Real Estate Income and Value Cycles: A Model of Market Dynamics

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***Abstract.* We develop a theoretical real estate cycles model linking economic fundamentals to real estate income and value. We estimate and test an econometric model specification, based on the theoretical model, using MSA level data for twenty office markets in the United States. Our major conclusion is that cities that exhibit seemingly different cyclical office market behavior may be statistically characterized by our three-parameter econometric specification. The parameters are MSA-specific amplitude, through the CAP rate, cycle duration (peak-to-peak), via the rate of partial adjustments to changing expectations about stabilized NOI and the market trend.**

Introduction

There is growing recognition among academics and practitioners that volatile macro, regional and local economic factors exert important influences on the cyclic behavior of real estate markets. Although the economy itself may have changed, real estate cycles remain. The most recent example of the commercial real estate cycle occurred in the late 1980s and early 1990s. The unusual and severely distressed state of the commercial real estate markets in the United States during this period has been followed with an upturn of these markets in the mid 1990s.

Commercial real estate markets across cities were not uniformly depressed from the late 1980s to the early 1990s, suggesting that cyclical behavior in various geographic real estate markets is asynchronous. For example, in 1987, data from Coldwell Banker (see Exhibit 1) show downtown office buildings in Denver and Houston had vacancy rates greater than 30% and 20%, respectively. Simultaneously, the vacancy rates in Philadelphia and Boston were less than 10%, while those in Los Angeles and San Francisco were approximately 15%. The same data suggest that, by early 1995, Denver vacancies had declined to nearly 10%, Houston's vacancy rates had stabilized and hovered at around 20%, and, Philadelphia and Boston vacancy rates had cycled up and then down to 15% and 10%, respectively. Concurrently, the office markets vacancy rate in Los Angeles was increasing and peaked at nearly 20%, while San Francisco's vacancy rate dropped to a low of 11%.[1]

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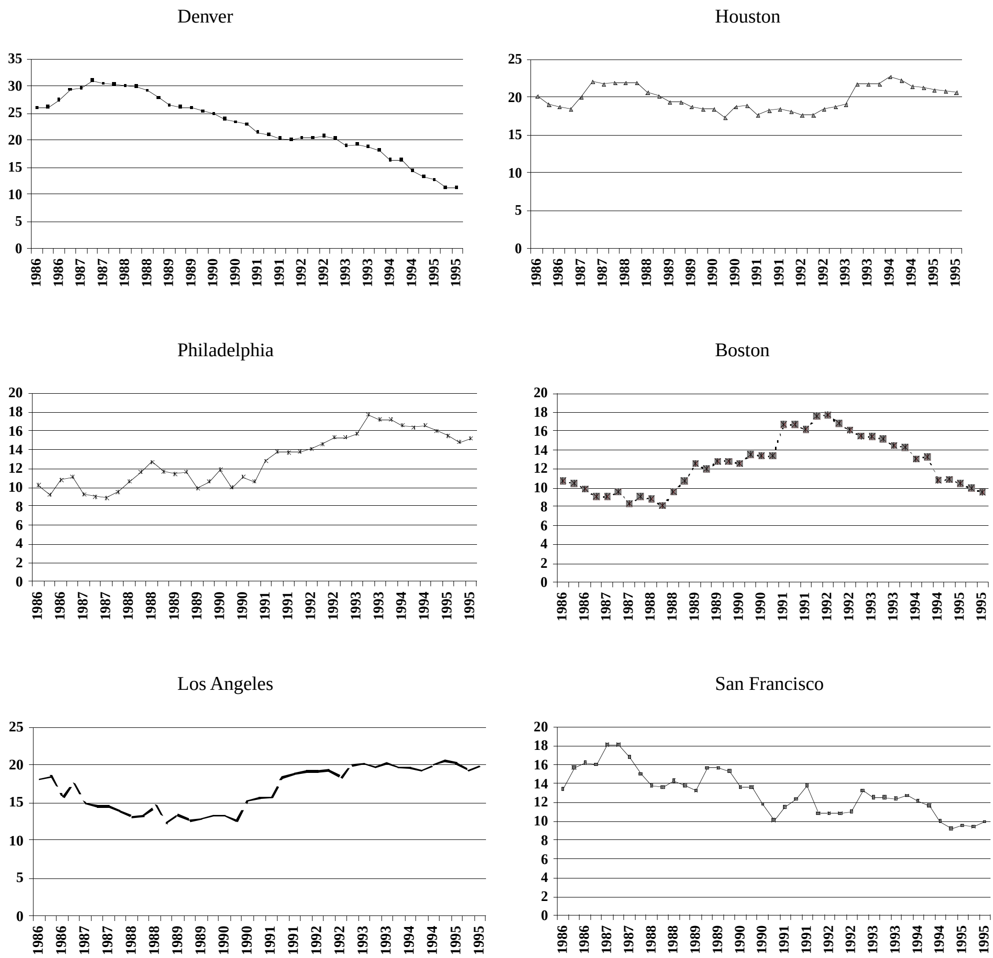
Exhibit 1
MSA Office Vacancy Rates (percentage) 1985:4–1995:4



In addition, real estate cycles are difficult to characterize because of varying severity across different real estate sectors. For example, the magnitude of the nationwide downturn in residential real estate markets during the late 1980s and early 1990s appears to be the worst since the Great Depression. However, commercial real estate market episodes of the 1960s and 1970s are by no means dissimilar in direction or severity to those observed more recently in residential markets.[2]

The lack of uniformity in direction and magnitude of these cycles by sector, locale and over time has made it difficult to create a uniform explanation for real estate market cycles. It is not sufficient to merely observe upturns and downturns in value or rents in order to characterize the economic behavior of any market as ''cyclical.'' Rather, one should devise a theoretical benchmark of the cycle that can be tested empirically.[3] A number of earlier research efforts develop behavioral models that examine the interrelationships among economic variables, real estate income and real estate values.[4] This article confirms and furthers our understanding of the cyclical nature of real estate income and value.

The main objective of this article is to extend research efforts by developing a theory of real estate cycles that demonstrates the interrelationships among the economic cycle, real estate rental rates and property value cycles over time. Our theory is a continuous time dynamic model that is econometrically identifiable. This allows us to test our model specification using observed real estate office market data, and to establish the model's practical usefulness in understanding idiosyncrasies of some (office) real estate markets.

The article is subdivided into four subsequent sections. First is a selective review of the germane real estate cycle literature. Next, a theoretical model of real estate market cycles is developed and it is used to analyze statistically market data for twenty large U.S. office markets. The final section is the conclusion.

Literature Review

Real Estate Cycle Identification

Real estate cycle research has linked the real estate cycle to the general macroeconomic cycle. This relationship has been recognized and documented since World War II. Grebler and Burns (1982) uncovered six residential and four non-residential construction cycles in the U. S. between 1950 and 1978. Pritchett's (1984) analysis indicates that the magnitudes of the construction cycles for office, industrial and retail real estate are different, with office the most volatile, industrial the least volatile and with retail somewhere in between.

The residential construction cycles tended to be counter-cyclical, while the commercial construction cycles tended to be co-incidental with the macroeconomic cycle. Guttentag (1960) explains the observed counter-cyclical residential construction activity as a function of credit and other resource availability to the residential building sector. Green (1997) performs tests for causality between economic and real estate investment cycles. Using Granger causality statistical tests for several alternative model specifications, Green's statistical analysis finds that while residential housing investment leads fluctuations in gross domestic product, the non-residential investment[5] series lags gross domestic product. Although Green does not provide an economic explanation of this result, his empirical work lends support to the hypothesis that structural economic factors cause commercial real estate value and income fluctuations.

Hekman (1985) finds that the office construction sector, for fourteen metropolitan statistical areas (MSAs), is highly cyclical, following the national economic cycle. He also observes that local and regional economic conditions exert important forces on the MSA office market. Similarly, Voith and Crone (1988), for seventeen U.S. MSAs, uncover significant cyclical vacancy differences between major city office markets. These findings are reinforced by Dokko, Edelstein and Urdang (1991), who demonstrate that local market conditions and macroeconomic conditions, especially inflationary expectations, operate in concert to generate cyclical outcomes for local real estate markets.

For the national office market, Wheaton (1987) identifies a twelve-year recurring cycle in construction and vacancy. Wheaton and Torto (1988) find that the peaks and troughs of the office real rent cycle lag the vacancy rate troughs and peaks, respectively, by roughly one year. Rosen (1984) develops a natural vacancy rate model for the San Francisco office market that identifies rental rate adjustments used to predict local new construction, absorption, changes in vacancy and changes in rental rates. Although similar simultaneous equation model specifications are employed in all three works, one major difference in their results stands out. While Wheaton and Torto and Wheaton did not find prices or interest rates statistically significant in explaining rent adjustments in national aggregates of the office markets, Rosen finds financial variables are statistically significant using MSA data. These results are not necessarily contradictory; instead, they may confirm that local office markets respond to macro variables that may not be significant in the aggregate, when examining office markets nationally. The above research complements results by Voith and Crone (1988), Dokko et al. (1991) and others.[6]

In sum, real estate construction, stock and rent-vacancy-value cycles have been identified and linked to both, local-regional and macroeconomic performance. However, cycle identification and theoretical explanations are not synonymous.

