UC Berkeley
Fisher Center Working Papers

Title

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

Permalink
https://escholarship.org/uc/item/0713h7sj

Authors
Dokko, Yoon
Edelstein, Robert H.
Lacayo, Allan J.
et al.

Publication Date
1999-02-17

Peer reviewed

eScholarship.org Powered by the California Digital Library
University of California

Institute of
Business and
Economic Research

University of
California at
Berkeley

FISHER CENTER FOR REAL ESTATE AND URBAN ECONOMICS

WORKING PAPER SERIES

WORKING PAPER NO. 99-265

REAL ESTATE INCOME AND VALUE CYCLES: A MODEL OF MARKET DYNAMICS

By

YOON DOKKO
ROBERT H. EDELSTEIN
ALLAN J. LACAYO
DANIEL C. LEE

These papers are preliminary in nature: their purpose is to stimulate discussion and comment. Therefore, they are not to be cited or quoted in any publication without the express permission of the author.

WALTER A. HAAS SCHOOL OF BUSINESS

FISHER CENTER FOR REAL ESTATE AND URBAN ECONOMICS
UNIVERSITY OF CALIFORNIA AT BERKELEY
Kenneth T. Rosen, Chair
Robert H. Edelstein, Co-Chair
Dwight M. Jaffee, Co-Chair

The Center was established in 1950 to examine in depth a series of major changes and issues involving urban land and real estate markets. The Center is supported by both private contributions from industry sources and by appropriations allocated from the Real Estate Education and Research Fund of the State of California.

INSTITUTE OF BUSINESS AND ECONOMIC RESEARCH
Carl Shapiro, Director

The Institute of Business and Economic Research is an organized research unit of the University of California at Berkeley. It exists to promote research in business and economics by University faculty. These working papers are issued to disseminate research results to other scholars. The authors welcome comments; inquiries may be directed to the author in care of the Center.

REAL ESTATE INCOME AND VALUE CYCLES:

A MODEL OF MARKET DYNAMICS

Date: Monday, February 17, 1999[1]

By:

Yoon Dokko
Dean and Professor
School of Business Administration
Ajou University, Korea

Robert H. Edelstein
Real Estate Development Chair
Haas School of Business
University of California at Berkeley

Allan J. Lacayo
Research Associate
Fisher Center for Real Estate and Urban Economics
Haas School of Business
University of California at Berkeley

Daniel C. Lee
Visiting Professor
Haas School of Business
University of California

ABSTRACT

We develop a theoretical real estate cycles model linking economic fundamentals to real estate income and value. The theoretical model generates a time sequence of economic events for real estate income and value cycles observed in prior empirical real estate cycle research. We also estimate and test an econometric model specification, based on the theoretical model, using MSA level data for 20 office markets in the U.S. Our model estimation shows that our theoretical model of real estate cycles is consistent with observed real estate income and value cycles. 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. Our approach represents an improvement on earlier research efforts in the development of inferential tools for real estate academics and practitioners.

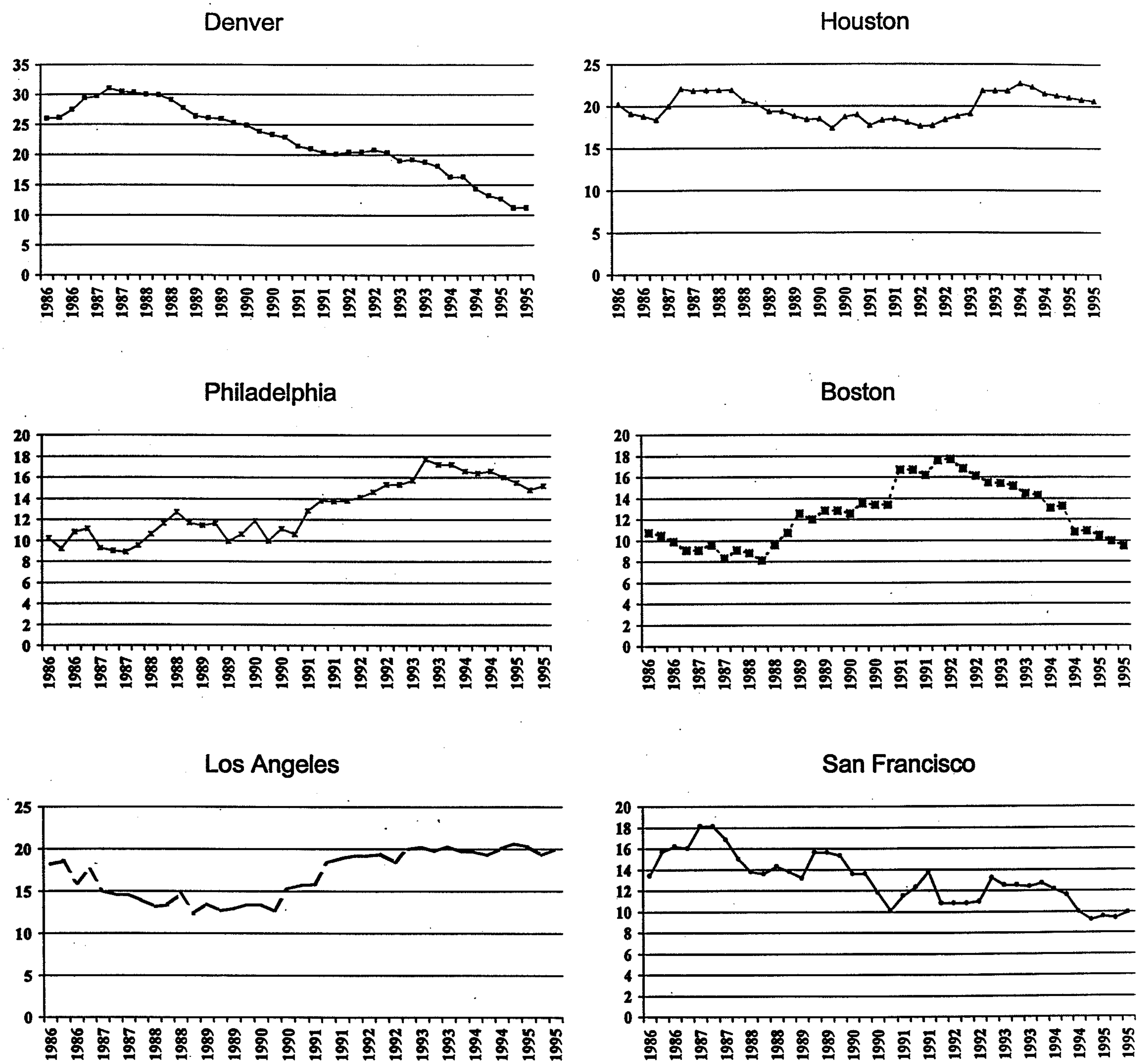
I. Introduction

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. Even though the economy itself may have changed, real estate cycles remain. The most recent example of the commercial real estate cycle occurred in the late 1980's and early 1990's. The unusual and severely distressed state of the U.S. commercial real estate markets during this period has been followed with an upturn of these markets in the mid 1990's.

Commercial real estate markets across cities were not uniformly depressed from the late 1980's to the early 1990's, suggesting that cyclical behavior in various geographic real estate markets is asynchronous. For example, in 1987, data from Coldwell Banker (figure 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%.[2]

In addition, real estate cycles are difficult to characterize because of varying severity across different real estate sectors. For example, the magnitude of the

Figure 1: MSA office vacancy rates (percent) 1985:4 – 1995:4



nationwide downturn in residential real estate markets during the late 1980's and early 1990's appears to be the worst since the great depression. But commercial real estate market episodes of the 1960's and 1970's are by no means dissimilar in direction or severity to those observed more recently in residential markets.[3]

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[4]. A number of earlier research efforts develop behavioral models that examine the interrelationships between economic variables, real estate income and real estate values[5]. This paper confirms and furthers our understanding of the cyclical nature of real estate income and value.

