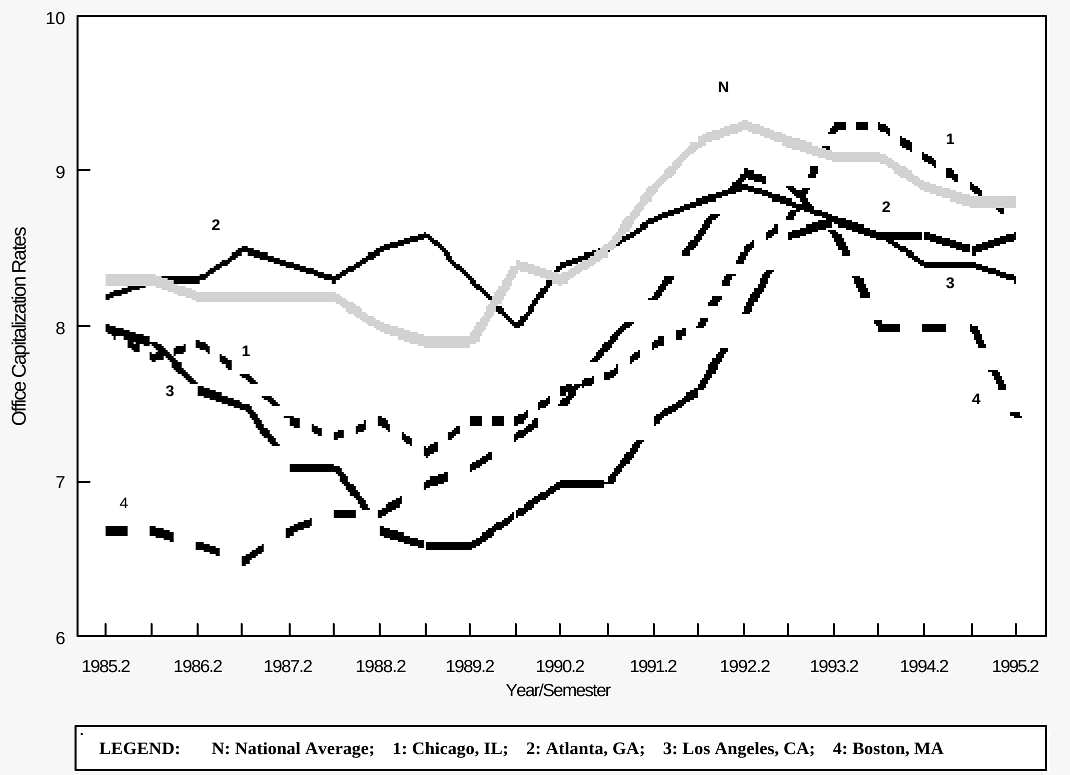
Building on the discussion in section 2 and using the office capitalization rate data described in section 3, the analysis focuses on the first set of questions posed in this article that place emphasis on the statistical significance of the components of the office capitalization rate, not its determinants. The latter are explored in section 5.

Figure 1. Average Metropolitan Capitalization Rates, 1995

Metropolitan Area	**Cap Rate (%)**
Atlanta, GA	8.3
Baltimore, MD	9.1
Boston, MA	7.9
Chicago, IL	8.7
Dallas, TX	9.5
Houston, TX	9.8
Los Angeles, CA	8.6
Minneapolis, MN	8.0
New York, NY	8.9
Orange County, CA	8.2
Philadelphia, PA	9.2
Phoenix, AZ	8.7
Portland, OR	8.7
Sacramento, CA	8.3
San Diego, CA	9.1
San Francisco, CA	7.1
Seattle, WA	8.3
Washington, D.C.	8.4
Average	8.6
Standard Deviation	0.6

Source: The National Real Estate Index (a CB Richard Ellis publication)

Figure 2. Intertemporal Movements in Office Capitalization Rates, 1985-1995



Source: The National Real Estate Inxex (a CB Richard Ellis publication)

4.1. The Base Model and Model Variants

A simple model, building on (7) and allowing for cross-section heterogeneity due to local-fixed and time-variant effects, is used to explore the components of the office capitalization rate. This model accounts for local-fixed and time-variant components that are *not* included in its random error term. As such, it allows for a clear representation (and measurement) of the equilibrium capitalization rate and disequilibrium deviations (see Grenadier, 1995 versus Gyourko and Voith, 1992).[12] The general form of this simple model is depicted by (8).

$$C^{e}_{jt} = a_j L_j + b_j F(t);$$
$$C_{jt} = C^{e}_{jt} + r_j e_{jt-1} + u_{jt} = a_j L_j + b_j F(t) + r_j e_{jt-1} + u_{jt} \qquad (8)$$

where a_j, L_j represent local-fixed effects and a vector of metropolitan dummies, respectively; r_j denotes the metropolitan-specific serial correlation coefficient; b_j, $F(t)$ denote time-variant effects, with $F(t)$ representing a time trend proxy modeled as $F(t) = t/(1+t^2)$[13]; u_{jt} represents an independent random error term; and j, t denote the metropolitan area and time index, respectively.

Building on this model, two variants, referred to as Model I-1 and Model I-2, are formulated. Defined as in (8) with b_j assumed to be fixed across markets, so that $b_j=b_k=b$ for all $j \neq k$, Model I-1 allows testing only for local-fixed and national time-variant influences. Similarly defined as in (8), but with b_j variant across markets, Model I-2 allows testing for both local-fixed and local time-variant influences.

4.2. *Empirical Results: Hypothesis Testing*

Model I-1 and Model I-2 have been estimated using a nonlinear Seemingly Unrelated Regression (SUR) procedure, which accounts for cross-sectionally correlated metropolitan-specific errors. This procedure is justified, as statistically significant cross-section correlations of an average magnitude of 0.31 are detected, implying that national factors may elicit effects that reverberate across markets.[14]

The full analytical results of Model I-1 and Model I-2 and the results of hypothesis tests applied to both models are displayed on table 1 and table 2, respectively. Exploring the importance of local-fixed effects, area-specific persistence, and time-variant effects, these hypothesis tests are discussed below.