Explanations of Real Estate Cycles

Several commonly espoused explanations for the boom-bust real estate construction and asset stock cycles hone in on the alleged ''inept'' and/or ''greedy'' developer and/or the ''bumbling'' lender.[7] Using the logic of those views, the developer faces a long lag, from start to finish, in commercial real estate project construction. The developer is unable to forecast the future state of the marketplace accurately. Development commences when the market indicators appear to be favorable, only to have new construction space available under much less favorable market conditions. Hence, vacancy rates increase above, and rents decline below, what they might have been under favorable market conditions as a result of poorly timed additions to the inventory of leaseable office space. In contrast, when the real estate market is tight, the developer is unable to respond quickly to increased space demand because of the lags in construction; thereby, vacancies remain lower and rents higher than they might have been without the long lags in construction.

The construction lag explanation, while at most partially capable of explaining moderate fluctuations in some industrial markets, is unsatisfactory, by itself, as the prime cause of cycles in other property types and thus in general. One reason is that developers must recognize the existence of lags in construction as well as their own limited abilities to forecast uncertain market fundamentals. Therefore, it is not obvious that the real estate market automatically should exhibit recurring, persistent over-building and under-building cycles. Furthermore, while large office construction projects in many markets have significant production lags, for other types of real estate, such as tilt-up industrial space, lags for production are brief (less than a year). Thus, the lag-forecast argument does not seem to explain the boom-bust cycle for this type of industrial real estate market.

An alternative explanation highlights lender behavior and nonrecourse financing as the culprits to cyclical real estate markets.[8] According to this view, the developer is ‘‘greedy’’ and if you provide nonrecourse project financing, or fees for construction, the developer will build. This argument depends on lenders making recurrent bad lending decisions, while failing to learn from prior history (*i.e.*, past lending mistakes). A variant of this theme attributes lender behavior to regulatory or profitability constraints.[9] In turn, these constraints create real estate credit availability cycles that interplay with real estate market demand cycles to cause real estate booms and busts. These explanations, while perhaps contributing to observed cycles, inadequately explain the full extent of observed real estate cycles.

In Chinloy’s (1996) cyclic real estate model, the key rental rate equation is a function of vacancies and space absorption expectations (*i.e.*, excess supply and changes in expected excess supply). To the extent that disequilibrium occurs because of excess demand for space, the need for new space construction will be triggered. These actions move the market toward equilibrium, and generate a cycle of activity that is observed in market values and rent fluctuations over time—as the adjustment toward equilibrium continues. In Chinloy’s model, the ‘‘indivisibility’’ of real estate space causes a ‘‘sluggish’’ response by the construction sector to increases in demand.

Pyhrr and Born (1994) incorporate cyclical economic factors—such as price cycles, inflation cycles, rent rate catch-up cycles and property life cycles—that impact cash flow variables and thus affect present value estimates of real estate assets. The model explains real estate value cycles as a convolution of fundamental, underlying economic, real estate supply and real estate demand cycles. The resulting model prescribes explicit incorporation of cyclical factors in appraiser cash flow models so as to produce superior present value estimates.

Other recent emerging explanations apply ‘‘real option’’ theory to real estate cycle analysis. These approaches give more weight to the impacts of the demand-side as a cause of the cycle than do other promulgated explanations. Grenadier (1995) develops a model that incorporates the significant costs of adjustment incurred by tenants when they move. These adjustment costs interplay with landlord, construction and development behavior to create prolonged periods of vacancy for vacant space and prolonged periods of occupancy, once space is occupied—a model of ‘‘hysteresis.’’[10]

The Typical Regional Real Estate Cycle

Several research efforts have been devoted to examining the interrelationships among regional and economic factors and real estate market cycles. For examples, see, Pritchett (1977), Voith and Crone (1988), Pyhrr, Webb and Born (1990a,b), Pyhrr and Born (1994), Chinloy (1996) and Green(1997). Three conclusions emerge from these studies. First, observed real estate cycles are a combination of several cycles produced by different underlying forces. Second, these forces are related to fundamental economic variables. Third, the typical real estate cycle usually follows a discernable pattern.

The cyclical pattern from this literature can be stylized as follows.[11] As the economic cycle declines to the trough, demand and supply forces result in an occupancy rate decline due to prior over-building and weakening subsequent demand caused by slackened economic activity. Occupancy rates are at the lowest level at the trough of the real estate cycle. Rental rates, simultaneously, are approaching the lowest point of their cycle. The rental rate cycle usually lags the occupancy rate cycle (Wheaton, 1987). Furthermore, over-building and other weakened general market demand lead to financial distress, insolvency, increased mortgage delinquency and foreclosures, especially for properties that are less desirable. Lower rental income collections, perceived higher risk and depressed future property resale price expectations are factors placing downward pressure on current market values. Frequently, in such cycles, market values decline substantially below replacement costs. Consequently, significant increases in market occupancy and rental rate levels are necessary to justify subsequent new construction. In this risky environment, the overall market cap rate and/or the discount rate for present value computations will tend to rise. Finally, lenders with substantial real estate holdings through the foreclosure process are eager to dispose of their real estate because of economic and regulatory pressures. As a likely result of financial institution sales, market values may be depressed for a substantial period of time.

The nature of real estate performance shifts dramatically as the economic cycle turns toward its peak. As the cycle recovers and the economy, in general, becomes more buoyant, demand begins to grow, and at some point will exceed supply. The property space market has reversed itself. Occupancy rates improve as the typical first sign, followed by lagged rental rate increases. Subsequently, property market values begin to increase as real estate property net operating income (NOI) increases (because rents are rising and vacancies are falling). Real estate lenders may return to the market, providing new debt capital for an additional boost to market values. Cap rate (lagged) declines follow this cyclical upturn.[12]

A Model of Real Estate Value Cycles

Our strategy is to develop a model of real estate value cycles that depends on and interplays with economic income cycles. The theory focuses on the cyclical analysis by abstracting from the economic trend. In order to do this, we recognize that the value of a property is the capitalized value of its future expected income. The key assumption is that the present value relationship obtains. Formally, borrowing from the appraisal literature, Equation (1) represents the continuous-time relationship between the capital asset value of a real estate parcel and the assumed ‘‘true’’—unobserved—expected stabilized net operating income at time t.[13]

$$\ln V = C_v + \delta(\ln Y_s^*), \tag{1}$$

where, $\ln V$ = the natural logarithm of fair market value of a parcel at time t, C_V = a constant; $\ln Y_s^*$ = the natural logarithm of ''true'' expected stabilized net operating income at time t; and δ = the point elasticity of fair market value, V, with respect to Y_s^*. This is a continuous-time reformulation of the appraiser's cap rate and serves as the income capitalization variable.

δ is a measure of the sensitivity of value to changes in the true (unobserved) stabilized NOI of the overall cap rate used in property valuation. δ takes into account the state of the market, including the persistence of market disequilibrium caused by lags on both the supply and demand sides. Supply lags may arise because of the time required to assemble land, receive governmental reviews and approvals, secure financing and construct real projects. Demand lags are usually the result of unanticipated changes in market economic fundamentals. Hence, embedded in δ are the expected secular and cyclical effects of future vacancy and rent changes.

Equation (1) is a characterization of the income approach from appraisal theory. Since Y_s^*, the true stabilized NOI is unobservable, we need to transform Equation (1) for two reasons. First, in order to focus on the cycle effects, the trend in Y_s^* is removed. Second, an adjustment process is assumed between observable NOI and de-trended, stabilized NOI.

Abstracting from the trend for stabilized NOI over time, we assume a secular growth rate of β. Equation (2) represents the de-trended stabilized NOI. β translates the trend for secular economic growth in the general economy into real estate property income.

$$\ln Y_s = \ln Y_s^* - \beta t - C_Y, \tag{2}$$

where $\ln Y_s$ is the natural logarithm of de-trended expected stabilized NOI and C_Y is a logarithmic constant in stabilized NOI.

Substituting Equation (2) into Equation (1) yields Equation (3):

$$\ln V = C^* + \delta \ln Y_s + \delta\beta t, \tag{3}$$

where C^* is a generalized constant.

Taking the time derivative of Equation (3), we obtain the instantaneous relationship between the rate of change of value and the rate of change in de-trended expected stabilized net operating income, Equation (4):[14]

$$\frac{\dot{V}}{V} = \delta\left(\frac{\dot{Y}_s}{Y_s}\right) + \delta\beta. \tag{4}$$

As noted, true de-trended stabilized NOI is not observed. Instead, for a real estate parcel at each point in time, actual NOI is observed. Equation (5) represents our hypothesis that there is a rational economic partial adjustment process for the change in de-trended stabilized NOI, based on the actual level of NOI, Y, and the expected de-trended stabilized NOI, Y_s:

$$\left(\frac{\dot{Y}_s}{Y_s}\right) = \omega(\ln Y - \ln Y_s). \tag{5}$$

Equation (5) indicates that differences between actual and de-trended, stabilized NOI lead to partial adjustments in expected, de-trended, stabilized NOI. These adjustments, in principle, move the market toward equilibrium. More precisely, changes between actual NOI and de-trended, stabilized NOI are deviations from expectations that require adjustments in the future expectations for changes in de-trended stabilized NOI growth. The partial adjustment coefficient, ω, needs to be less than unity in absolute value ($-1 \leq \omega \leq 1$), for the hypothesized adjustments in de-trended, stabilized NOI to converge. Values of ω reflect efforts by local office market players to adjust their expectations about stabilized NOI based on observed market NOI. Depending on the difference between actually observed and stabilized, unobserved, NOI, corrections in the growth rate of stabilized NOI may run counter ($\omega < 0$) or with ($\omega > 0$) the instantaneous difference between observed and stabilized NOI.