The main objective of this paper is to extend earlier 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.

Our paper is subdivided into four subsequent sections. First, we introduce the reader to a selective review of the germane real estate cycle literature. We then proceed with the prime focus of this paper: we develop a theoretical model of real estate market cycles. We use this theoretical model in section IV to evaluate and statistically fit the model against actual market data. This enables us to ascertain if our real estate cycle theory is consistent with the observed market behavior. Finally, in the last section, we place our conclusions in perspective and suggest a strategy for future research in real estate cycles, as well as discuss the potential practical applications for our analysis.

II. A Selective Review of the Real Estate Cycle Literature

II.1 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. Burns and Grebler (1982) uncovered six residential and four non-residential construction cycles in the United States between 1950 and 1978. Pritchett's (1984) analysis indicates that the magnitudes of the construction cycles for office, industrial and retail are different, with office the most volatile, industrial the least volatile and with retail somewhere in between the two.

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[6] series lags gross domestic product. Although Green does not provide us with 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, 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, Crone and Voith (1988), for seventeen United States metropolitan statistical areas, uncover significant cyclical vacancy differences between major city office markets. These findings are reinforced by Dokko, et. al. (1991), who demonstrate that local market conditions and macro-economic 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. Torto and Wheaton (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 (1987) and Torto and Wheaton (1988) did not find prices or interest rates statistically significant in explaining rent adjustments in national aggregates of the office markets, Rosen (1984) finds financial variables are statistically significant using metropolitan statistical area --local market-- 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 Crone and Voith (1988), Dokko, et. al. (1991) and others[7].

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.

II.2 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[8]. 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[9]. 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 upon 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[10]. 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 <u>expected</u> 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.

Born and Pyhrr (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"[11].

II.3 <u>The Typical Regional Real Estate Cycle</u>

Several research efforts have been devoted to examining the interrelationships among regional and economic factors and real estate market cycles. For examples, see, Pyhrr, et. al., (1994, 1990, a, b), Pritchett (1977), Voith and Crone (1988), 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[12]. 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 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. The cap rate (lagged) declines following this cyclical upturn[13].

III. A Model of Real Estate Value Cycles

Our strategy is to develop a model of real estate value cycles that depends upon 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 for our analysis 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[14].

$$\ln V = C_v + \delta(\ln Y_s^*) \qquad (1)$$

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.

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 resultant 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, we remove the trend in Y^*_s. Second, we assume an adjustment process between observable NOI and de-trended, stabilized NOI.

Abstracting from the trend for stabilized net operating income 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.

$$\ln Y_S = \ln Y_S^* - \beta t - C_Y \qquad (2)$$

Where $\ln Y_s$ = the natural logarithm of de-trended expected stabilized NOI, and

C_Y = a logarithmic constant in stabilized NOI.

Substituting equation (2) into equation (1) we obtain yields equation (3):

$$\ln V = C^* + \delta \ln Y_s + \delta\beta t \qquad (3)$$

where, in Equation (3), 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)[15]:

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

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

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

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 our 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:

$$\ln Y = \left(\frac{1}{\omega}\right)\left(\frac{\dot{Y}_s}{Y_s}\right) + \ln Y_s \qquad (5)$$

Using equations (3) and (5), we can express expected de-trended stabilized NOI 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 (6). This equation is expressed solely in terms of observable market data:

$$\ln Y = \left(\frac{1}{\delta\omega}\right)\left(\frac{\dot{V}}{V}\right) + \left(\frac{1}{\delta}\right)\ln V - \beta t - \left(\frac{\beta}{\omega}\right) + C^{**} \quad (6),$$

where C** = -C*/δ, is a generalized constant.

In equation (6), 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. And two of the coefficients are non-parametric constants: C_v and C_y, which are embedded in C**.

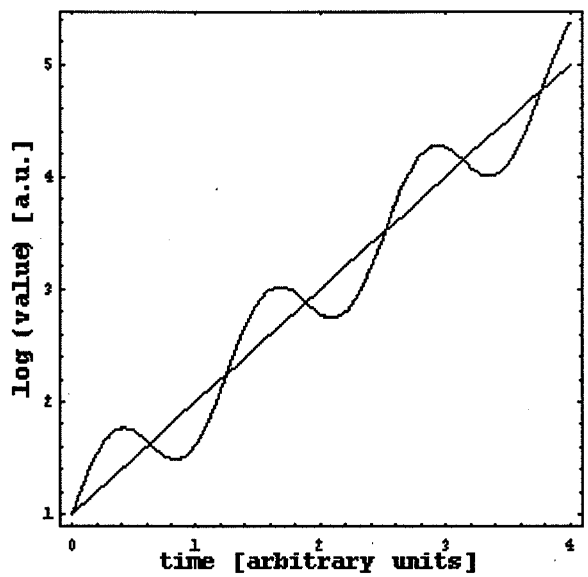
Since we are interested in understanding the real estate cycle relationship between observable NOI and V, we take the time derivative of equation (6). This yields equation (7), a full characterization of a local market real estate cycle in terms of β, δ, and ω:

$$\left(\frac{\dot{Y}}{Y}\right) = \left(\frac{1}{\delta\omega}\right)(\dot{g}_v) + \left(\frac{1}{\delta}\right)g_v - \beta \qquad (7)$$

g_v is the instantaneous rate of change in fair market value, expressed in percent terms, $\dot{V}/V$. We define $\dot{g}_v$ in the following way: $\dot{g}_v$ is the time derivative of g_v and is the instantaneous rate of change for the percent change of fair market value[16]. Equation (7) has the trend removed, and is expressed in terms of "observable" market data for actual NOI and parcel market values. We can utilize equation (7) to trace out the dynamics of the cycles for observable net operating income, Y, and property fair market values, V. Equation (7) also permits us to examine the time sequencing of our expected real estate income and value cycles.

To examine the cyclical pattern of real estate income and real estate value, we subsume, for convenience and illustration purposes, a simple smooth de-trended sine function cycle for income and thus value growth –see figure 2. Under the assumed sine cycle with a constant trend rate for income growth, value will grow exponentially with a cycle around this trend. Figure 2, with the axes of time, t and log-value, V, show the expected exponential value growth with a cyclical fluctuation around this trend.

Figure 2. Log of Value over time

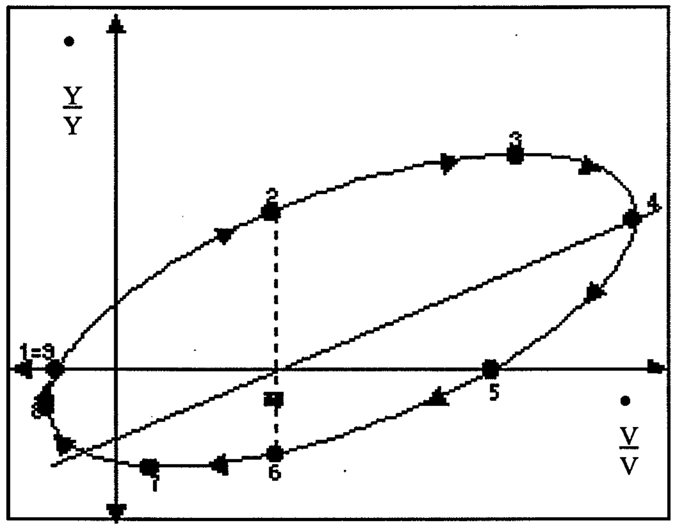


Figures 3 and 4 translate equation (7) and our cycle into a graphical presentation[17]. The axes for figure 3 are $\frac{\dot{V}}{V}$, defined as g_V, and $\frac{\dot{Y}}{Y}$, defined as g_Y. For figure 4, the axes measure g_v and $\dot{g}_v$. In figure 3, the second term of the right hand side of equation (7) is shown as the oblique straight line intercepting the growth in value, g_V, axis at $\delta\beta$. To understand why this is so, 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 slope of $1/\delta$, the reciprocal of the income capitalization rate from equation (1).