4.2.1. Local-Fixed Effects

As shown by the rejection of the first set of null hypotheses displayed on table 2, H_{01}: $a_j=0$, for all j and H_{02}: $a_j=a_k$, for $j \neq k$, the office capitalization rate includes a local-fixed component that exhibits statistically significant intermarket variations. Such variations may stem from local office-market traits that may induce differential investor risk perceptions or income-growth expectations.

4.2.2. Persistence of Time Trends

The rejection of the second set of null hypotheses displayed on table 2, H_{03}: $r_j=0$, for all j, and H_{04}: $r_j=r_k$, for all $j \neq k$, points to the existence of persistence in time trends and to statistically significant variations in such persistence across markets. Notably, there are no oscillations, as all $r_j>0$, and adjustments toward equilibrium are only gradual, with Model I-1's and I-2's respective estimates indicating that deviations from such equilibrium dissipate to 50% of their initial magnitude after a time span, on average, of 2.0 and 1.5 years. Assuming no other sources of autocorrelation, such findings do not only corroborate arguments for highly inefficient office markets but also point to differing degrees of local asset-market inefficiencies (Wheaton and Torto, 1994).[15] Conceivably, the latter may stem from local idiosyncrasies giving rise to differing degrees of inertia in asset-demand or (existing) asset-supply responses and, hence, asset-price and capitalization-rate movements. Some of the sources of such inefficiency have already been discussed in section 1.

Table 1 . Local-Fixed Effects, Time-Variant Effects, and Persistence: Estimation Results [a]
(Dependent Variable: Office Capitalization Rate)

	Model I-1			Model I-2		
Metropolitan Area	Local-Fixed Effects a_j	Time Trend Coefficient $b_j = b_k$	Persistence r_j	Local-Fixed Effects a_j	Time Trend Coefficient b_j	Persistence r_j
Atlanta, GA	8.10 **	5.71 **	0.71 **	8.57 **	-1.19	0.73 **
	(0.137)	(0.535)	(0.025)	(0.289)	(3.903)	(0.020)
Baltimore, MD	8.90 **		0.86 **	9.44 **	1.93 **	0.93 **
	(0.161)	Same	(0.013)	(0.291)	(0.502)	(0.017)
Boston, MA	7.82 **	across	0.84 **	7.10 **	19.95 **	0.80 **
	(0.518)	markets	(0.026)	(0.563)	(4.770)	(0.019)
Chicago, IL	9.08 **		0.91 **	8.37 **	8.80 **	0.85 **
	(0.923)		(0.036)	(0.570)	(3.181)	(0.035)
Dallas, TX	9.37 **		0.80 **	9.92 **	-6.55 **	0.64 **
	(0.158)		(0.019)	(0.188)	(2.252)	(0.058)
Houston, TX	9.37 **		0.69 **	10.22 **	-16.30 **	0.81 **
	(0.234)		(0.055)	(0.536)	(3.505)	(0.029)
Los Angeles, CA	11.35 **		0.96 **	9.90 **	4.15 **	0.95 **
	(2.217)		(0.014)	(1.845)	(1.901)	(0.022)
Minneapolis, MN	8.54 **		0.76 **	8.33 **	8.47 **	0.76 **
	(0.228)		(0.028)	(0.274)	(2.309)	(0.019)
New York, NY	9.34 **		0.90 **	8.88 **	6.85 **	0.88 **
	(0.645)		(0.017)	(0.524)	(2.474)	(0.028)
Orange County, CA	8.46 **		0.90 **	8.67 **	3.57 **	0.92 **
	(0.617)		(0.022)	(0.974)	(1.581)	(0.042)
Philadelphia, PA	9.15 **		0.87 **	9.10 **	5.06 **	0.87 **
	(0.376)		(0.020)	(0.432)	(2.523)	(0.036)
Phoenix, AZ	8.78 **		0.71 **	8.10 **	20.74 **	0.67 **
	(0.225)		(0.048)	(0.454)	(8.251)	(0.058)
Sacramento, CA	8.20 **		0.77 **	8.41 **	1.04	0.56 **
	(0.220)		(0.026)	(0.172)	(1.145)	(0.065)
San Diego, CA	10.17 **		0.93 **	11.67 **	4.32 **	0.96 **
	(0.878)		(0.020)	(3.411)	(1.256)	(0.038)
San Francisco, CA	8.50 **		0.92 **	7.01 **	15.92 **	0.84 **
	(1.696)		(0.027)	(0.859)	(7.977)	(0.035)
Seattle, WA	8.24 **		0.82 **	8.56 **	-2.99 **	0.51 **
	(0.250)		(0.023)	(0.121)	(0.860)	(0.045)
Washington, DC	8.47 **		0.92 **	7.58 **	9.61 *	0.84 **
	(1.722)		(0.045)	(0.928)	(5.585)	(0.062)

Notes : [a]Standard errors are in paranthesis below the coefficients. One and two asterisks indicate statistical significance at the 10% and 5% levels, respectively

Table 2. Exploring Capitalization Rate Components: Hypothesis Testing [a,b]

Tests	Null Hypotheses	Test-statistics: Model I-1	Test-statistics: Model I-2
Local Fixed Effects	H_{01}: $\alpha_j = 0$, for all j	$\chi^2(17)=139360^{**}$	$\chi^2(17)=943734^{**}$
	H_{02}: $\alpha_j = \alpha_k$, for all $j \neq k$	$\chi^2(16)=592^{**}$	$\chi^2(16)=2682^{**}$
Persistence	H_{03}: $\rho_j = 0$, for all j	$\chi^2(17)=282045^{**}$	$\chi^2(17)=101719^{**}$
	H_{04}: $\rho_j = \rho_k$, for all $j \neq k$	$\chi^2(16)=3539^{**}$	$\chi^2(16)= 84011^{**}$
Time-variant Effects	H_{05}: $\beta = 0$	$\chi^2(1)=113^{**}$	NA
	H_{06}: $\beta_j = 0$, for all j	NA	$\chi^2(17)=5163^{**}$
	H_{07}: $\beta_j = \beta_k$, for all $j \neq k$	NA	$\chi^2(16)=5147^{**}$