Equation (5) can be conveniently rearranged to solve for actual NOI as a function of de-trended, stabilized NOI:

$$\ln Y = \left(\frac{1}{\omega}\right)\left(\frac{\dot{Y}_s}{Y_s}\right) + \ln Y_s. \tag{6}$$

Using Equations (3) and (6), the de-trended stabilized NOI can be expressed in terms of property values. Moreover, Equation (4) allows us to express the rate of change in stabilized NOI in terms of a change in value. The outcome of these two transformations yields a relationship in value and actual income, denoted as Equation (7). This equation is expressed solely in terms of observable market data:

$$\ln Y = \left(\frac{1}{\delta\omega}\right)\left(\frac{\dot{V}}{V}\right) + \left(\frac{1}{\delta}\right)\ln V - \beta t - \left(\frac{\beta}{\omega}\right) + C^{**}, \tag{7}$$

where $C^{**} = -C^{*}/\delta$ is a generalized constant.

In Equation (7), the full relationship between observable NOI and value requires full identification of five coefficients. Three coefficients are parametric: trend, β, income capitalization, δ, and the partial adjustment coefficient, ω. In addition, two of the coefficients are non-parametric constants: C_v and C_y, which are embedded in C^{**}.

Since we are interested in understanding the real estate cycle relationship between observable NOI and V, we take the time derivative of Equation (7). This yields

Equation (8), a full characterization of a local market real estate cycle in terms of δ, β and ω:

$$\left(\frac{\dot{Y}}{Y}\right) = \left(\frac{1}{\delta\omega}\right)(\dot{g}_v) + \left(\frac{1}{\delta}\right) g_v - \beta, \tag{8}$$

where g_v is the instantaneous rate of change in fair market value, expressed in percent terms, $\dot{V}/V$, and $\dot{g}_v$ is the time derivative of g_v and is the instantaneous rate of change for the percentage change of fair market value.[15] Equation (8) has the trend removed, and is expressed in terms of ''observable'' market data for actual NOI and parcel market values. Equation (8) can be utilized to trace out the dynamics of the cycles for observable net operating income, Y, and property fair market values, V. Equation (8) also permits an examination of the time sequencing of the expected real estate income and value cycles.

To examine the cyclical pattern of real estate income and real estate value, a simple smooth de-trended sine function cycle is assumed for income and thus value growth (see Exhibit 2). Under the assumed sine cycle with a constant trend rate for income growth, value will grow exponentially with a cycle around this trend. Exhibit 2 shows the expected exponential value growth with a cyclical fluctuation around this trend.

Exhibits 3 and 4 translate Equation (8) and the cycle into a graphical presentation.[16] The axes for Exhibit 3 are $\dot{V}/V$, defined as g_v, and $\dot{Y}/Y$, defined as g_Y. For Exhibit 4,

Exhibit 2
Log of Value Over Time

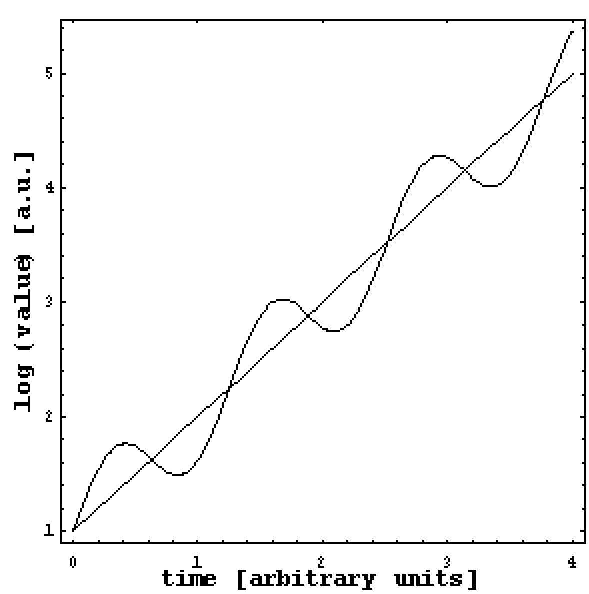


Exhibit 3
The Cyclical Relationship between NOI and Property Value

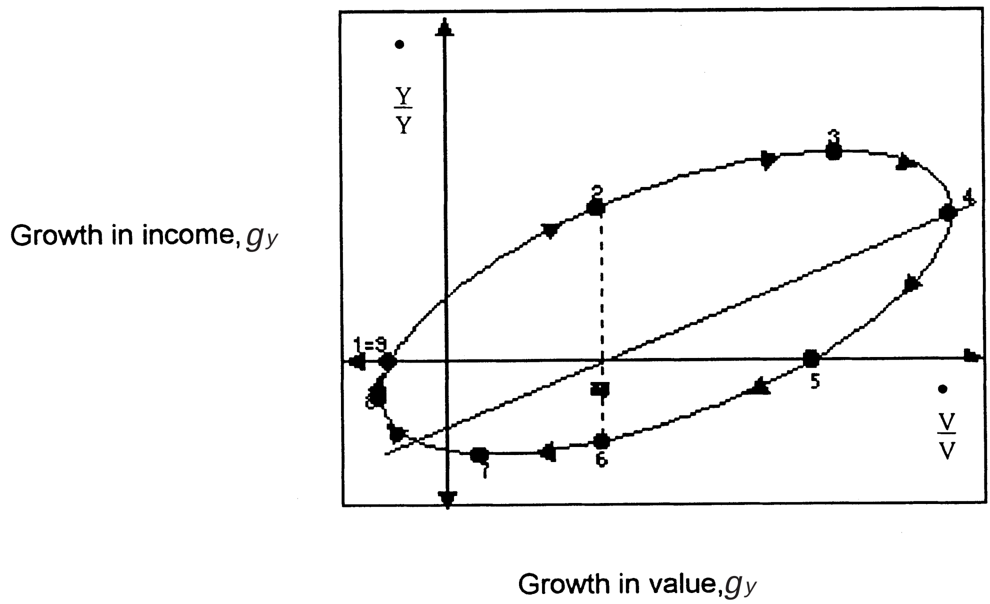
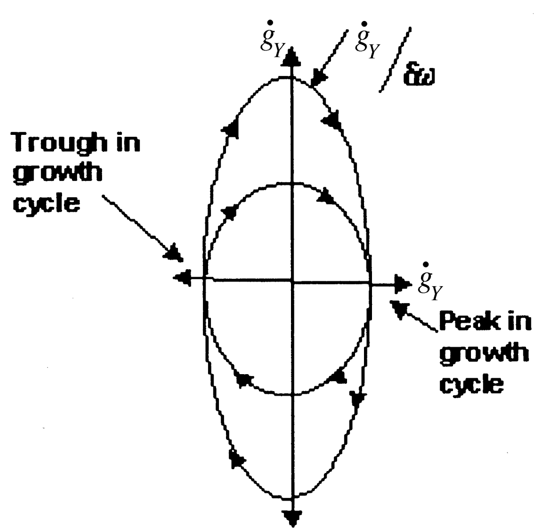


Exhibit 4
Cyclical Relationship between Value Growth Rate and the Change in the Rate of Change of Growth Value



the axes measure g_v and $\dot{g}_v$. In Exhibit 3, the second term of the right hand side of Equation (8) is shown as the oblique straight line intercepting the growth in value, g_V, axis at $\delta\beta$. To understand why, consider the case of observing a de-trended stabilized NOI growth rate of zero (*i.e.*, $\dot{Y}/Y = 0$). In such a case, the change in the rate of growth in value (*i.e.*, the acceleration) would be zero and the growth rate in property values would necessarily be constant at $\delta\beta$ in order to remove the trend parameter, β. As the cycle in NOI growth oscillates, the growth rate in value will oscillate along this line with a slope of $1/\delta$, the reciprocal of the income capitalization rate from Equation (1).

In Exhibit 4, the inner circle is the relationship between the rate of growth of values and its time derivative (g_v and $\dot{g}_v$, respectively). To represent the first term on the right hand side, in Equation (8), $\dot{g}_v$ is divided by $\delta\omega$, creating the elliptical path around the first circle. For each value of g_v, in Exhibit 4, we add $\dot{g}_v/\delta\omega$ to the straight line—the second term on the right hand side in Equation (8)—corresponding to a value of g_v to obtain the ellipsoid relationship between g_v and $\dot{g}_v$ in Exhibit 4.

As can be seen from Exhibits 3 and 4, NOI changes over the cycle are expected to occur in advance (lead) of value changes. This will be the result, in the up-turn, of a combination of both vacancies declining and rental rate increases.

In contrast, when the real estate market reaches the trough, vacancies are expected to peak (*i.e.*, occupancy to be at its trough) before rents achieve the trough, leading to a declining NOI to its trough and a subsequent fall in property value toward its trough. The cyclical value for real estate income and parcel market value for the model is delineated in Exhibit 5, with corresponding numbered positions in Exhibit 3.

Because δ is anticipated to be greater than unity, using Equation 1, a 1% decrease in NOI is accompanied by a greater than one percent decrease in market value, and vice versa. Hence, the cap rate derived from the model's cycle pattern would be counter-cyclical with cap rates rising as real estate markets decline, and vice versa. Therefore,

Exhibit 5
Expected Sequential Cyclical Patterns for NOI and Value

1	Trough of NOI
2	Trough of Value (less trend)
3	Peak of NOI Growth
4	Peak of Value Growth
5	Peak of NOI
6	Peak of Value (less trend)
7	Trough in Growth of NOI
8	Trough in Growth of Value
9	Trough in NOI

as previously mentioned, the cycle theory generates an expected observable sequence of real estate income and value events that is consistent with earlier empirical research findings, and with the current understanding of the way real estate markets function.