Figure 3. The Cyclical Relationship between NOI and Property Value

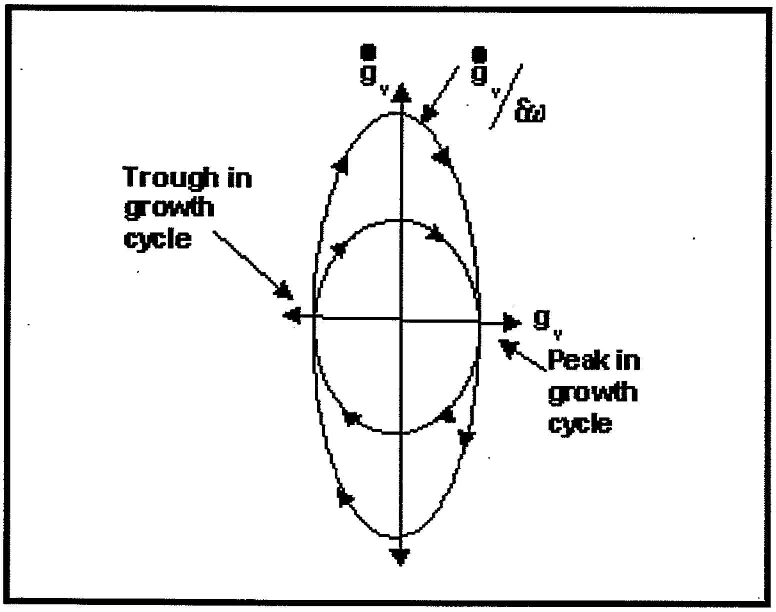
Growth in income, g_y



Growth in value, g_v

In figure 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 (7), $\dot{g}_v$ is divided by $\delta\omega$, creating the elliptical path around the first circle. For each value of g_v, in figure 4, we add $\dot{g}_v/\delta\omega$ to the straight line --the second term on the right hand side in equation (7)-- at the corresponding value of g_v to obtain the ellipsoid relationship between g_v and $\dot{g}_v$ in figure 4.

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



As can be seen from this schematic analysis of figures 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 Table 1, with corresponding numbered positions in figure 3.

Table 1. 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

Because δ is anticipated to be greater than unity, using equation 1, a one percent 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, as previously mentioned, our 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.

IV. Empirical Results

IV.1 The Statistical Model and Data Set

We employ equation (8) to estimate and test our model from section III[18]. Equation (8) is the statistical version of equation (6):

$$\ln Y = a_0 + a_1 \ln V + a_2\left(\dot{V}/V\right) + a_3 t + \varepsilon \quad (8)$$

The coefficients to be estimated are functions of the cyclical parameters defined in the theory section. 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 presented in section III; for every city, for the four coefficients, a_0, a_1, a_2, a_3, of equation (8), we are unable algebraically to unravel the five parameters needed to identify equation (6). However, the same four coefficients permit the identification of the cyclic parameters β, δ, and ω. In particular, we can solve for the following: $\beta = -a_3$, $\delta = (1/a_1)$, and $\omega = a_1 / a_2$. Thus, a complete analysis of the income and value cycles is possible, even though full identification of equation (6) is not.

The econometric specification of our cyclical model is a system of twenty simultaneous equations, one for each of the twenty metropolitan office markets from our data set[19]. Using the method of three-stage least squares (3SLS), we estimate this system of equations to obtain the four coefficients of equation (8)[20] [21]. The 3SLS procedure takes into account the impact of structural supply and demand instruments upon the closed form system of 20. 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[22].

Table 2 summarizes the quarterly time series (1985:4 to 1995:2) for the 20 MSA's employed in the estimation of the model: NOI, Market Value and growth in Market Value. In addition, the table lists eighty-four instrumental variables utilized during the second stage of the 3SLS estimation of the twenty-equation system.

Table 2. 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

IV.2 Statistical Findings

Tables 3 and 4 contain two significant groups of results from our estimation; table 3 shows the consistent and unbiased estimates for the equation (8) coefficients a_0, a_1, a_2, a_3, with their respective t-Statistics. Table 4 reports the results of unit root tests performed on the time series vector of residuals for the system of twenty office markets we estimated using 3SLS[23]. Other summary regression statistics for the model are shown in Appendix 1.

The individual t-statistics in table 3 show that seventy of the eighty coefficients for equation (8) are significantly different from zero at the 95% confidence level. For convenience, we shade the coefficients that are statistically insignificant.

The estimated coefficients statistically differ from city to city[24]. This result is consistent with Crone and Voith (1988), and with Dokko, et. al. (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.[25]

Table 3. Estimated Coefficients, t-Statistics and Implied Model Parameters

Model Coefficient	Coefficient Estimate	t-statistic	Model Coefficient	Coefficient Estimate	t-statistic
Atlanta a_0	-0.1829	-1.06354	Min. a_0	-2.2625	-26.3842
Atlanta a_1	0.5421	15.7656	Min. a_1	0.9498	55.5605
Atlanta a_2	0.0555	1.99469	Min. a_2	-0.21437	-15.9763
Atlanta a_3	-0.0022	-7.67128	Min. a_3	0.0027	6.00521
Baltimore a_0	-0.9120	-16.3742	New Orl. a_0	-0.0579	-0.293985
Baltimore a_1	0.6696	58.6961	New Orl. a_1	0.4890	11.9783
Baltimore a_2	-0.0570	-4.80172	New Orl. a_2	0.0440	1.15448
Baltimore a_3	0.0010	6.13632	New Orl. a_3	0.0012	2.56672
Boston a_0	-0.6224	-9.2551	Phil. a_0	-0.8455	-6.375
Boston a_1	0.6251	54.094	Phil. a_1	0.6608	25.1473
Boston a_2	-0.0296	-2.9642	Phil. a_2	-0.2374	-9.99967
Boston a_3	0.0020	5.17156	Phil. a_3	0.0046	27.5308
Charlotte a_0	-1.2846	-24.9461	Phoenix a_0	-0.9982	-8.26506
Charlotte a_1	0.7551	72.4133	Phoenix a_1	0.7050	28.7766
Charlotte a_2	-0.0162	-1.90713	Phoenix a_2	-0.2278	-9.22471
Charlotte a_3	0.0011	6.67683	Phoenix a_3	-0.0015	-4.17259
Chicago a_0	-0.2348	-2.81122	Sac a_0	-1.0489	-8.02781
Chicago a_1	0.5751	39.3674	Sac a_1	0.7178	27.3825
Chicago a_2	0.1001	6.51337	Sac a_2	-0.0782	-3.27488
Chicago a_3	-0.0007	-1.78006	Sac a_3	0.0001	0.289406
Dallas a_0	-1.0519	-6.30743	San Diegoa_0	-1.4669	-25.2181
Dallas a_1	0.7101	20.8407	San Diegoa_1	0.7771	69.1498
Dallas a_2	0.0885	3.67832	San Diegoa_2	0.0333	2.98036
Dallas a_3	0.0025	5.18547	San Diegoa_3	0.0041	17.2521
Denver a_0	-0.5750	-10.9154	S.F. a_0	-0.5621	-4.31211
Denver a_1	0.6301	53.8165	S.F. a_1	0.5652	24.3175
Denver a_2	0.2092	17.0463	S.F. a_2	-0.1963	-9.81186
Denver a_3	-0.0061	-16.2707	S.F. a_3	0.0060	8.83546
Houston a_0	-0.1426	-3.50898	Seattle a_0	-1.4207	-9.10457
Houston a_1	0.5146	59.2008	Seattle a_1	0.7786	25.3064
Houston a_2	-0.2908	-43.5298	Seattle a_2	-0.1792	-7.89092
Houston a_3	-0.0001	-0.36446	Seattle a_3	0.0019	7.81595
L.A a_0	0.6420	6.48826	Tampa a_0	-0.1080	-0.688346
L.A a_1	0.4165	24.1912	Tampa a_1	0.5262	16.51
L.A a_2	0.0118	0.903302	Tampa a_2	0.0711	3.58404
L.A a_3	-0.0020	-6.6413	Tampa a_3	-0.0050	-11.1527
Miami a_0	-0.1366	-1.50978	D.C. a_0	0.1629	2.04746
Miami a_1	0.5392	26.6061	D.C. a_1	0.4938	35.6114
Miami a_2	-0.0935	-6.71705	D.C. a_2	0.0184	2.16127
Miami a_3	-0.0020	-2.9009	D.C. a_3	0.0027	8.13106