Notes:[a] Two asterisks next to the statistic indicates that the null hypothesis can be rejected at the 5% significance level
[b] NA stands for not applicable

4.2.3. Time-Variant Effects

Focusing on Model I-1, the rejection of null hypothesis H_{05}*:* $\beta = 0$ suggests that a common national trend in capitalization rates is statistically discernible. Turning now to Model I-2, the rejection of null hypothesis H_{06} *:* $\beta_j=\beta_k$, for all $j \neq k$, suggests that time trends do differ across local markets, thus lending considerable support to Model I-2's specification. The inequality of the β_j coefficients points, perhaps, to the influence of local real estate market idiosyncrasies that may elicit differential asset-market behavior. A market's sectoral mix, for example, may be responsible for differential local responses to common macroeconomic shocks and, as such, for distinct real estate market trends. Such trends may, in turn, be responsible for intermarket differences in the time paths of risk perceptions or income-growth expectations.

5. Empirical Analysis II: Exploring the Determinants of the Office Capitalization Rate

Given the statistical importance of local fixed and time-variant effects, this section focuses on the second set of questions posed in this research, centered on the specific factors that may determine them. Discussed below are the models used, the variables they utilize, and their estimation results.

5.1. Base Model

Building on (7) and the discussion in section 2, the base model used to explore the determinants of the various capitalization-rate components is formulated. This is depicted, in general form, by (9):

$$C_{jt} = a_j + F(L_j, M_{jt}, X_t) + r_j e_{jt-1} + u_{jt} \quad (9)$$

where a_j denotes a constant, which is treated differently depending on the specific model formulation used; L_j denotes time-invariant traits of local office markets; M_{jt} represent time-variant features of local office markets; X_t represent time-variant features of the national capital market; r_j denotes the serial correlation coefficient, treated differently depending on the specific model used; and *j, t* denote the metropolitan location and time index, respectively.

Presented in Table 3 are more detailed definitions, expected signs, and data sources for all variables used to represent the effects depicted by (9). A brief discussion of them follows.

5.1.1. Local-Fixed Office-Market Influences

Time-invariant, locational influences on the capitalization rate include features that are not virtually fixed but only slowly change through time (see Section 2). These include *CBDS*, *DIVERS*, *PGOV*, and *SIZE*. *CBDS* measures the 1990 share of office inventory (occupied stock) concentrated in each metropolitan area's traditional business district, as defined spatially by CB Commercial/Torto Wheaton Research. This variable is intended to capture the degree of decentralization or spatial heterogeneity of office space within metropolitan areas.[16] A higher CBD share may reflect more compact or less spatially heterogeneous office markets, which may be characterized by lower information or search costs, lower risks and, hence, lower capitalization rates. The expected sign for *CBDS* is therefore negative.[17]

Intended to measure the degree of sectoral richness of the office-space market's demand base, *DIVERS* reflects the *H*-Index or Shannon-Wiener Index, H_j, normalized by the maximum possible sectoral diversity, H_{max}. Referred to sometimes as the Shannon *evenness* index, this index of sectoral diversity was calculated as in (10), where E_{ij} reflects market *j*'s ratio of employment in detailed FIRE and Service SIC *i (=1,2,...l)* over that market's total office employment and *ln(l)* reflects maximum possible diversity:[18]

$$DIVERS_j = H_j/H_{max} = -\sum_{i=1}^{l} (E_{ij}) \ln (E_{ij}) / \ln(l) \quad (10)$$

Given that a more diversified office demand base may imply more stability, lower risk, and, hence, a lower capitalization rate, the expected sign for *DIVERS* is negative.

PGOV measures the ratio of government over traditional office tenants (FIRE and Services), thus exemplifying a more specific measure of tenant mix. Such an indicator may be relevant for two interrelated reasons. First, government tenants may hold longer term leases and, as such, may be perceived as sources of less risky rental income streams. Second, although markets within local economies that are dependent in part on the government sector have not escaped recessionary impacts (such as Washington, DC), they may still be perceived as more stable and, hence, less risky. *PGOV*, therefore, is expected to exhibit a negative sign.

Lastly, *SIZE*, representing office-market size as proxied by occupied stock, is intended to also capture perceptions of liquidity risk. Investments in markets with a larger number of buyers, for

Table 3. Exploring the Determinants of the Office Capitalization Rate: Variable Proxies and Expected Effects

Variable Group	Variable Name	Variable Definition	Data Source	Expected Sign
Dependent Variable	*CAP*	Office capitalization rate, 1985-1995	National Real Estate Index	NA[a]
Independent Variables[b]				
Time-invariant local office market traits (*L*)	*CBDS*	CBD office inventory share, 1990	CB Commercial/ Torto Wheaton Research	(-)
	DIVERS	Office tenant demand diversity, representing the normalized Shannon-Wiener Index, 1990	Bureau of Economic Analysis (BEA)	(-)
	PGOV	Government tenant mix, representing the ratio of government over FIRE and Service office tenants, 1990	CB Commercial/ Torto Wheaton Research	(-)
	SIZE	Metropolitan occupied office stock, 1990	CB Commercial/ Torto Wheaton Research	(+/-)
Time-variant local office market influences (*M*)	*INVAC*	Lagged inverted ratio of office vacant stock over net absorption (lag=1 semester), 1985-1995	CB Commercial/ Torto Wheaton Research	(-)
	GROST	Office employment growth stability, measured by the mean growth rate during the previous 5 semesters over the standard deviation of growth rates, 1985-1995	CB Commercial/ Torto Wheaton Research	(-)
	DRENT	Lagged inflation-adjusted office rent growth (lag=1 semester), 1985-1995	CB Commercial/ Torto Wheaton Research	(-)
	ABS	Net absorption of office space, averaged over the previous 5 semesters, 1985-1995	CB Commercial/ Torto Wheaton Research	(-)
Time-variant national capital market influences (*X*)	*INFL*	Lagged expected inflation, measured by the difference between the long- and the short-term Treasury rates (lag=1 semester),1985-1995	Federal Reserve Bulletin	(+/-)
	SRET	Lagged stock returns (lag=1 semester), 1985-1995	Federal Reserve Bulletin	(+)

Notes

[a] NA stands for not applicable

[b] All time-variant explanatory variables assume semiannual values, just as the capitalization rate does

example, may be perceived as more liquid and, as such, may be associated with a lower capitalization rate. Larger markets, however, may be expected to appreciate at a slower rate than smaller markets and, as such, may command a higher capitalization rate. The sign of *SIZE*, then, may be suggestive of the extent to which one or the other of the aforementioned hypothesized effects prevails.