Empirical Results

The Statistical Model and Data Set

Equation (8) is employed to estimate and test the model.[17] Equation (9) is the statistical version of Equation (7):

$$\ln Y = a_0 + a_1 \ln V + a_2(\dot{V}/V) + a_3 t + \varepsilon. \tag{9}$$

The coefficients to be estimated are functions of the cyclical parameters. In particular, $a_0 = (C_v/\delta) - C_y - (\beta\omega/\delta)$, $a_1 = (1/\delta)$, $a_2 = (1/\delta\omega)$ and $a_3 = -\beta$. These four coefficients under-identify the cyclical model. For every city, for the four coefficients, a_0, a_1, a_2, a_3, of Equation (9), we are unable algebraically to unravel the five parameters needed to identify Equation (7). However, the same four coefficients permit the identification of the cyclic parameters β, δ and ω. In particular: $\beta = -a_3$, $\delta = (1/a_1)$ and $\omega = a_1/a_2$. Thus, a complete analysis of the income and value cycles is possible, even though full identification of Equation (7) is not.

The econometric specification of the cyclical model is a system of twenty simultaneous equations, one for each of the twenty metropolitan office markets from the data set.[18] Using the method of three-stage least squares (3SLS), this system of equations is estimated to obtain the four coefficients of Equation (9).[19,20] The 3SLS procedure takes into account the impact of structural supply and demand instruments on the closed form system of 20 equations. For example, Mueller (1995) suggests that macro-variables affect real estate through their impact on capital market variables (*e.g.*, flow of funds, interest rates), while regional-city variables affect local real estate market supply-demand factors. Our analysis takes this dichotomy into account by utilizing macroeconomic instrumental variables, such as GDP, real interest rates, and inflation rates and local instrumental variables such as absorption rates and construction permits. The use of these variables as instruments within the 3SLS procedure corrects for two classical statistical complications related to the structure of the error terms in the 20-equation simultaneous system, cross-equation correlations and simultaneity bias.[21]

Exhibit 6 summarizes the quarterly time series (1985:4 to 1995:2) for the twenty MSAs employed in the estimation of the model: NOI, market value and growth in market value.

Statistical Findings

Exhibit 7 shows the consistent and unbiased estimates for the Equation (9) coefficients a_0, a_1, a_2, a_3, with their respective t-Statistics. Exhibit 8 reports the results of unit root tests performed on the time series vector of residuals for the system of twenty office

Exhibit 6
Primary and Instrumental Variables Used in 3SLS Estimation of a_0, a_1, a_2, a_3

Number of Variables	Primary and Instrumental Variables Employed in 3SLS Estimation	Source
1 per system	U.S. Gross Domestic Product Growth—used as an instrumental variable	Federal Reserve Economic Data
1 per system	U.S. Employment Growth—used as an instrumental variable	U.S. Bureau of Labor Statistics
1 per system	U.S. Real Interest Rate (10–yr. Treasury rate, adjusted for inflation)—used as an instrumental variable	Federal Reserve Economic Data
1 per system	U.S. Inflation Rate—used as an instrumental variable	U.S. Bureau of Labor Statistics
20 per system	Office Vacancy Rates for 20 MSAs—used as instrumental variables	Coldwell Banker Commercial
20 per system	NOI/sf and Price/sf for 20 MSAs—are the primary variables used in the 3SLS procedure	National Real Estate Index
20 per system	Office Absorption Rates for 20 MSAs—used as instrumental variables	Fisher Center for Real Estate and Urban Economics
20 per system	Office Construction Permitted for 20 MSAs—used as instrumental variables	F. W. Dodge, MacGraw Hill construction data

markets estimated using 3SLS.[22] Other summary regression statistics for the model are shown in the Appendix.

The individual *t*-Statistics in Exhibit 7 show that seventy of the eighty coefficients for Equation (9) are significantly different from zero at the 95% confidence level.

The estimated coefficients statistically differ from city to city.[23] This result is consistent with Voith and Crone (1988) and Dokko, Edelstein and Urdang. (1991). It suggests that different cities experience cycles with either varying secular time trends, β, different elasticities for fair market value growth to changes in stabilized NOI, δ, or distinct rates of adjustments (*i.e.*, cycle durations) to NOI perturbations, ω.[24]

With regards to the unit root tests in Exhibit 9, they confirm the stationarity of the regression residuals and hence the unbiasedness and consistency of the estimated model coefficients.[25] In all Phillips and Perron, Augmented Dickey Fuller and Weighted Symmetric Test Statistics, for all twenty office markets, and for lags of at most seven quarters, Exhibit 7 reports the closest statistics to the critical region for unit roots.

All the aforementioned statistics yield rejections of the hypothesis that (residuals are non-stationary) unit roots are present in the regression residuals for the MSAs in the

Exhibit 7
Estimated Coefficients, *t*-Statistics and Implied Model Parameters

Model Coefficient	Coefficient Estimate	*t*-Statistic	Model Coefficient	Coefficient Estimate	*t*-Statistic
Atlanta a_0*	−0.183	−1.1	Min. a_0	−2.263	−26.4
Atlanta a_1	0.542	15.8	Min. a_1	0.950	55.6
Atlanta a_2	0.056	2.0	Min. a_2	−0.214	−16.0
Atlanta a_3	−0.002	−7.7	Min. a_3	0.003	6.0
Baltimore a_0	−0.912	−16.4	New Orl. a_0*	−0.058	−0.3
Baltimore a_1	0.670	58.7	New Orl. a_1	0.489	12.0
Baltimore a_2	−0.057	−4.8	New Orl. a_2*	0.044	1.2
Baltimore a_3	0.001	6.1	New Orl. a_3	0.001	2.6
Boston a_0	−0.622	−9.3	Phil. a_0	−0.846	−6.4
Boston a_1	0.625	54.1	Phil. a_1	0.661	25.1
Boston a_2	−0.030	−3.0	Phil. a_2	−0.237	−10.0
Boston a_3	0.002	5.2	Phil. a_3	0.005	27.5
Charlotte a_0	−1.285	−24.9	Phoenix a_0	−0.998	−8.3
Charlotte a_1	0.755	72.4	Phoenix a_1	0.705	28.8
Charlotte a_2*	−0.016	−1.9	Phoenix a_2	−0.228	−9.3
Charlotte a_3	0.001	6.7	Phoenix a_3	−0.002	−4.2
Chicago a_0	−0.235	−2.8	Sac a_0	−1.049	−8.0
Chicago a_1	0.575	39.4	Sac a_1	0.718	27.4
Chicago a_2	0.100	6.5	Sac a_2	−0.078	−3.3
Chicago a_3*	−0.001	−1.8	Sac a_3*	0.001	0.3
Dallas a_0	−1.052	−6.3	San Diego a_0	−1.467	−25.2
Dallas a_1	0.710	20.8	San Diego a_1	0.777	69.1
Dallas a_2	0.089	3.7	San Diego a_2	0.033	3.0
Dallas a_3	0.003	5.2	San Diego a_3	0.004	17.3
Denver a_0	−0.575	−10.9	S.F. a_0	−0.562	−4.3
Denver a_1	0.630	53.8	S.F. a_1	0.565	24.3
Denver a_2	0.209	17.0	S.F. a_2	−0.196	−9.8
Denver a_3	−0.006	−16.3	S.F. a_3	0.006	8.8
Houston a_0	−0.143	−3.5	Seattle a_0	−1.421	−9.1
Houston a_1	0.515	59.2	Seattle a_1	0.779	25.3
Houston a_2	−0.291	−43.5	Seattle a_2	−0.179	−7.9
Houston a_3*	−0.001	−0.4	Seattle a_3	0.002	7.8
L.A. a_0	0.642	6.5	Tampa a_0*	−0.108	−0.7
L.A. a_1	0.417	24.2	Tampa a_1	0.526	16.5
L.A. a_2*	0.012	0.9	Tampa a_2	0.071	3.6
L.A. a_3	−0.002	−6.6	Tampa a_3	−0.005	−11.2
Miami a_0*	−0.137	−1.5	D.C. a_0	0.163	2.0
Miami a_1	0.539	26.6	D.C. a_1	0.494	35.6
Miami a_2	−0.094	−6.7	D.C. a_2	0.018	2.2
Miami a_3	−0.002	−2.9	D.C. a_3	0.003	8.1

*Statistically insignificant.