With regards to the unit root tests in Table 4, they confirm the stationarity of our regression residuals and hence the unbiasedness and consistency of our estimated model coefficients[26]. In all Phillips and Perron, Augmented Dickey Fuller and Weighted Symmetric Test Statistics, for all twenty office markets, and for lags of at most 7 quarters, table 4 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 regression specification for all 20 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 3 quarters in most cases, except for the cases of Phoenix and Boston –where stationarity is still present for lags in variables of up to 2 quarters.

Table 4. Summary of Unit Root Tests Performed on the Regression Residuals for the 20 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
-4.2040	-3.9965	-2.2873	-4.1044	-2.7248	3	3	2	3	3	0.0025	0.0047	0.4388	0.0034	0.1745
-3.8409	-3.7863	-2.8617	-3.8302	-2.8824	3	3	2	3	3	0.0146	0.0173	0.1752	0.0151	0.1683
-13.4734	-9.9844	-11.0213	-18.2277	-15.9578	3	3	2	3	3	0.2452	0.4372	0.3712	0.1002	0.1551
DAL	DEN	HOU	LA	MIA	DAL	DEN	HOU	LA	MIA	DAL	DEN	HOU	LA	MIA
-1.3646	-3.1979	-2.8107	-2.7619	-3.4801	3	3	3	3	3	0.9249	0.0489	0.1405	0.1591	0.0216
-1.2187	-3.2628	-3.1705	-2.5901	-3.4533	2	3	3	3	3	0.9066	0.0726	0.0904	0.2845	0.0447
-4.5167	-12.3466	-11.6747	-15.2942	-16.2589	2	3	3	3	3	0.8546	0.2981	0.3337	0.1757	0.1465
MIN	ORL	PHI	PHO	SAC	MIN	ORL	PHI	PHO	SAC	MIN	ORL	PHI	PHO	SAC
-2.7819	-2.4352	-3.4616	-2.4312	-2.6315	3	3	3	2	3	0.1513	0.3344	0.0228	0.3370	0.2184
-2.9002	-2.4676	-3.2667	-2.1132	-2.3285	3	3	3	2	3	0.1621	0.3444	0.0719	0.5387	0.4183
-9.8924	-4.9529	-13.6298	-10.8046	-11.3340	3	3	3	2	3	0.4434	0.8247	0.2384	0.3844	0.3529
SD	SF	SEA	TPA	DC	SD	SF	SEA	TPA	DC	SD	SF	SEA	TPA	DC
-3.6033	-2.6422	-4.6620	-3.0228	-3.8245	3	3	3	3	3	0.0151	0.2130	0.0006	0.0798	0.0078
-3.3574	-2.6521	-4.0416	-2.7458	-3.5533	3	3	3	3	3	0.0573	0.2565	0.0077	0.2176	0.0340
-10.3966	-9.4727	-14.2627	-8.7058	-12.5109	3	3	3	3	3	0.4100	0.4726	0.2125	0.5289	0.2899

IV.3 Implied Real Estate Cycles

From our statistical results in Table 3, we compute the parameters, $\beta, \delta,$ and ω[27]. Fifty-four of the sixty coefficients used in the computations are statistically significant. We report the "implied" cyclic-parameters $\beta, \delta,$ and ω, for the 20 MSAs, in Table 5. Even the six statistically insignificant estimated coefficients used to produce implied model parameters, $\beta, \delta,$ 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 cyclic parameters yield cyclic parameter values for our theoretical equation (6) -- within theoretical model bounds.

Table 5. MSA-specific, Implied Model Parameters

Model Parameter	Parameter Value	Model Parameter	Parameter Value
Atlanta		Minneapolis	
β-trend	.22	β-trend	-.27
δ-cap	1.845	δ-cap	1.053
ω-expectations	.0977	ω-expectations	-.0887
Baltimore		Orlando	
β-trend	-.10	β-trend	-.12
δ-cap	1.493	δ-cap	2.045
ω-expectations	-.1175	ω-expectations	.1112
Boston		Philadelphia	
β-trend	-.20	β-trend	-.46
δ-cap	1.600	δ-cap	1.513
ω-expectations	-.2114	ω-expectations	-.0557
Charlotte		Phoenix	
β-trend	-.11	β-trend	.15
δ-cap	1.324	δ-cap	1.418
ω-expectations	-.4670	ω-expectations	-.0619
Chicago		Sacramento	
β-trend	.07	β-trend	-.01
δ-cap	1.739	δ-cap	1.393
ω-expectations	.0574	ω-expectations	-.0918
Dallas		San Diego	
β-trend	-.25	β-trend	-.41
δ-cap	1.408	δ-cap	1.287
ω-expectations	.0802	ω-expectations	.2335
Denver		San Francisco	
β-trend	.61	β-trend	-.60
δ-cap	1.587	δ-cap	1.769
ω-expectations	.0602	ω-expectations	-.0576
Houston		Seattle	
β-trend	.01	β-trend	-.19
δ-cap	1.943	δ-cap	1.284
ω-expectations	-.0354	ω-expectations	-.0869
Los Angeles		Tampa	
β-trend	.20	β-trend	.50
δ-cap	2.401	δ-cap	1.900
ω-expectations	.3544	ω-expectations	.0740
Miami		Washington D. C.	
β-trend	.20	β-trend	-.27
δ-cap	1.855	δ-cap	2.025
ω-expectations	-.0577	ω-expectations	.0672

Using the calculated cyclic parameters reported in table 5, inferences may be drawn about the nature of income cycles --and thus value cycles-- in different cities. For example, our estimated parameter values indicate that eight of the twenty MSA's 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 12 MSA's show a negative secular growth trend in office market NOI. These results coincide with the perceived downturn in commercial real estate during the late 1980's and early 1990's.

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 our 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, our model estimates that a 1% change in NOI will cause a quarterly growth rate in market value of 1.053% to 2.401% for our selected MSA's. 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 our data set consists of information for about a decade, our findings need to be interpreted with care.

IV.4 Other Empirical Observations About our Model

The success in the estimation of this model specification is also evident in Figure 5, 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 (refer to table 4), reveal no apparent econometric problems with residuals from the regression of our twenty MSA's.

A close examination of Figure 5, in the light of our statistical results, suggests three major conclusions about our model of real estate cycles. First, the estimated values of NOI by office market (MSA) derived from our 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 for our sample period. Our findings are consistent with our theoretical model as well as findings of earlier studies. Put somewhat differently, our theory conforms to earlier cycle assessments, whether stylized facts or formal models, about the evolution of real estate cycles --with added advantage that it's 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.