5.1.2. Time-Variant Local Office-Market Influences

Office-space market variables influencing the capitalization rate through their impacts on the discount rate are proxied by *ABS*, *INVAC*, and *GROST*. Representing the level of average absorption over the past five semesters, *ABS* is intended to capture perceptions of leasing risk. The effect of *ABS* is expected to be negative, as institutional investors may more easily lease vacant space in markets with higher absorption levels.

INVAC is a function of a normalized (lagged) vacancy index, intended to capture the softness of the office-space market as depicted by the ratio of short-run available supply (vacant stock) and short-run (ex-post) demand (net office absorption). This normalized vacancy index enters the model in an inverse form, as net office absorption assumes in some instances zero values. The expected sign for *INVAC* is negative, as the higher the vacancy rate compared to the absorption rate, the higher the risk of future decreases in rents and asset values.

Reflecting the perceived stability of the local office market, *GROST* represents the inverse ratio of the standard deviation of office employmen growth rates during the past five semesters over the average employment growth rate during this period. Representing an inverse coefficient of variation, this variable has been defined as such, due to the near-zero values mean office employment growth rates assume in some semesters. The expected sign for *GROST* is negative, as more stable and less volatile markets may be perceived as less risky.

Finally, real estate market influences on income-growth expectations and, hence, capitalization rates, are proxied by the lagged inflation-adjusted rental change *DRENT*, which is expected to exhibit a negative sign. Assuming myopic expectations, higher past increases in rents may shape investor expectations for higher income growth and thus motivate them to accept a lower return. The (inverted) vacancy index, *INVAC*, may also reflect differential expectations for rental growth across metropolitan office markets. Assuming that, all else equal, lower vacancy rates may give rise to higher income-growth expectations, *INVAC* is again expected to exhibit a negative sign.

5.1.3. Time-Variant National Capital-Market Influences

Capital market influences on the capitalization rate are proxied by (lagged) stock returns, *SRET*, and (lagged) expected inflation, *INFL*. Assuming a reasonably integrated capital market, *SRET* may reflect the opportunity cost of investment capital and, as such, is expected to exhibit a positive sign. Simply stated, real estate may compete for a share of total investment funds with stocks (among other alternative investment vehicles). Higher stock returns would induce investors to shift capital out of the real estate market and into the stock market. This would, in turn, render the real estate asset market less competitive, thereby allowing higher returns.[19]

Expected inflation, *INFL*, measured by the spread between the short-term and long-term Treasury rates, may exert conflicting influences on the office capitalization rate. If expected inflation is used by investors as a proxy for the potential erosion of purchasing power, a positive influence on the capitalization rate should be expected for investors would require a higher return to compensate for this risk. In contrast, if expected inflation is used by investors as a proxy for future capital appreciation, a negative influence on the capitalization rate should be expected, as investors would be willing to accept a lower return in exchange for a higher asset-appreciation potential. To the extent income growth or asset-value appreciation is sufficiently captured by the real estate market variables included in the empirical model, a positive effect for *INFL* should be expected.

5.2. Estimated Model Variants

The analysis relies on the empirical estimation of three model variants, all consistent with the general model structure in (9) and referred to as Model II-1, Model II-2, and Model II-3. All models account for serially correlated and heteroskedastic errors but differ in the treatment of local-fixed effects, spatial variability of r, and degree of cross-section correlation of metropolitan-specific errors.

Model II-1, in particular, represents a Fixed-Effects Model (FEM). It incorporates assumptions of cross-section heterogeneity due to local-fixed effects, just as Model I-1 does. These are accounted for by the inclusion in (9) of metropolitan dummies, so that $a_j=0$, for all j; $L_j = MSA_j$. Model II-1 does account for autocorrelated error structures but, unlike Model I-1, restricts r_j to be equal across markets, such that $r_j=r_k$, for all j ¹ k. Lastly, this model variant does not account for cross-section correlation and, most importantly, does not allow testing for the effects of specific time-invariant influences.[20]

Model II-2 represents a Random-Effects Model (REM). Under the most restrictive REM specification, parameter heterogeneity is assumed to stem from stochastic variations rather than parametric shifts of the regression function. However, given the focus of this research on underlying determinants of metropolitan differences in capitalization rates, the estimated REM variant accounts for local-fixed traits in the set of regressors, so that $L_j=L(CBDS_j, DIVERS_j, PGOV_j, SIZE_j)$. *Omitted* metropolitan effects, a_j, are assumed to be incorporated in the model's random error term. Autocorrelated error structures are accounted for, as in (9), but similarly to Model II-1, r_j is restricted to be equal across markets, such that $r_j=r_k$, for all j ¹ k. Cross-section correlation is not accounted for. Lastly, it is noted that, unlike Model II-1, this model produces consistent (and efficient) estimates only if the testable assumption that the omitted metropolitan effects are uncorrelated with the error term is valid.