Exhibit 8
Summary of Unit Root Tests Performed on the Regression Residuals for the Twenty Office Markets Estimated Jointly in the Model

	Test Statistics					Vol. Lags					*p*-Values				
	ATL	BAL	BOS	CHR	CHI	ATL	BAL	BOS	CHR	CHI	ATL	BAL	BOS	CHR	CHI
Wtd. Sym.	−4.2	−4.0	−2.3	−4.1	−2.7	3	3	2	3	3	0.003	0.005	0.439	0.003	0.175
Dickey-F	−3.8	−3.8	−2.9	−3.8	−2.9	3	3	2	3	3	0.015	0.017	0.175	0.015	0.168
Phillips	−13.5	−10.2	−11.0	−18.2	−16.0	3	3	2	3	3	0.245	0.437	0.371	0.100	0.155
	DAL	DEN	HOU	LA	MIA	DAL	DEN	HOU	LA	MIA	DAL	DEN	HOU	LA	MIA
Wtd. Sym.	−1.4	−3.2	−2.8	−2.8	−3.5	3	3	3	3	3	0.925	0.049	0.141	0.159	0.022
Dickey-F	−1.2	−3.3	−3.2	−2.6	−3.5	2	3	3	3	3	0.907	0.073	0.090	0.285	0.045
Phillips	−4.5	−12.3	−11.7	−15.3	−16.3	2	3	3	3	3	0.855	0.298	0.334	0.176	0.147
	MIN	ORL	PHI	PHO	SAC	MIN	ORL	PHI	PHO	SAC	MIN	ORL	PHI	PHO	SAC
Wtd. Sym.	−2.8	−2.4	−3.5	−2.4	−2.6	3	3	3	2	3	0.151	0.334	0.023	0.337	0.218
Dickey-F	−2.9	−2.5	−3.3	−2.1	−2.3	3	3	3	2	3	0.162	0.344	0.072	0.539	0.418
Phillips	−9.9	−5.0	−13.6	−10.8	−11.3	3	3	3	2	3	0.443	0.825	0.238	0.384	0.353
	SD	SF	SEA	TPA	DC	SD	SF	SEA	TPA	DC	SD	SF	SEA	TPA	DC
Wtd. Sym.	−3.6	−2.6	−4.7	−3.0	−3.8	3	3	3	3	3	0.015	0.213	0.001	0.080	0.008
Dickey-F	−3.4	−2.7	−4.1	−2.7	−3.6	3	3	3	3	3	0.057	0.257	0.008	0.218	0.034
Phillips	−10.4	−9.5	−14.3	−8.7	−12.5	3	3	3	3	3	0.410	0.473	0.213	0.529	0.290

Exhibit 9
MSA-specific, Implied Model Parameters

Model Parameter	Parameter Value	Model Parameter	Parameter Value
Atlanta		Minneapolis	
β-trend	.22	β-trend	−.27
δ-cap	1.85	δ-cap	1.05
ω-expectations	.098	ω-expectations	−.089
Baltimore		Orlando	
β-trend	−.10	β-trend	−.12
δ-cap	1.49	δ-cap	2.05
ω-expectations	−.118	ω-expectations	.111
Boston		Philadelphia	
β-trend	−.20	β-trend	−.46
δ-cap	1.60	δ-cap	1.51
ω-expectations	−.211	ω-expectations	−.056
Charlotte		Phoenix	
β-trend	−.11	β-trend	.15
δ-cap	1.32	δ-cap	1.42
ω-expectations	−.467	ω-expectations	−.062
Chicago		Sacramento	
β-trend	.07	β-trend	−.01
δ-cap	1.74	δ-cap	1.39
ω-expectations	.057	ω-expectations	−.092
Dallas		San Diego	
β-trend	−.25	β-trend	−.41
δ-cap	1.41	δ-cap	1.29
ω-expectations	.080	ω-expectations	.234
Denver		San Francisco	
β-trend	.61	β-trend	−.60
δ-cap	1.59	δ-cap	1.77
ω-expectations	.060	ω-expectations	−.058
Houston		Seattle	
β-trend	.01	β-trend	−.19
δ-cap	1.94	δ-cap	1.28
ω-expectations	−.035	ω-expectations	−.087
Los Angeles		Tampa	
β-trend	.20	β-trend	.50
δ-cap	2.40	δ-cap	1.90
ω-expectations	.354	ω-expectations	.074
Miami		Washington D. C.	
β-trend	.20	β-trend	−.27
δ-cap	1.86	δ-cap	2.03
ω-expectations	−.058	ω-expectations	.067

regression specification for all twenty MSAs. Specifically, all p-values indicate the absence of unit roots for all office markets, at the 5% significance level, for lags of up to three quarters in most cases, except for the cases of Phoenix and Boston—where stationarity is still present for lags in variables of up to two quarters.

Implied Real Estate Cycles

From our statistical results reported in Exhibit 7, the parameters, β, δ and ω are computed.[26] Fifty-four of the sixty coefficients used in the computations are statistically significant. The implied cyclic-parameters β, δ and ω for the twenty MSAs are reported in Exhibit 9. Even the six statistically insignificant estimated coefficients used to produce implied model parameters, β, δ and ω result in statistical values well within the range of reasonable, expected cycle parameter values: β has no restrictions, $\delta > 1$ and $|\omega| \leq 1$. Thus, all sixty statistical coefficients yield cyclic parameter values for Equation (7), well within theoretical model bounds.

Using the calculated cyclic parameters reported in Exhibit 9, inferences may be drawn about the nature of income cycles—and thus value cycles—in different cities. For example, the estimated parameter values indicate that eight of the twenty MSAs show an increasing secular growth rate of office market NOI. These MSAs are Atlanta, Phoenix, Chicago, Denver, Houston, Los Angeles, Tampa and Miami. The remaining MSAs show a negative secular growth trend in office market NOI. These results coincide with the perceived downturn in commercial real estate during the late 1980s and early 1990s.

With respect to the implied partial adjustment coefficient, ω, all calculated coefficients are less than unity in absolute value, some are positive, and some are negative. While the sign is indicative of direction of adjustment between observed NOI and expected stabilized NOI, the magnitude of ω reflects the speed of adjustment of the partial adjustment process described by Equation (5). For example, the estimated ω for Charlotte reflects relatively rapid adjustments to observed NOI in the opposite direction to that of the market change in NOI (with negative adjustment, $\omega < 0$). Whereas Los Angeles and San Diego exhibit comparably dramatic changes in expectation about stabilized NOI that reinforce expectations about growth in NOI (*i.e.*, positive coefficient of adjustment, $\omega > 0$). The reasons as to why these cities behave so differently may be found in market fundamentals. One explanation may be that absorption rates make the Southeast structurally different from Southern California. Southern California had a significantly slower rate of absorption than Charlotte during much of the sample period. Thus, the pace at which expectations changed did not have to be so fast or dramatic in direction—reversing past expectations about NOI surprises.

All of the estimates of point elasticity of fair market value with respect to expected stabilized NOI, δ, are greater than unity in magnitude and with the appropriate sign. In all cases, increases in expected stabilized NOI result in a greater increase in fair market value. The observed range of point elasticities by MSA is quite broad, from a low of 1.053 for Minneapolis, to a high of 2.401 for Los Angeles. Put differently,

Exhibit 10
Actual vs. Fitted NOI for 20 Office Markets Used in Regression Estimation
Actual versus Fitted NOI: Atlanta, Baltimore, Boston, Charlotte, Chicago, Dallas, Denver and Houston
1986:4 to 1995:2

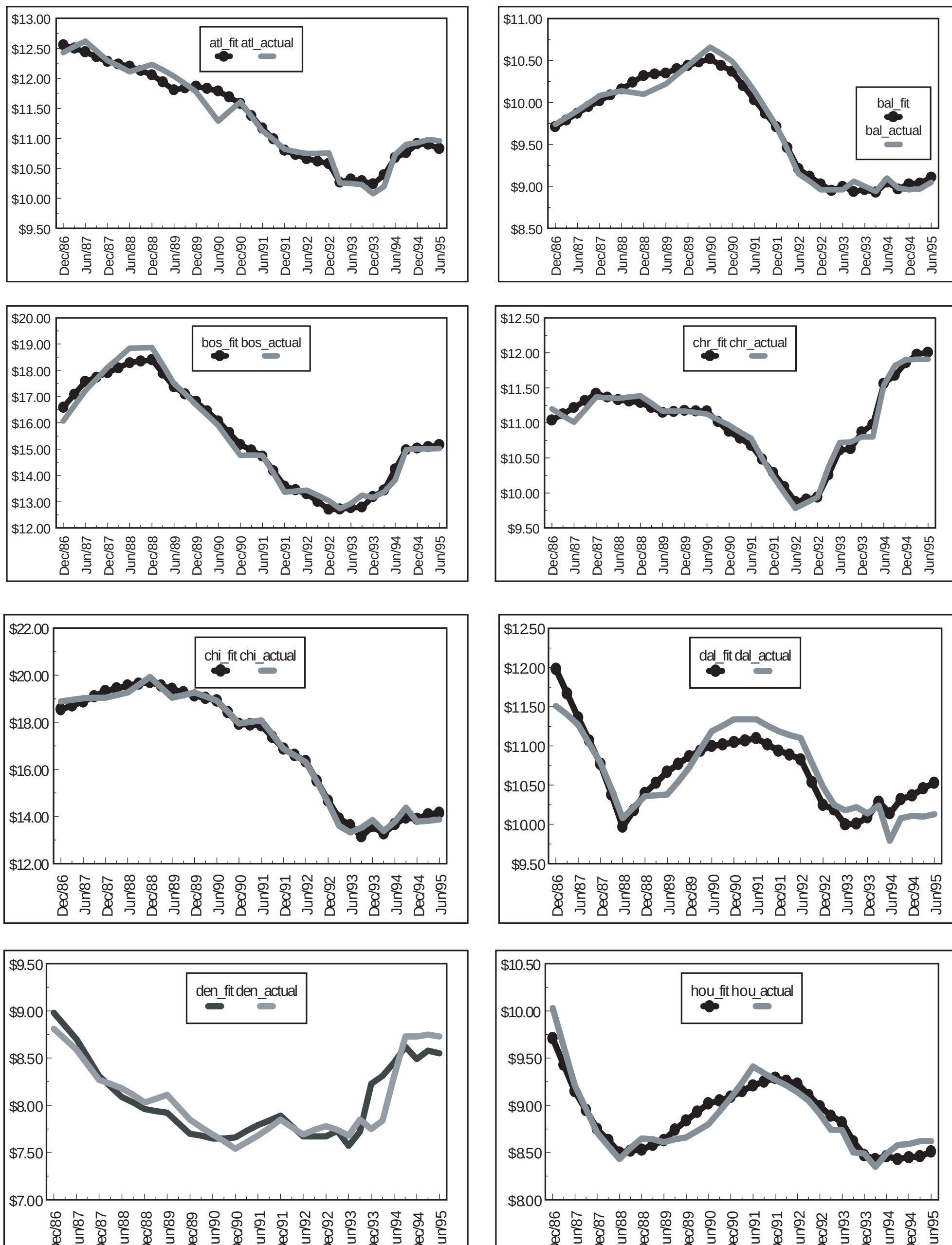


Exhibit 10 (continued)
Actual versus Fitted NOI: Los Angeles, Miami, Minneapolis, Orlando, Philadelphia, Phoenix, Sacramento and San Diego
1986:4 to 1995:2