V. Concluding Perspective

In this paper, we develop and statistically test a real estate cycles theory that examines the interrelationships among economic activity and real estate in come and value cycles. While our findings reinforce those of many earlier studies, our 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 its associated structural explanations of cycles represent potentially useful knowledge advancements for both academics and practitioners. Understanding real estate price volatility, correlations, and auto-correlations 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 statistical 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. A city specific cycle capitalization rate, δ, which captures the relative volatility of the city cycle. A city trend growth rate, β, that synthesizes the citywide market value trend fundamentals. And a city specific cyclical adjustment, ω, that reflects the dynamic duration of the city cycle.

By utilizing 3SLS, we are able to incorporate into our 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 upon parcel value and cash flow (income) should enhance practitioner's ability to determine the locus of expected rewards and risks, leading to enhanced decision-making. Our 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 our 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.

Also, 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.

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

It is our hope that our analyses should stimulate others to continue rigorous research that combines and links real estate cycle theory, available real estate cycle data and enhanced empirical techniques to study the nature of real estate cycles.

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.

Figure 5. Actual vs. Fitted NOI for 20 Office Markets Used in Regression Estimation

Actual versus Fitted NOI: Atlanta, Baltimore, Boston and Charlotte
1986:4 to 1995:2

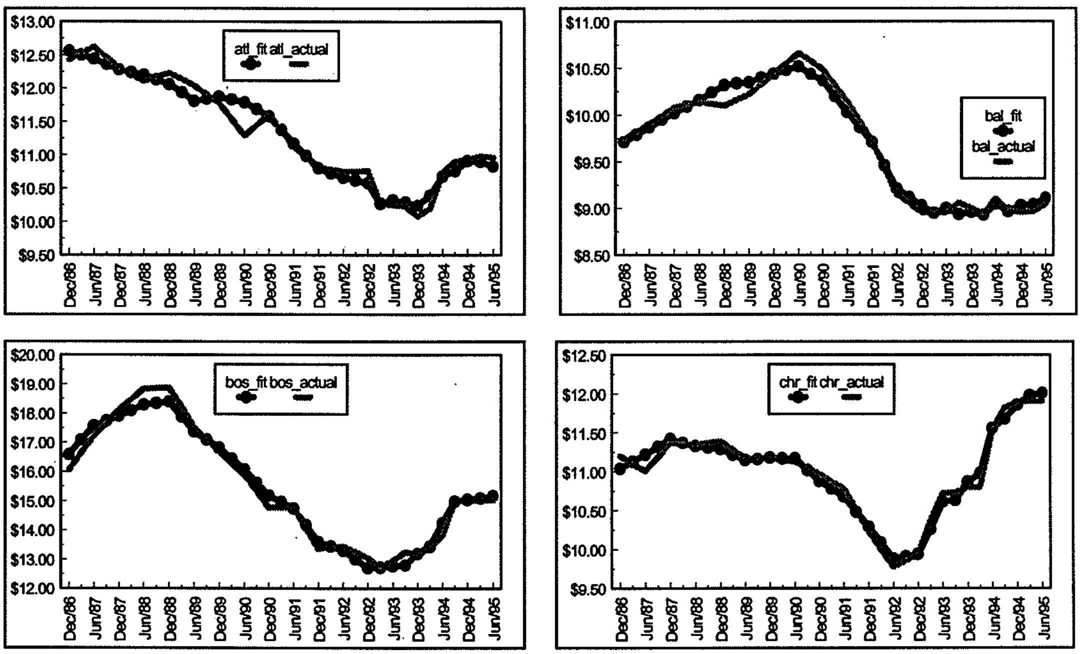


Figure 5. Actual vs. Fitted NOI for 20 Office Markets Used in Regression Estimation

Actual versus Fitted NOI: Chicago, Dallas, Denver and Houston
1986:4 to 1995:2

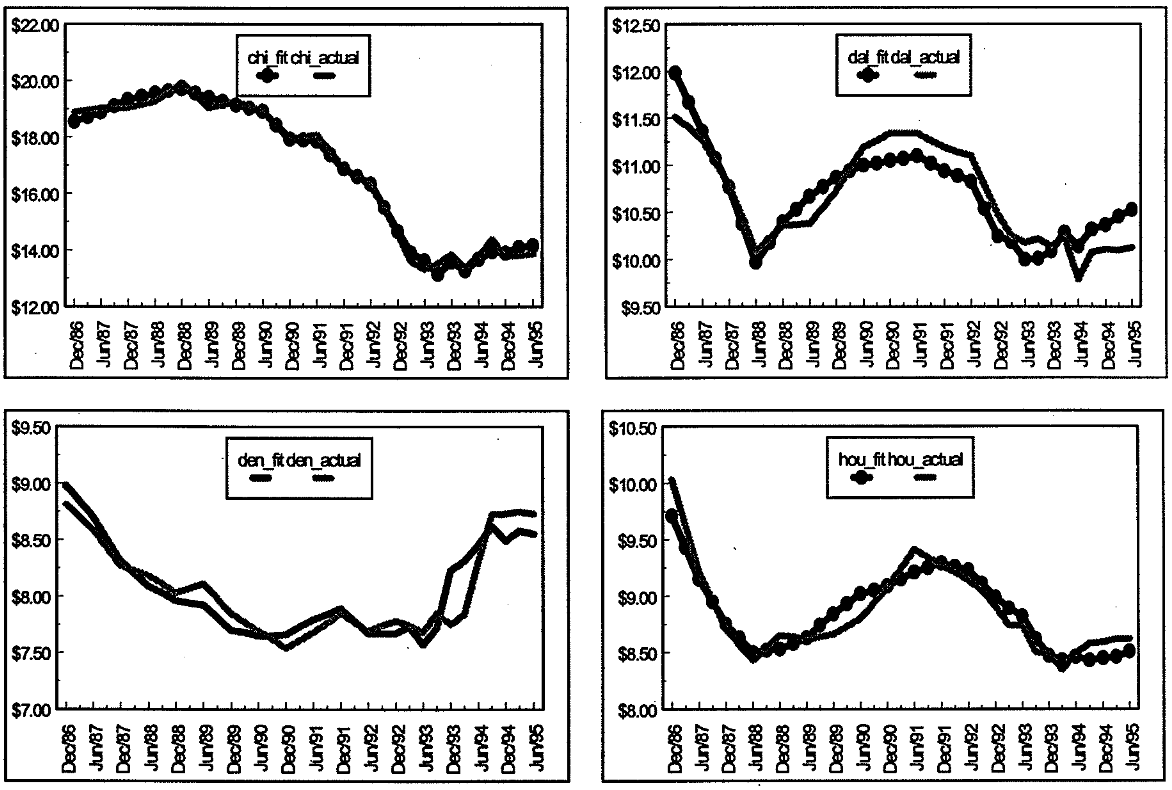


Figure 5. Actual vs. Fitted NOI for 20 Office Markets Used in Regression Estimation

Actual versus Fitted NOI: Los Angeles, Miami, Minneapolis and Orlando
1986:4 to 1995:2