Lastly, Model II-3, occasionally referred to as the Time Series-Cross Section Model (TSCS), is derived from the application of *group-specific* autocorrelated, heteroskedastic, and cross-sectionally correlated error structures to the classical regression model (CRM), as in Kmenta (1986). In such a model, metropolitan dummies are neither included as fixed terms, as in Model II-1, nor assumed to be an identifiable part of the error term, as in Model II-2. However, the model variant used in this analysis does provide for the incorporation of time-invariant local-office market traits, as in Model II-2 (see Greene, 1993). It should be emphasized that, in contrast to Model II-1and Model II-2, Model II-3 does allow for a spatially differentiated r and a cross-section correlation correction.[21]

5.3. Estimation Results

Table 4 presents the estimation results for Models II-1, II-2, and II-3, along with estimated group effects, while figure 3 demonstrates the relative importance of Model II-3's individual regressors. *All* empirical results are presented in Table 4, first, for comparison purposes and, second, because there can be no indications of the clear superiority of one model over another, especially when the number of cross-section units is not substantially smaller than the number of time-series observations (Hsiao, 1996). Model II-1 and Model II-2 were tested for the equality of the FEM and REM estimators using the Hausman test ($\chi^2(6) = 4.00$); although the latter does lend support to the REM specification, the estimation results of both models are very similar. Model II-3 was also tested for several panel data biases, with such tests justifying that model's error structure.[22] Again, however, despite differences in their underlying structure, Models II-1, II-2, and II-3 yield similar results.

5.3.1. Office-Market and Capital-Market Influences

The estimation results indicate that local real estate and capital market factors all appear to exert substantial influences on the office capitalization rate. Focusing first on the role of fixed metropolitan office-market effects, the metropolitan dummy coefficients of Model II-1 are both *individually* and *jointly* significant at high levels of confidence.[23] The statistical significance of the dummy variable coefficients indicates that after controlling for all other factors accounted for by the model, capitalization rates still exhibit statistically significant fixed differences across markets. The significance of such local-fixed effects corroborates recent findings by Jud and Winkler (1995).

The prevalence of local-fixed differentials in capitalization rates may mirror (in part) differentials in fixed risk premia stemming from such local office-market features as location heterogeneity, sectoral diversity, and idiosyncratic tenant mix. As Model II-2 and Model II-3 show, such features seem to matter. *CBDS* exhibits a statistically significant negative effect that is consistent with the hypothesis that more compact office markets are less spatially heterogeneous, thus allowing for lower information and search costs and perceptions of lower risk on the part of investors. *DIVERS* exhibits a negative sign as well, thus lending support to the proposition that office markets with a more diverse employment base may be considered less risky, thereby leading to a lower capitalization rate. *PGOV* also exhibits a negative sign, thus supporting the proposition that office markets with more sizable government tenant segments may be deemed more stable and, hence, less risky for investment purposes. Lastly, *SIZE* neither exhibits a consistent sign nor appears to be statistically significant in any model, a result that does not seem to stem from multicollinearity. This should not necessarily suggest that *SIZE* is inconsequential; its effects on risk perceptions and income-growth expectations may simply induce capitalization-rate adjustments that nearly offset each other.

Turning now to the role of time-variant *real estate market variables*, the negative sign of *ABS* and *INVAC* may mirror lower risk premia or upward adjustments in income-growth expectations in light of higher net absorption levels and lower vacancy rates. Similarly, the sign and statistical significance of *GROST* demonstrates, perhaps, risk premia requirements by real estate investors when buying assets in less stable, more volatile markets. Lastly, the significant negative effect of *DRENT* may signify upward adjustments in investor income-growth expectations in office markets or time periods that are characterized by higher past increases in inflation-adjusted office rents.

Table 4. Exploring the Determinants of the Office Capitalization Rates: Estimation Results [a]
(Dependent Variable: Office Capitalization Rate)

Variables [b]	Model II-1 Fixed Effects Model (FEM)	Model II-2 Random Effects Model (REM)	Model II-3 Time-Series Cross-Section Model (TSCS)
Time-invariant local office market traits (L)			
CBDS	-	-1.004 *	-1.182 **
		(0.549)	(0.175)
DIVERS	-	-18.509 *	-18.706 **
		(10.554)	(1.444)
PGOV	-	-0.170 +	-0.174 **
		(0.105)	(0.013)
SIZE	-	-0.034	0.023
		(0.284)	(0.057)
Time-variant office market influences (M)			
ABS	-0.167 **	-0.169 **	-0.209 **
	(0.038)	(0.033)	(0.011)
GROST	-0.020 **	-0.019 **	-0.014 **
	(0.008)	(0.007)	(0.003)
INVAC	-0.313 **	-0.313 **	-0.303 **
	(0.139)	(0.121)	(0.040)
DRENT	-0.011 *	-0.011 **	-0.007 **
	(0.006)	(0.005)	(0.002)
Time-variant national capital market influences (X)			
INFL	0.110 **	0.110 **	0.065 **
	(0.032)	(0.027)	(0.011)
SRET	0.208 *	0.208 **	0.108 *
	(0.121)	(0.105)	(0.045)
Constant	-	95.521 **	96.449 **
		(47.654)	(6.876)
Rho	*0.812*	*0.812*	*0.925* [c]
R-squared	*0.35*	*0,25*	*0.75* [d]
Log-Likelihood	*20.12*	NA	*172.92*
Standardized Group Coefficients:			
Time-invariant local effects	*0.68*	*0.52*	*0.56*
Time-variant office market effects	*0.26*	*0.26*	*0.31*
Time-variant capital market effects	*0.08*	*0.08*	*0.05*

Notes:

[a] Standard errors are in parenthesis below the coefficients. One and two asterisks indicate statistical significance at the 10% and 5% levels, respectively. A + indicates statistical significance very close to the 10% level.

[b] See Table 3 for variable explanations. Variables that do not take zero, near-zero, or negative values in any of the analysis years (such as CBDS, DIVERS, SIZE, and INFL) are expressed in logarithms to account for the nonlinearities embedded in (4).

[c] Reported here is the average of metropolitan-specific serial correlation estimates, ρ_i.

[d] Buse R-squared statistics are reported. See Judge *et al.* (1985) for details. The Buse R-squared in the absence of cross-sectional correlation correction is comparable in magnitude to those reported for the FEM and REM.