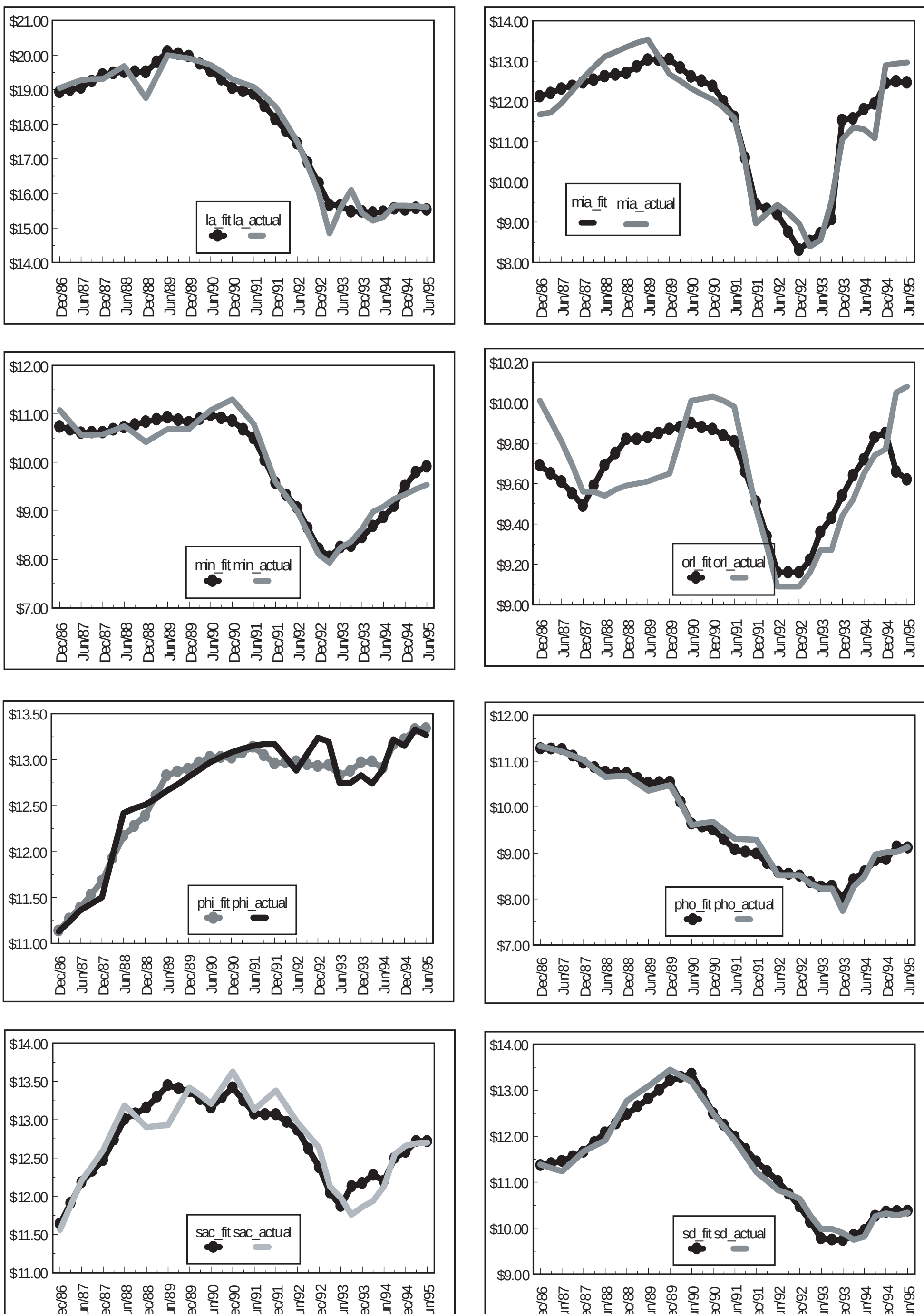
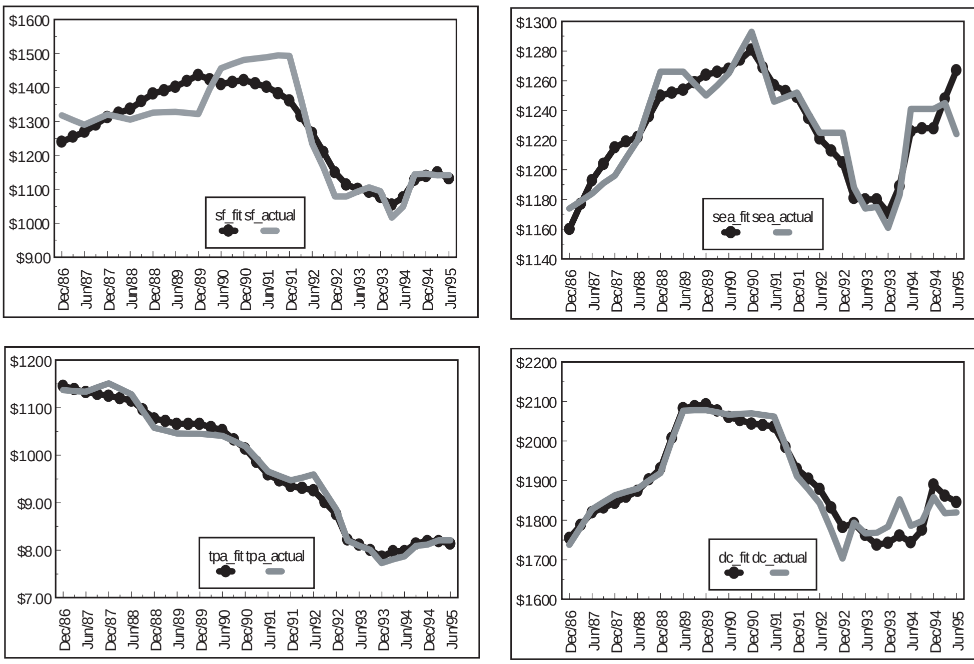


Exhibit 10 (continued)
Actual versus Fitted NOI: San Francisco, Seattle, Tampa and D.C.
1986:4 to 1995:2



the model estimates that a 1% change in NOI will cause a quarterly growth rate in market value of 1.05% to 2.40% for the selected MSAs. Intuitively, if income changes are temporally inter-correlated, an observed increase in NOI is likely to have a very large impact on value; and faster growing regions are likely to have the largest elasticities, δ.

Finally, given that the data set consists of information for about a decade, the findings need to be interpreted with care.

Other Empirical Observations About our Model

The success in the estimation of this model specification is also evident in Exhibit 10, which contains the fitted versus the actual NOI cycles for each of the twenty office markets. In virtually all cases, the estimated model fits actual NOI cycles well. As noted, unit root and co-integration tests (see Exhibit 8), reveal no apparent econometric problems with residuals from the regression of our twenty MSAs.

A close examination of Exhibit 10, in the light of the results, suggests three major conclusions. First, the estimated values of NOI by office market (MSA) derived from the model closely replicate observed cycles in NOI. The empirical model fits the data extremely well. Second, office market cycles vary significantly across MSAs with respect to cycle phase, timing and amplitudes. The three-parameter model appears to be sufficiently flexible to adapt to such differences. The findings are consistent with the theoretical model as well as the findings of earlier studies. Put somewhat differently, the theory conforms to earlier cycle assessments, whether stylized facts or formal models, about the evolution of real estate cycles—with the added advantage that the structure is uniform across geographic locales. And third, the consistency, efficiency and unbiasedness of the estimated coefficients and the implied NOI and value cycle relationships make the model a potentially useful tool for understanding and predicting the dynamics of real estate markets.

Conclusion

In this article, we develop and test a real estate cycles theory that examines the interrelationships between economic activity and real estate income and value cycles. While the findings reinforce those of many earlier studies, the explicit link between theory and the empirical modeling improves our interpretive reliability and fundamental understanding of real estate income and value cycles. Further, the excellent overall fit of the statistical model and the associated structural explanations of cycles represent potentially useful knowledge advancements for both academics and practitioners. Understanding real estate price volatility, correlations and autocorrelations in market values and income, and identifying the timings of these peaks and troughs in real estate markets, allow practitioners to develop better value expectations and the ability to make more informed investment decisions.