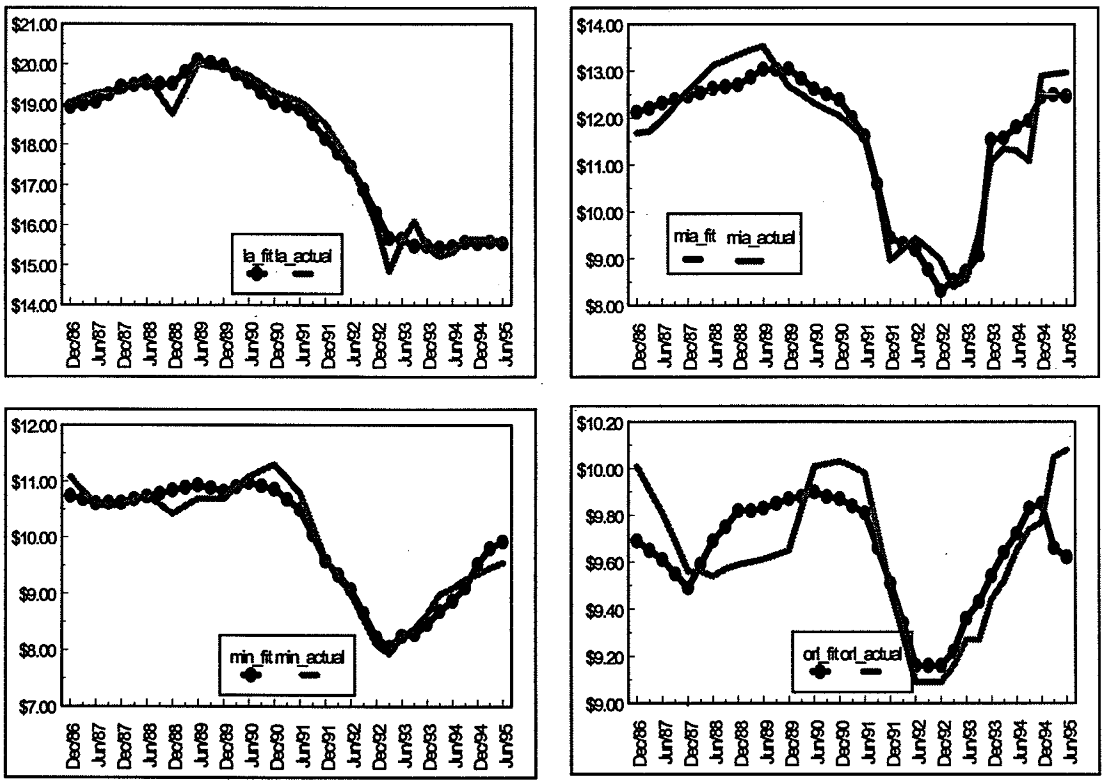


Figure 5. Actual vs. Fitted NOI for 20 Office Markets Used in Regression Estimation

Actual versus Fitted NOI: Philadelphia, Phoenix, Sacramento and San Diego
1986:4 to 1995:2

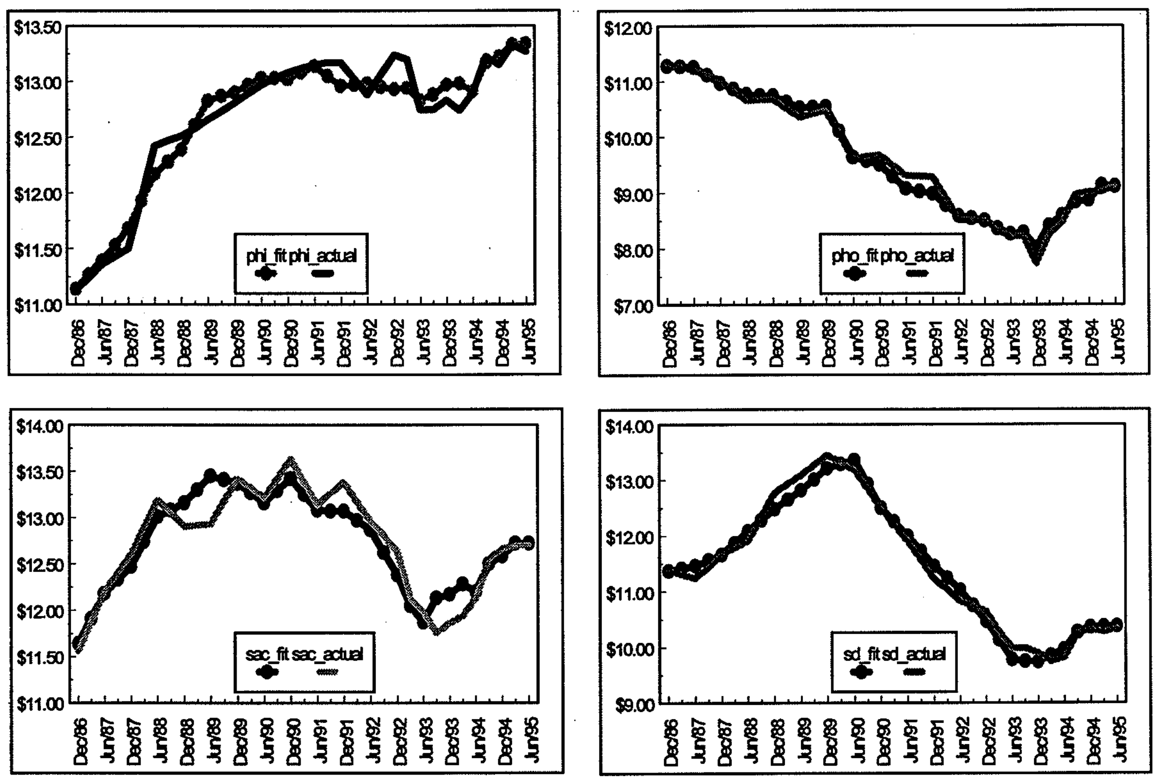
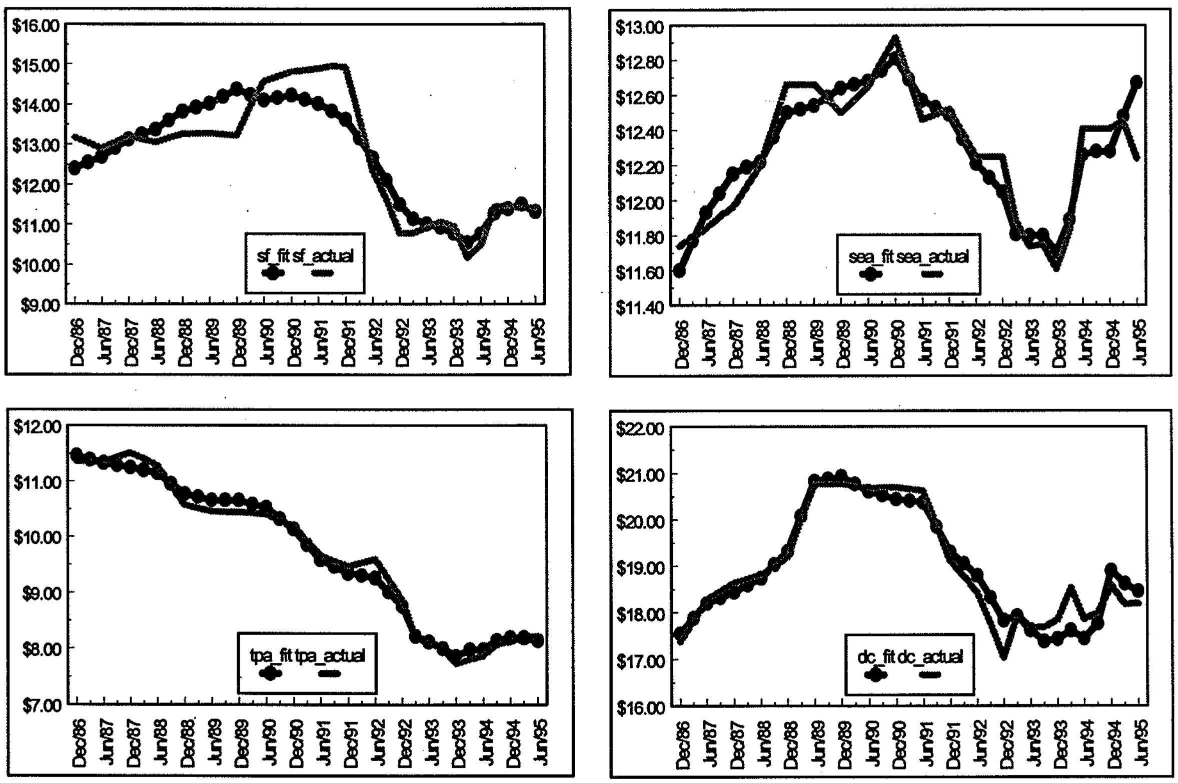


Figure 5. Actual vs. Fitted NOI for 20 Office Markets Used in Regression Estimation

Actual versus Fitted NOI: San Francisco, Seattle, Tampa and D.C.
1986:4 to 1995:2



VI. References

1. Ambrose, Brent and Hugh Nourse, "Factors Influencing Capitalization Rates," The Journal of Real Estate Research, Vol. 8, No. 2, (Spring, 1993), pp. 221-238.