Focusing on the role of *capital-market variables*, the significant positive sign of *INFL* indicates that, in light of higher expected inflation, real estate investors may upwardly adjust their discount rate, after they account for past real rental growth. Consistent with Ambrose and Nourse's (1993) results, such finding implies that expected inflation may differ from the realized inflation embedded in past rental growth, thus signaling purchasing-power risk. Finally, the positive sign of *SRET* may reflect upward discount-rate adjustments in light of higher returns in competing investment vehicles. This finding is consistent with results of existing studies pointing to a significant link between the national capitalization rate and the stock market (Evans, 1990; Jud and Winkler, 1995) and does not necessarily contradict empirical findings indicating the absence of association between *ex-post realized* real estate and stock market returns (e.g., Liu, Hartzell, Greig, and Grissom, 1990).[24] A potential explanation lies in the argument that *ex-post* realized returns do not necessarily reflect *ex-ante* required returns and, hence, the capitalization rate required by the investor at the time of the purchase. These two types of return could be entirely different if actual rent growth deviates significantly from what is actually expected by the investor at the time of the purchase. Lending support to this argument are Wheaton and Torto's (1994) empirical findings, suggesting that appraised values may have been systematically based on erroneous future income-growth expectations.

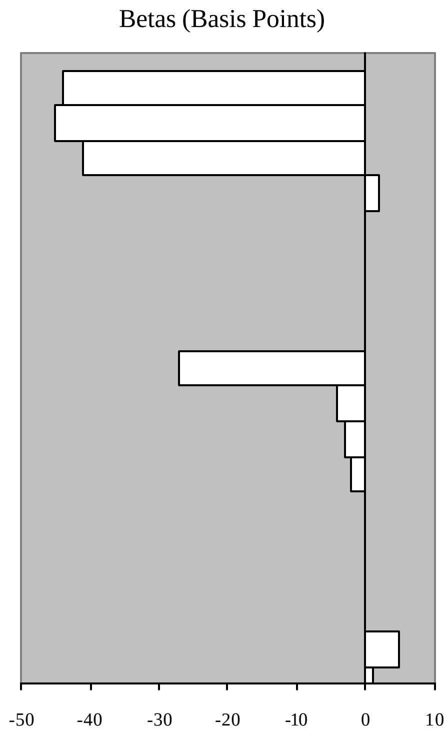
5.3.2. Relative Importance of Local Real Estate and National Capital Market Factors

Given the use of GLS estimation across models, the irrelevance of the traditional R-squared, and imprecision of proposed alternatives, the relative importance of variable groups was not assessed using R-squared measures (Judge *et al.*, 1985; Greene, 1993). Standardized group coefficients, measuring the effect of a variable group while holding constant the effects of other groups, were instead computed based on the estimated regression and intragroup correlation coefficients (see Heise, 1981). The latter indicate that time-invariant effects, presumably mirroring risk premia stemming from local-market heterogeneity or other local-market characteristics, contribute the most to the explanation of variations in the capitalization-rate series examined. Focusing on Model II-2 and Model II-3 that explicitly include local time-invariant traits, such conclusion is evidenced in those variables' standardized group coefficient of 0.52 and 0.56, respectively. Time-variant real estate market effects, with estimated group coefficients of 0.26 and 0.31, follow with the second-highest contribution. Lastly, as indicated by the estimated group coefficient of 0.08 and 0.05, national capital-market variables contribute the least to the explanation of variations in metropolitan-specific office capitalization rates. Notably, such small contribution does not seem to arise out of the lack of variability in capital-market factors during the period of analysis.[25]

Figure 3 provides insights into individual variable effects based on Model II-3's estimation results. To facilitate direct comparison of these effects, changes in the capitalization rate induced by a one standard deviation increase in each regressor are presented. As indicated by figure 3, among the local-fixed influences considered, a one standard deviation increase in *DIVERS* results in a 45 basis points reduction in the office capitalization rate. This is a stronger response than the 44 and 41 basis points decrease in the office capitalization rate stemming from one standard deviation increase in *CBDS* and *PGOV*, respectively. The effect of market size is much smaller, as one standard deviation increase in *SIZE* only causes a 2 basis point increase in the office capitalization rate.

Turning to time-variant real estate market effects, the effect of *ABS* clearly dominates, as one standard deviation increase in this indicator results in a 27 basis points decrease in the office

Figure 3. Relative Importance of the Determinants of the Office Capitalization Rates
(Based on the TSCS model)



Time-Invariant Local Office Market Traits *(L)*	Standard Deviation	Betas (Basis Points)
CBDS	1.43%	-44
DIVERS	1.02	-45
PGOV	2.28%	-41
SIZE	1,959	2
Time-Variant Local Office Market Influences *(M)*		
ABS	1,240	-27
GROST	2.65	-4
INVAC	0.11	-3
DRENT	2.73%	-2
Time-Variant National Capital Market Influences *(X)*		
INFL	2.13%	5
SRET	12.07%	1

capitalization rate. By comparison, the effects of *GROST*, *INVAC*, and *DRENT* are appreciably weaker, as one standard deviation increase in these variables yields a 4, 3, and 2 basis point decrease in the capitalization rate, respectively. Focusing now on time-variant capital-market effects, one standard deviation increase in *INFL* and *SRET* result in a 5 and 1 basis point increase in the office capitalization rate. Once again, these results reinforce the conclusion that national capital-market effects are substantially weaker than the effects of local office markets.

6. Conclusion

This study differs from the majority of existing capitalization-rate studies, as it exclusively focuses on metropolitan *office* asset markets, utilizes transaction-based capitalization-rate data that have not yet been adequately mined, and, most importantly, explores in an integrated fashion both the *components* and the *determinants* of the office capitalization rate.

Returning to the two sets of questions posed in the introduction sets the stage for highlighting the paper's main research findings which, taken together, underscore the links between local space and asset markets. Starting with the first set of questions, centered on *components*, these findings suggest that the office capitalization rate incorporates both a local-fixed component and a time-variant component that exhibits *differential* persistence across markets. Turning now to the second set of questions, focusing on *determinants*, this research suggests that these components are shaped to a substantial extent by local office-market traits, including fixed traits (such as location heterogeneity, the diversity of the local office employment base, and tenant mix) or time-variant features (such as the level of office space absorption, normalized vacancy rates, office employment growth stability, and past rates of rental-income growth). These features evidently complement the effect of such national capital-market indicators as expected inflation and stock returns. Notably, local office-market influences are substantially stronger than national capital-market influences.