The findings provide a simple way to characterize real estate cycles among and across MSAs. Each MSA's real estate cycle is described by three parameters: (1) a city specific cycle capitalization rate, δ, which captures the relative volatility of the city cycle; (2) a city trend growth rate, β, that synthesizes the citywide market value trend fundamentals; and (3) a city specific cyclical adjustment, ω, that reflects the dynamic duration of the city cycle.

By utilizing 3SLS, we are able to incorporate into the cyclical analyses the impacts of MSA (local) supply and demand variables, macroeconomic forces, simultaneity effects among value, income and other variables, as well as MSA auto-and-cross correlation effects.

For real estate professionals, such as lenders, developers or investors, a clear view of the dynamics of the real estate cycle should be an integral part of real estate investment analysis and decision making. At the property level, an improved understanding of the dynamics of the real estate cycle and its impact on parcel value and cash flow (income) should enhance practitioners ability to determine the locus of expected rewards and risks, leading to enhanced decision making. The model analyses could be adapted to link economic scenarios and MSA real estate cycles needed to create property specific financials that could be used for investment decision making.

A better understanding of MSA real estate cycle differences could be employed to refine and improve real estate portfolio allocation decisions. For example, using the statistical analyses, for a set of macroeconomic and MSA economic scenarios, the market value and income performance for a multi-city office portfolio could be simulated or (conditionally) forecasted. These simulated results could be translated into a locus of portfolio expected returns and risks. Using this approach, an investor could evaluate diversification benefits for alternative MSA real estate investment portfolio allocations. In addition, improved understanding of real estate cycle effects on portfolio risks and rewards could be used by institutional investors to more effectively determine the proper allocation of real estate in the overall investment portfolio.

The modeling should be considered a first step. The statistical findings appear robust, albeit based on only a decade of office market data, thus one needs to interpret and use these findings with care. The rapid generation of ever increasing and improving local real estate and economic databases should be used for re-testing and re-calibrating the statistical model for additional MSAs as well as other property land uses.

These new analyses should be used by real estate investors, developers and lenders for improving real estate decisions in terms of quantifying the impacts of cycles on risks and rewards.

Appendix

Summary Regression Statistics

Dependent Variable: NOI

MSA	Atlanta	Minneapolis	Dallas	San Diego
Mean	2.43	2.29	2.37	2.43
Std. Dev.	0.07	0.12	0.05	0.10
Sum of Squared Residuals	5.92E-03	0.02	0.02	6.49E-03
Variance of Residuals	1.69E-04	4.45E-04	4.50E-04	1.85E-04
Std. Error of Regression	0.01	0.02	0.02	0.01
R^2	0.96	0.96	0.80	0.98
Durbin-Watson Statistic	0.68	0.32	0.22	0.54
MSA	Baltimore	Orlando	Denver	San Francisco
Mean	2.27	2.27	2.09	2.54
Std. Dev.	0.06	0.03	0.05	0.12
Sum of Squared Residuals	2.64E-03	0.01	0.015	0.06
Variance of Residuals	7.53E-05	3.36E-04	3.94E-04	1.79E-03
Std. Error of Regression	8.68E-03	0.02	0.02	0.04
R^2	0.98	0.64	0.83	0.86
Durbin-Watson Statistic	0.44	0.32	0.72	0.39
MSA	Boston	Philadelphia	Houston	Seattle
Mean	2.73	2.54	2.18	2.51
Std. Dev.	0.13	0.05	0.04	0.03
Sum of Squared Residuals	0.01	3.65E-03	6.28E-03	3.53E-03
Variance of Residuals	3.04E-04	1.04E-04	1.80E-04	1.01E-04
Std. Error of Regression	0.02	0.01	0.01	0.01

Appendix

Summary Regression Statistics

Dependent Variable: NOI

R^2	0.98	0.96	0.89	0.88
Durbin-Watson Statistic	0.60	0.89	0.44	0.80
MSA	Charlotte	Phoenix	Los Angeles	Tampa
Mean	2.40	2.26	2.89	2.27
Std. Dev.	0.05	0.11	0.10	0.13
Sum of Squared Residuals	2.30E-03	7.00E-03	9.34E-03	7.46E-03
Variance of Residuals	6.58E-05	2.00E-04	2.67E-04	2.13E-04
Std. Error of Regression	8.11E-03	0.01	0.02	0.01
R^2	0.98	0.98	0.97	0.99
Durbin-Watson Statistic	0.91	0.64	1.12	0.32
MSA	Chicago	Sacramento	Miami	Washington D.C.
Mean	2.82	2.54	2.44	2.94
Std. Dev.	0.15	0.04	0.15	0.06
Sum of Squared Residuals	5.98E-03	8.46E-03	0.05	0.01
Variance of Residuals	1.71E-04	2.42E-04	1.32E-03	2.86E-04
Std. Error of Regression	0.01	0.02	0.04	0.02
R^2	0.99	0.88	0.94	0.93
Durbin-Watson Statistic	1.09	0.58	0.99	0.60

Endnotes

[1] Inter-city differences in real estate vacancy rates (as well as other real estate economic measures) are not unique for either our sample of cities or time set (1985–1995). For example, in September 1998, the national average for metropolitan vacancy rates had been 9.0%. Simultaneously, Albuquerque and Columbus had vacancy rates of 12.4% and 6.7%, respectively, somewhere between the 14.1% vacancy of Los Angeles, and that of 3.0% in San Francisco.

[2] While the price deflation of the late 1980s for residential real estate was the worst since the Great Depression, commercial real estate price fluctuations of a similar magnitude as those observed during the late 1980s and early 1990s have been historically observed in the past. Burns and Grebler (1982) provide a time series comparison on public versus private sector real estate market activity—housing and non-housing. Hendershott and Kane (1995) also examine commercial market cycles using appraisal data.

[3] Koopmans (1947) makes a compelling case for the necessity of integrating theory with empiricism in conducting cycles studies.

[4] For example, see Grenadier (1995) and references contained therein. Also, see Chinloy (1996) for a theory based study of rental housing markets cycles.

[5] Green's results are robust in that they are consistent across many specifications. However, one should interpret these results with caution on two counts. First, when testing for causality, statistical correlations may appear to imply causality when in effect none is present, if the underlying model specification is incorrect. Second, the identity relation between investment and gross domestic product in national income and product accounting data may be at the core of Green's results, not Granger causality.

[6] For an excellent review of the fundamental issues in the office market real estate literature and some of the articles reviewed herein, see Clapp (1993).

[7] An excellent summary of explanations for the relationship between real estate cycles, developers and financial institutions is contained in *Origins and Causes of the S&L Debacle: A Blueprint for Reform* (1993), especially, pp. 43–57.

[8] *Origins and Causes of the S&L Debacle: A Blueprint for Reform* (1993).

[9] See, for example, Edelstein and Friend (1976), Jaffee and Rosen (1979) and Dokko, Edelstein and Urdang (1990).

[10] Consistent with Grenadier's (1995) analysis, Meese and Wallace (1994) show that fundamental economic variables determine long run residential values but with a significant adjustment lag.

[11] See Mueller (1995) for an excellent reference on this topic.

[12] Obviously, this does not necessarily describe a market equilibrium adjustment. In fact, many analysts believe that real estate market equilibrium is the exception rather than the rule.

[13] The continuous time present value model specifies fair market value as the following function in true (unobserved) expected stabilized NOI: $V = c_V(Y_s^*)^\delta$. Taking the natural logarithm of this expression, we obtain Equation (1).

[14] By taking this time derivative, the constants are eliminated from the model structure in order to focus attention on β, the cycle trend, and δ, the continuous time cap rate.

[15] It is a term that enables us to quantify the relationship between fluctuations in the value and income cycles.

[16] Our results are robust with respect to different underlying cycles. The analysis can incorporate stochastic–cyclical NOI functions and can be solved for with respect to real estate value instead of real estate value growth. For example, consider the alternative structure for true NOI:

$dY = Y\mu[\bullet]dt + Y\sigma[\bullet]dz$, where $V = e^cY^\delta$, which implies that $V = g(Y)$. Then, by applying Ito's Lemma:

$$\begin{aligned} dV &= g_YdY + gtdt + (1/2)g\upsilon dY^2 \\ &= e^c\delta Y^{\delta-1}dY + (1/2)e^c\delta(\delta - 1)Y^{\delta-2}dY^2 \\ &= e^cY^\delta\{Y\mu[\bullet]dt + Y\sigma[\bullet]dz\} + (1/2)e^c\delta\,(\delta - 1)Y^{\delta-2}Y^2\sigma^2[\bullet]dt. \end{aligned}$$

Thus, $dV = e^cdY^\delta\{\mu[\bullet] + (1/2)(\delta - 1)\sigma^2[\bullet]\}dt + e^cdY^\delta\sigma[\bullet]dz = V^\delta\{\mu[\bullet] + (1/2)(\delta - 1)\sigma^2[\bullet]\} + V^\delta\sigma[\bullet]dz$, which can be written as $(dV/V) = \delta\{\mu[\bullet](1/2)\,(\delta - 1)\sigma^2[\bullet]\}\,dt + \delta\sigma[\bullet]dz$. Since $(dY/Y) = \mu[\bullet]dt + \sigma[\bullet]dz$, we then obtain: $(dV/V) = \delta(dY/Y) + (1/2)\delta(\delta - 1)dt$.