2. Case, Karl and Robert Shiller, "Forecasting Prices and Excess Returns in the Housing Market," Journal of the American Real Estate and Urban Economics Association, Vol. 18, No. 3, (Fall, 1990) pp. 253-273.

3. Chinloy, Peter, "Real Estate Cycles and Empirical Evidence," Journal of Housing Research, vol. 7, Vol. 2, (1996).

4. Clapp, John M., Dynamics of Office Markets: Empirical Findings and Research Issues, AREUEA Monograph Series, Vol. 1, 1993

5. Clayton Pritchett, "The Effect of Regional Growth Characteristics on Regional Housing Prices," Journal of the American Real Estate and Urban Economics Association, Vol. 5, (Summer, 1977) pp. 189-208.

6. Corgel, John and Gerald Gay, "Local Economic Base, Geographic Diversification, and Risk management of Mortgage Portfolios," Journal of the American Real Estate and Urban Economic Association, Vol. 15, (Fall, 1987) pp. 256-267.

7. Crone, Theodore and Richard Voith, "National Vacancy Rates and the Persistence of Shocks in U.S. Office Markets," Journal of the American Real Estate and urban Economic Association, (Winter, 1988) pp. 437-458.

8. Dokko, Yoon, Robert Edelstein and Scott Urdang, "Does Credit Rationing Affect Residential Construction? Déjà vu All over Again," Journal of Real Estate Finance and Economics, Vol. 3 (1990) pp. 357-371.

9. Dokko, Yoon, Robert Edelstein, Marshall Pomer and Scott 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, Vol. 19, (Spring, 1991) pp. 52-69.

10. Edelstein, Robert H. and Irwin Friend, "Allocating Resources to Housing: the Private Sector," Proceedings of the First Annual Conference on Housing, Federal Home Loan Bank of San Francisco, (1976).

11. Froland, Charles, "What Determines Cap Rates on Real Estate?" The Journal of Portfolio Management, (Summer, 1987), pp. 55-60.

12. Gatzlaff, Dean and Dogan Tirtiroglu, "Real Estate Market Efficiency: Issues and Evidence," Working Paper, (June, 1993).

13. Grebler, Leo and Leland Burns, "Construction Cycles in the United States Since World War II," Journal of the American Real Estate and Urban Economics Association, Vol. 10 (Summer, 1982) pp. 123-151.

14. Green, Richard K. "Follow the Leader: How Changes in Residential and Non-residential Investment Predict Changes in GDP," Real Estate Economics, Vol. 25, No. 2, 1997, pp. 253-270.

15. Grenadier, Steven, "The Persistence of Real Estate Cycles," Journal of Real Estate Finance and Economics, Vol.10, No. 2, March 1995.

16. Harris, Jack and Waldo Born, "Timing Real Estate Acquisitions," Real Estate Review, (Summer, 1986) pp. 79-83.

17. Hartzell, David, John Hekman and Mike Miles, "Real Estate Returns and Inflation," Journal of the American Real Estate and Urban Economics Association, (Spring, 1987) pp. 617-637.

18. Hekman, John, "Rental Price Adjustment and Investment in the Office Market," Journal of the American Real Estate and Urban Economics Association, (Spring, 1985) pp. 32-47.

19. Hendershott, Patrick and Edward Kane, "US Office Market Value During the Past Decade: How Distorted Have Appraisals Been?" Real Estate Economics, Vol. 23, No. 2, (Summer 1995).

20. Jaffee, Dwight and Kenneth T. Rosen, "Mortgage Credit Availability and Residential Construction," Brookings Papers on Economic Activity, Vol. 2 (1979), pp. 333-386.

21. Kling, John and Thomas McCue, "Office Building Investment and the Macroeconomy: Empirical Evidence, 1973-1985," Journal of the American Real Estate and Urban Economics Association, Vol. 15, (Fall, 1987) pp. 234-255.

22. Koopmans, Tjalling C. "Measurement without Theory," Review of Economics and Statistics, Vol. 29, August, 1947.

23. Leybourne, S.J. "Testing for Unit Roots: A Simple Alternative to Dickey-Fuller," Applied Economics, Vol. 26, No. 7, July, 1994, pp.721-729.

24. Meese, Richard and Nancy Wallace, "Testing the Present Value Relation for Housing Prices: Should I Leave my House in San Francisco?" Working paper, (November, 1992)

25. Meese, Richard and Nancy Wallace, "Determinants of Residential Housing Prices: Effects of Economic Factors or Speculative Bubbles?" Working Paper No. 91-193, IBER, U.C. Berkeley.

26. Mueller, Glenn, "Understanding Real Estate's Physical and Financial Market Cycles," Real Estate Finance, Vol. 12, No. 3, Fall 1995, pp. 47-52.

27. 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.

28. Peiser, Rick, "Capitalization Rates, Inflation and Investment Analysis in U.S. Real Estate," Appraisal Review Journal, (Spring/Summer, 1983) pp. 42-43.

29. Pritchett, Clayton, "Forecasting the Impact of Real Estate Cycles on Investment," Real Estate Review, (Winter, 1984) pp. 85-89.

30. Pyhrr, Stephen A., and Waldo L. Born, "Real Estate Valuation: The Effect of Market and Property Cycles," The Journal of Real Estate Research, Vol. 9, No. 4, (Fall, 1994), pp. 455-486.

31. Pyhrr, Stephen A., Waldo L. Born and James R. Webb, "Development of a Dynamic Investment Strategy under Alternative Inflation Cycle Scenarios," The Journal of Real Estate Research, Vol. 5, No. 2, (Summer, 1990), pp. 177-194.

32. Pyhrr, Stephen A., James R. Webb and Waldo L. Born, "Analyzing Real Estate Asset Performance During Periods of Market Disequilibrium Under Cyclical Economic Conditions: A Framework for Analysis," pp. 75-106 in Kappline, and Schwartz, editors, Research in Real Estate, Vol. 3, 1990.

33. Rayburn, William, Michael Devaney and Richard Evans, "A Test of Weak-Form Efficiency in Residential Real Estate Returns," Journal of the American Real Estate and Urban Economics Association. Vol. 15, (Fall, 1987) pp. 220-233.

34. Rosen, Kenneth, "Toward A Model of the Office Building Sector," Journal of the American Real Estate and Urban Economics Association. Vol. 12, (Fall, 1984) pp. 261-269.

35. Sagalyn, Lynne B., "Real Estate Risk and the Business Cycle: Evidence from Security Markets," The Journal of Real Estate Research, Vol. 5, No. 2, (Summer, 1990), pp. 203-220.

36. Wheaton, William, "Vacancy, Search, and Prices in a Housing Market Matcing Model," Journal of Political Economy, Vol. 98, No. 6, 1990.

37. Wheaton, William, "The Cyclical Behavior of the National Office Market," Journal of the American Real Estate and Urban Economics Association (Winter, 1987), pp. 281-299.