Overall, then, despite evidence for some degree of market integration, these findings are c*onsistent* with arguments that the office asset market is segmented to a significant extent along metropolitan boundaries and that metropolitan office asset markets are inefficient in varying degrees.

Several implications for valuation and investment practices stem from such findings. Focusing on valuation aspects, the importance of local effects does lend support to appraisal practices involving the use of *local* (as opposed to national) capitalization rates in asset-price estimates based on the direct-income capitalization approach. At the same time, however, the presence of serial correlation in area-specific time trends indicates that the use of *prevailing* as opposed to (implicit) equilibrium capitalization rates may induce biases in property valuation.

Focusing on investment aspects, the sluggishness of capitalization-rate adjustments suggests that impending changes in capitalization rates across markets may be forecastable, thereby providing a basis for evaluating the merits of short-term investment strategies. Furthermore, the presence of considerable local-fixed differentials in capitalization rates implies that, all else equal, investors willing to assume a higher risk may be able to secure higher income returns by investing in stabilized properties located within markets with smaller absorption levels, less diversified tenant demand base or more decentralized office sectors. The importance of local time-variant factors implies that real estate investors may be able to diversify some of the capitalization-rate risk by spreading investments across office markets that exhibit substantial behavioral differences in terms of the factors identified in this analysis. Lastly, given that (common) stocks are driven by the national market to a significant extent (see Sharpe 1985), the inclusion of asset classes driven by local factors, such as office real estate, along with stocks in mixed-asset portfolios may provide some diversification benefits.

This article has by no means exhausted the analysis of the role that local markets for real estate space play in influencing asset-market behavior. Further research could address several related issues. First, it needs to look at the extent to which the relative magnitude of the effect of local real estate versus national capital markets varies across property types, metropolitan areas, and different time periods. Time series that are sufficiently longer than the series used in this article are required to address such questions. Second, the extent to which capitalization rates vary across submarkets *within* metropolitan areas needs to be examined. It is especially interesting to explore changes in the relevance of intraurban location factors in light of the continuing dispersion of economic activities within modern metropolises (Gordon and Richardson 1996; Sivitanidou 1997). Third, the source of sluggish capitalization-rate adjustments across and within metropolitan markets needs to be further investigated. To this end, asset prices need to be modeled and the extent to which they respond to changes in market fundamentals analyzed.

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Notes

1. A more detailed discussion of the observed differentials is provided in section 3.
2. Focusing on capitalization rates across broadly-defined regional markets, Ambrose and Nourse (1993) have not uncovered any fixed effects, while Jud and Winkler (1995), measuring fixed effects by area-specific growth rates, have suggested that they matter. Studies examining *real estate returns* in nonresidential markets were, by and large, more successful in uncovering the importance of fixed effects. Dokko, Edelstein, Homer and Urdang (1991), for example, suggested that fixed effects on nonresidential returns across states are not trivial, a conclusion that points toward the spatial segmentation of nonresidential asset markets. Such a conclusion corroborates earlier research findings by Grissom, Hartzell, and Liu (1987), who examined industrial return differentials using the arbitrage pricing modeling framework.
3. Case and Shiller (1991) have already established the existence of persistence in residential price changes and excess returns in the market for single-family housing. Dokko, Edelstein, Homer and Urdang (1991) have similarly traced sluggish adjustments in nonresidential returns. In examining capitalization rates in the context of the *national*, broadly defined nonresidential market, Nourse (1987) detected autocorrelated residuals, while Jud and Winkler (1995), alluding to the statistical significance of lagged capital market variables in affecting capitalization-rate movements concluded that commercial asset markets are inefficient.
4. Within the context of this short-run framework, if prevailing prices are above P^e_{jt}, investors would earn a return that is below the minimum required, and suppliers would be realizing excess profits. This would induce investor exit and supplier entry, thereby driving prices down to the level that provides for the minimum required rate of return. If prevailing prices are below P^e_{jt}, investors would earn an income return above the minimum required, while suppliers would be experiencing losses. This would induce investor entry and supplier exit, thereby driving prices up to the level that again provides for the minimum required rate of return. In a long-run equilibrium framework, however, office rents, asset prices, and the office stock must all adjust to restore equilibrium. Asset-price adjustments may lead to new construction, changes in the office stock, and adjustments in office rents. A framework accounting for joint equilibrium in the asset and space markets is required to examine such long-run adjustments. For discussions of long-run links between space and asset markets, see Fisher (1992) and DiPasquale and Wheaton (1996).
5. Note that this model does not explicitly account for potential debt financing and taxes, as relevant data for the individual transactions included in each metropolitan area's sample analyzed in this article are not available. For analyses accounring for debt financing and taxes, see Nourse (1987) and Ambrose and Nourse (1993).
6. See Clark (1996) for a present-value model used to address the question of whether investor expectations for price appreciation 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, $C=d-g$ (also see Brueggeman and Fisher, 1993).
7. In a long-run analysis framework, regulatory constraints that may hinder the supply of new structures in different degrees (depending on their rigidity) could be advanced as an additional factor explaining different degrees of inefficiencies across markets.
8. Fisher (1992) suggests that unsystematic real estate risk is determined in the space market while risk premia associated with factors that vary systematically are determined in the capital market.
9. In contrast to variables that may be subject to pronounced temporal fluctuations, "slowly changing variables" are those that are subject to small (largely monotonic) changes through a time period of 10 years (as is the time period studied). Although it would be desirable to account for such small changes, time-series data for these variables are not readily available.