The first term in the last expression is identical to the first term in Equation (4). However, the second term is the stochastic contribution: as long as δ is constant and greater than unity, the increased volatility of NOI will increase the value of the property. The analysis is otherwise similar to our non-stochastic case in the text. To proceed, the cycles from macroeconomic variables would be put into the system by letting μ vary over time in some cyclic fashion. Likewise, taking the time derivative of Equation (7) and expressing it in value terms we get that $\ln V = C(V) + dlnY + A(\delta, \omega, \beta)$, which is a second order partial differential equation. With the appropriate initial conditions for value and the instantaneous rate of change for value and NOI, this solution generates the non-linear, cyclical, interrelated path followed by Y and V.

[17] In order to characterize the real estate value and income cycles, it is sufficient to identify β, δ and ω. Ideally, the econometric specification should mirror Equation (8) of the model and not Equation (7). However, Equation (8) is impossible to estimate as data is lacking that can reflect instantaneous changes in the rate of change of fair market value over time. If we were to difference the logarithm of the fair market value observations twice, incorrect ''accelerators''

would be obtained for value and the simultaneous equation system would have to be restructured as one with an errors in variables problem. For simplicity, Equation (7) is used as the model specification of choice as it is sufficient to yield identification of β, δ and ω.

[18] All necessary data are available, at the MSA level, for twenty selected cities: Atlanta, Baltimore, Boston, Charlotte, Chicago, Dallas, Denver, Houston, Los Angeles, Miami, Minneapolis, Orlando, Philadelphia, Phoenix, Sacramento, San Diego, San Francisco, Seattle, Tampa and Washington D.C. The reason for specifying a separate equation for each city is the belief that each market is characterized by its own cycle in income and value. Thus, it would be inappropriate to estimate data from different cities in the same equation.

[19] Three-stage least squares permits an estimation of the income cycles in twenty cities simultaneously, while allowing an opportunity to incorporate the economic, supply and demand factors that are at the core of fluctuations in income and value for the twenty office markets employed in this study. Each of the three stages of least squares regression serves the purpose of yielding unbiased estimators for the coefficients a_0, a_1, a_2, a_3. Specifically, the first stage provides residuals valuable in calculating a variance-covariance matrix used in the third stage to enhance the efficiency of the final estimators for a_0, a_1, a_2, a_3, while correcting for sources of bias such as the presence of autocorrelation. In addition, the second stage of the procedure allows for the introduction of instruments that corrects for residual autocorrelation and enhances the efficiency of the final estimators for a_0, a_1, a_2, a_3.

[20] One year of data is lost in generating the log-differenced value data needed on the right hand side of Equation (9) to obtain estimates of the four statistical coefficients a_0, a_1, a_2, a_3.

[21] Applying 3SLS to a simultaneous equation system will result in statistically efficient and consistent estimates for the coefficients in the twenty-equation system—a total of eighty estimates, presented in Exhibit 7. These estimators are also unbiased, implying real estate cycles that are similar to results obtained in earlier studies and to the theoretical cycles model. For a technical discussion on the merits of our claims about the estimated coefficients, refer to Amemiya (1994).

[22] Unit root tests are important to perform in any time series estimation because they provide evidence on stationarity of the series or lack thereof. Whenever time series are non-stationary, the resulting coefficient estimates are biased and inconsistent. Again, refer to Amemiya (1994) or any other textbook on time series analysis for technical reference.

[23] Although we do not formally test these hypotheses, visual inspection of the data and statistical findings suggest this conclusion.

[24] The Appendix reveals that most R^2, standard errors for the regressions and variance of residuals suggest that the 3SLS procedure produced a good fit between observed Log-NOI from the National Real Estate Index data and estimated Log-NOI. 3SLS also produced very low Durbin Watson statistics—values statistically different from two—at the 95% confidence level. In single equation models, the combination of good overall fits and low Durbin-Watson statistics typically implies biased coefficient estimates due to autocorrelation in the data. However, neither fit statistics nor autocorrelation statistics are very important in the estimation of simultaneous equation systems. 3SLS will correct for simultaneity bias, cross equation correlation as well as autocorrelation. Durbin-Watson statistics do not account for cross-correlation corrections that occur in this last stage of 3SLS, thus misdiagnosing the presence of autocorrelation, and bias in estimation. For these reasons, the Appendix reports other, less significant statistics, as opposed to placing these in the text. These results lend support to our belief that the theoretical model explains observed real estate NOI cycles (and thus value cycles).

[25] For a formal treatment of the subject of testing for the presence of nonstationarity in our regression residuals, see Leybourne (1994).

[26] As is evident from our earlier discussion, the estimated intercept coefficients are not necessary to identify β, δ and ω.

References

Amemiya, T., *Advanced Econometrics*, Cambridge, MA: Harvard University Press, 1994.

Chinloy, P., Real Estate Cycles and Empirical Evidence, *Journal of Housing Research*, 1996, 7:2, 173–90.

Clapp, J. M., Dynamics of Office Markets: Empirical Findings and Research Issues, American Real Estate and Urban Economics Association Monograph Series, Vol. 1, 1993.

Dokko, Y., R. Edelstein and S. Urdang, Does Credit Rationing Affect Residential Construction? Déjà vu All over Again, *Journal of Real Estate Finance and Economics*, 1990, 3, 357–71.

Dokko, Y., R. Edelstein, M. Pomer and S. Urdang, Determinants of the Rate of Return for Nonresidential Real Estate: Inflation Expectations and Market Adjustment Lags, *Journal of the American Real Estate and Urban Economics Association*, 1991, 19:1, 52–69.

Edelstein, R. H. and I. Friend, Allocating Resources to Housing: The Private Sector, Proceedings of the First Annual Conference on Housing, Federal Home Loan Bank of San Francisco, 1976.

Grebler, L. and L. Burns, Construction Cycles in the United States Since World War II, *Journal of the American Real Estate and Urban Economics Association*, 1982, 10:2, 123–51.

Green, R. K., Follow the Leader: How Changes in Residential and Non-Residential Investment Predict Changes in GDP, *Real Estate Economics*, 1997, 25:2, 1997, 253–70.

Grenadier, S., The Persistence of Real Estate Cycles, *Journal of Real Estate Finance and Economics*, 1995, 10:2, 95–119.

Hekman, J. Rental Price Adjustment and Investment in the Office Market, *Journal of the American Real Estate and Urban Economics Association*, 1985, 2, 32–47.

Hendershott, P. and E. Kane, U.S. Office Market Value During the Past Decade: How Distorted Have Appraisals Been? *Real Estate Economics*, 1995, 23:2, 101–16.

Jaffee, D. and K. T. Rosen, Mortgage Credit Availability and Residential Construction, *Brookings Papers on Economic Activity,* Vol. 2, 1979, 333–86.

Koopmans, T. C., Measurement without Theory, *Review of Economics and Statistics*, August, 1947, 29.

Leybourne, S. J., Testing for Unit Roots: A Simple Alternative to Dickey-Fuller, *Applied Economics*, 1994, 26:7, 721–29.

Meese, R. and N. Wallace, Testing the Present Value Relation for Housing Prices: Should I Leave my House in San Francisco?, *Journal of Urban Economics*, 1994, 35, 245–66.

Mueller, G., Understanding Real Estate's Physical and Financial Market Cycles, *Real Estate Finance*, 1995, 12:3, 47–52.

National Commission on Financial Institution Reform, Recovery and Enforcement, Origins and Causes of the S&L Debacle: A Blueprint for Reform, A Report to the President and Congress of the United States, Washington, D.C., July 1993.

Pritchett, C., The Effect of Regional Growth Characteristics on Regional Housing Prices, *Journal of the American Real Estate and Urban Economics Association*, 1977, 5:2, 189–208.

——. Forecasting the Impact of Real Estate Cycles on Investment, *Real Estate Review*, 1984, 4, 85–89.

Pyhrr, S. A. and W. L. Born, Real Estate Valuation: The Effect of Market and Property Cycles, *Journal of Real Estate Research*, 1994, 9:4, 455–86.

Pyhrr, S. A., W. L. Born and J. R. Webb, *Development of a Dynamic Investment Strategy under Alternative Inflation Cycle Scenarios*, *Journal of Real Estate Research*, 1990, 5:2, 177–94.

Pyhrr, S. A., J. R. Webb and W. L. Born, Analyzing Real Estate Asset Performance During Periods of Market Disequilibrium Under Cyclical Economic Conditions: A Framework for Analysis, In Kappline and Schwartz, (Eds.), *Research in Real Estate*, Vol. 3, 1990.

Rosen, K., Toward a Model of the Office Building Sector, *Journal of the American Real Estate and Urban Economics Association*, 1984, 12:4, 261–69.

Sagalyn, L. B., Real Estate Risk and the Business Cycle: Evidence from Security Markets, *Journal of Real Estate Research*, 1990, 5:2, 203–20.

Voith, R. and T. Crone, National Vacancy Rates and the Persistence of Shocks in U.S. Office Markets, *Journal of the American Real Estate and Urban Economic Association*, 1988, 4, 437–58.

Wheaton, W., The Cyclical Behavior of the National Office Market, *Journal of the American Real Estate and Urban Economics Association*, 1987, 4, 281–99.

Wheaton, W. and R. Torto, Vacancy Rates and the Future of Office Rents, *Journal of the American Real Estate and Urban Economics Association*, 1988, 4, 430–36.

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