38. Wheaton, William and Ray Torto, "Vacancy Rates and The Future of Office Rents," Journal of the American Real Estate and Urban Economics Association (Winter, 1988) pp. 430-436.

Appendix 1: Summary Regression Statistics

Dependent Variable: NOI				
MSA	**ATLANTA**	**MINNEAPOLIS**	**DALLAS**	**SAN DIEGO**
Mean of dependent variable	2.42811	2.29305	2.3671	2.43486
Std. dev. of dependent var.	0.068047	0.10621	0.047822	0.101372
Sum of squared residuals	5.92E-03	0.015562	0.015751	6.49E-03
Variance of residuals	1.69E-04	4.45E-04	4.50E-04	1.85E-04
Std. Error of regression	0.013005	0.021086	0.021214	0.013619
R-squared	*0.962402*	*0.959479*	*0.798321*	*0.981429*
Durbin-Watson statistic	0.683164	0.321424	0.224591	0.543682
MSA	**BALTIMORE**	**ORLANDO**	**DENVER**	**SAN FRANCISCO**
Mean of dependent variable	2.27216	2.2652	2.08533	2.54124
Std. dev. of dependent var.	0.062335	0.030979	0.048717	0.115402
Sum of squared residuals	2.64E-03	0.011751	0.013807	0.062531
Variance of residuals	7.53E-05	3.36E-04	3.94E-04	1.79E-03
Std. Error of regression	8.68E-03	0.018323	0.019862	0.042268
R-squared	**0.980194**	**0.640939**	**0.838615**	**0.863607**
Durbin-Watson statistic	0.441927	0.321564	0.720328	0.389168
MSA	**BOSTON**	**PHILADELPHIA**	**HOUSTON**	**SEATTLE**
Mean of dependent variable	2.73211	2.53859	2.18073	2.50798
Std. dev. of dependent var.	0.128009	0.051403	0.041645	0.029065
Sum of squared residuals	0.010644	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	0.017439	0.01021	0.0134	0.010046
R-squared	*0.980904*	*0.95954*	*0.894243*	*0.877472*
Durbin-Watson statistic	0.604194	0.892301	0.444244	0.796101
MSA	**CHARLOTTE**	**PHOENIX**	**LOS ANGELES**	**TAMPA**
Mean of dependent variable	2.39623	2.25861	2.88504	2.26663
Std. dev. of dependent var.	0.052196	0.110327	0.10364	0.13422
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	0.014137	0.016332	0.014596
R-squared	*0.975123*	*0.983122*	*0.974544*	*0.987832*
Durbin-Watson statistic	0.909326	0.635285	1.12291	0.320779
MSA	**CHICAGO**	**SACRAMENTO**	**MIAMI**	**WASHINGTON D.C.**
Mean of dependent variable	2.82315	2.54361	2.43745	2.94125
Std. dev. of dependent var.	0.146754	0.044523	0.145164	0.062695
Sum of squared residuals	5.98E-03	8.46E-03	0.046306	0.010019
Variance of residuals	1.71E-04	2.42E-04	1.32E-03	2.86E-04
Std. error of regression	0.013072	0.015548	0.036373	0.016919
R-squared	*0.991867*	*0.874834*	*0.936282*	*0.925867*
Durbin-Watson statistic	1.09463	0.580785	0.987515	0.601699

[1] A special thanks to Samir Dutt, Steven J. Manson, David Howe and David Sapoznikow for their research assistance, and the participants of the Real Estate PhD seminar at the Haas School of Business Administration, University of California at Berkeley for their invaluable suggestions. We also have benefited from many suggestions and comments from our colleagues and anonymous referees. We acknowledge and thank the Fisher Center for Real Estate and Urban Economics at the Haas School of Business for its generous support of this project. Of course, any remaining errors of omissions and/or commissions are our responsibility.

[2] 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.

[3] As Smith and Tesarek (1991) note, the price deflation of the late 1980's for residential real estate was the worst since the great depression. However, commercial real estate price fluctuations of a similar magnitude as those observed during the late 1980' and early 1990's have been historically observed in the past. Burns and Grebler (1982) provides 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.

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

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

[6] 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 there is none present, if the underlying model specification is incorrect. And 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.

[7] For an excellent review of the fundamental issues in the office market real estate literature and some of the papers reviewed herein, please refer to Clapp (1993).

[8] 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.

[9] Again refer to "Origins and Causes of the S&L Debacle: A Blueprint for Reform" (1993).

[10] See, for example, Dokko, et. al. (1990), Edelstein and Friend (1976) and Jaffee and Rosen (1979).

[11] Consistent with Grenadier's (1995) analysis, Meese and Wallace (1993) show that fundamental economic variables determine long run residential values, but with a significant adjustment lag.

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

[13] 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.

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

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

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

[17] Our results are robust with respect to different underlying cycles. Our 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:

$$dV = g_Y\, dY + gtdt + (1/2)gvdY^2 = e^c\delta Y^{\delta-1}dY + (1/2)e^c\delta(\delta-1)Y^{\delta-2}dY^2$$

$$= e^cY^\delta\{Y\mu[\bullet]dt + Y\sigma[\bullet]dz\} + (1/2)\, e^c\delta(\delta-1)\, Y^{\delta-2}\, Y^2\, \sigma^2[\bullet]dt.$$

Thus, $dV = e^c dY^\delta\{\mu[\bullet] + (1/2)(\delta-1)\sigma^2[\bullet]\}dt + e^c dY^\delta\sigma[\bullet]dz$

$= V^\delta\{\mu[\bullet] + (1/2)(\delta-1)\sigma^2[\bullet]\} + V^\delta\sigma[\bullet]dz$, 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 this last expression is identical to the first term in equation (4). But 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, we would put cycles from macroeconomic variables into the system by letting μ vary over time in some cyclic fashion. Likewise, taking the time derivative of equation (6) and expressing it in value terms we get that $\ln V = C(V) + d\ln Y + A(\delta,\omega,\beta)$, 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.

[18] Following our earlier discussion, in order to characterize the real estate value and income cycles it is sufficient to identify β, δ, and ω. Ideally, our econometric specification should mirror equation (7) of our model and not equation (6). However, equation (7) is impossible to estimate as we lack data that can reflect instantaneous changes in the rate of change of fair market value over time. If we were to difference the logarithm of our fair market value observations twice we would obtain incorrect "accelerators" for value and need to restructure our simultaneous equation system as one with an errors in variables problem. For simplicity, we use equation (6) as our model specification of choice as it is sufficient to yield identification of β, δ, and ω.

[19] All necessary data is 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 our 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.

[20] Three stage least squares allows us to estimate the income cycles in twenty cities simultaneously, while enabling us the 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.

[21] One year of data is lost in generating the log-differenced value data needed on the right hand side of equation (8) to obtain estimates of the four statistical coefficients a_0, a_1, a_2, a_3.

[22] Applying 3SLS to a simultaneous equation system will result in statistically efficient and consistent estimates for the coefficients in the 20-equation system –a total of 80 estimates, presented in table 3. These estimators are also unbiased, implying real estate cycles that are similar to results obtained in earlier studies andto our own theoretical cycles model. For a technical discussion on the merits of our claims about our estimated coefficients please refer to Amemiya (1988).

[23] 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 (1988) or any other textbook on time series analysis for technical reference.

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

[25] Inspection of Appendix 1 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 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 we report in Appendix 1 other, less significant statistics, as opposed to placing these in the main body of our paper. These results lend support to our belief that our theoretical model explains observed real estate NOI cycles (and thus value cycles) very well.

[26] For a formal treatment of the subject of testing for the presence of nonstationarity in our regression residuals please refer to Leybourne (1994).

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