10. The prevalence of faster price appreciation and income growth rates in smaller, less amenable office markets may also be consistent with long-run spatial-equilibrium theory. As Gyourko and Voith (1992) argue, such appreciation-rate differentials may be necessary in order to maintain price differentials between smaller, less amenable and larger, more amenable markets within the bounds implied by differences in those markets' amenity packages. Put differently, equal appreciation rates across markets would imply increasingly divergent rent and asset-price levels that cannot be sustained. Suggestive evidence provided by the same authors does support the proposition that higher-price residential markets (which, all else equal are more amenable and larger) appreciate at a lower rate than lower-price residential markets (which are less amenable and smaller). Following a similar rationale, price appreciation rates in less decentralized markets may be expected to be lower than in more decentralized markets (see DiPasquale and Wheaton, 1996).
11. Wheaton and Torto (1989) suggest that appraised values may be systematically biased as they appear to incorporate consistently erroneous expectations regarding future income growth. Geltner (1989, 1991) discusses extensively biases associated with the smoothing of appraisal-based real estate returns. Using an assumed appraisal process, Geltner (1989) suggests that the use of appraised values understates the true volatility of real estate returns and overstates risk-adjusted returns. Wang, Erickson, Gaw, and Chan (1995), among others, question whether the appraisal process assumed by Geltner resembles the actual process used by appraisers. Quan and Quigley (1991) suggest that under alternative assumptions, higher variance in appraisal-based returns can arise.
12. More specifically, the equilibrium capitalization rate can be computed based on the estimated coefficients of (8), as $C^e_{jt} = a_j L_j + b_j F(t)$. The deviation of prevailing capitalization rates from this equilibrium rate can be computed as the difference between the prevailing and the equilibrium capitalization rate, captured by the error term in (8).
13. Given that the preferred empirical specification involves spatially variable persistence, more elaborate specifications of the time-trend variable, such as an *n*-order polynomial (see, for example, Grenadier, 1995), would introduce an excessive number of parameters to be estimated and would thus result in efficiency losses. Thus only simple specifications of the time trend were attempted and tested against each other using J-tests (see Greene, 1993). Preliminary models also involved breakpoints in the time trend to detect possible post-recession changes in investor behavior. The estimation results yielded no evidence for such a "structural break," but it is acknowledged that the time series available for this research is not sufficiently long for a test of this nature.
14. Yet, it is worth noting that estimates produced with and without cross-section correlation not only support the same conclusions in terms of the strength of local-fixed and time-variant effects but, with the exception of those pertaining to the *neighboring* and more economically integrated Los Angeles and Orange markets, are also similar in magnitude.
15. The presence of serial correlation is not necessarily indicative of inefficient markets. In principle, as noted by, among others, Kennedy (1992), such serial correlation may reflect the effect of data smoothing or model misspecification arising, for example, from omitted relevant independent variables that are autocorrelated or incorrect functional form. If omitted variables affect the equation parameters, then a structural change could be interpreted as autocorrelation as well. Data smoothing is a non-issue, and tests for structural change have been conducted (see note 13). The omission of a relevant variable proxying capital availability from the models discussed in section 5, however, might have contributed to biased autocorrelation estimates.
16. Other surrogates of spatial structure used in preliminary models include average commuting time from the 1990 Census of Population and Housing and number of office districts, as defined by CB Commercial/Torto Wheaton Research. By and large, these variables have not performed as well as *CBDS*.
17. Note that arguments for a positive sign for CBDS can be advanced if a long-run analysis framework is adopted. In the longer run, more decentralized metropolitan areas may experience higher rates of asset-price appreciation, thus leading to a lower required rate of return and, hence, a lower prevailing capitalization rate (see the discussion in DiPasquale and Wheaton, 1996).
18. The estimation of preliminary models employing alternative specifications of this index that accounted for detailed SICs across *all* economic sectors yielded considerably less robust results.
19. The risk-free rate of return is also thought to reflect the opportunity cost of investment capital, a proposition that Jud and Winkler (1995), among others, demonstrated by combining the Weighted Average Cost of Capital (WACC) model with the Capital Asset Pricing Model (CAPM). Thus the risk-free Treasury rate was also used in preliminary models as a proxy of the opportunity cost of investment capital. However, this

variable performed much worse than stock returns and was consequently excluded from the final empirical model specification.

20. The model yields consistent estimates of identifiable parameters regardless of whether metropolitan effects are correlated with the included regressors or not. Note, however, that if the metropolitan effects are correlated with the regressors, the FEM estimates are not efficient (see Hsiao, 1996).

21. The Seemingly Unrelated Regression (SUR) technique has not been used in estimating any of these models. In addition to the provision for cross-sectionally correlated metropolitan-specific errors, SUR would present advantages over the other formulations only if variable coefficients across cross-section units were allowed. However, this is not possible given the limited time series and the number of explanatory variables employed in this analysis. Moreover, employing the SUR specification with the restriction of equal coefficients across cross-section units would yield the same results as the TSCS model with one regression constant. Most importantly, a SUR formulation cannot be used to test for the effects of time-invariant local office-market traits that are an important part of this analysis and that can be tested under the REM and TSCS model formulations. See Greene (1993, chs. 16-17)) for an extensive discussion of alternative panel data formulations.

22. The tests and appropriate correction procedures that have been applied to Model II-3 include: (1) an LM test for the presence of groupwise heteroskedasticity, yielding $c^2(16)=82.30$, which suggests that the null hypothesis of homoskedastic disturbances be rejected at the 0.01 significance level; (2) an LM test for the presence of cross-section correlation, yielding $c^2(16)=297.73$, which suggests that the null hypothesis of no cross-section correlation be rejected at the 0.01 level of significance; and (3) tests for the significance of metropolitan-specific autocorrelation estimates, r_j, involving the statistic $(m-1)r_j^2/(1-r_j^2)$, where m is the length of time series. Following a c^2 distribution with 1 degree of freedom, these statistics point to the significance of most autocorrelation estimates at the 0.01 significance level.

23. The Wald test of the joint significance of the metropolitan dummy coefficients yields $c^2(16) = 451.16$, suggesting that the null hypothesis can be rejected at the 0.01 significance level.

24. However, in Evans (1990), such relationship is captured by the stock earning-price ratio, not stock returns. The latter variable performed appreciably better in this study.

25. More specifically, if expected inflation or stock returns do not vary during the sample period, their effect on capitalization rates could be captured by the constant term. Inspection of the data does not lend support to this argument, as both variables exhibit nonnegligible variations during the analysis period. In particular, expected inflation ranges from 0.26% to 3.70%, with a standard deviation of 106 basis points, while stock returns range from -7.10% to 35.43%, with a standard deviation of 1206 basis points.

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