

UC Berkeley

Fisher Center Working Papers

Title

Real Estate Value Cycles: A Theory of Market Dynamics

Permalink

<https://escholarship.org/uc/item/0gm2w91f>

Authors

Dokko, Yoon
Edlestein, Robert H.
Lacayo, Allan J.
et al.

Publication Date

1995-08-01

Peer reviewed



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. 95-238

**REAL ESTATE VALUE CYCLES:
A THEORY 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

Richard Sutch, 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 VALUE CYCLES: A THEORY OF MARKET DYNAMICS

Date: August, 1995¹

WORKING PAPER NO. 95-238

By
Yoon Dokko
Associate Professor
School of Business Administration
Ajou University, Korea

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

Allan J. Lacayo
Researcher
Fisher Center for Real Estate and Urban Economics
University of California at Berkeley

Daniel C. Lee
Associate Professor of Finance
School of Business Administration
California State University at Fullerton

ABSTRACT

This paper develops a theoretical model linking general economic cycles to real estate income and value cycles. The model generates a time sequence for economic events and the real estate income and value cycles typically observed in prior empirical real estate cycle research. It then estimates and tests a resulting model specification using MSA level data for the 20 largest office markets in the U.S. As such, the model is perhaps the first theoretical model of real estate cycles that is able to "replicate" the observed real estate value cycles, and represents an encouraging step towards integrating real estate cycle theory and the empirical real estate cycle literature.

¹ A special thanks to Steven J. Manson for his creative and energetic 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 benefitted from many suggestions and comments from our colleagues. 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.

I. Introduction

There is growing recognition among academics and practitioners that volatile macro, regional and local economic cycles exert major influences on real estate markets. The currently distressed state of the U.S. real estate market is perceived as unusual and at least in part the result of the real estate cycle. This does not imply that real estate markets are uniformly depressed. In fact, United States real estate markets are, and have been experiencing substantial dislocations, with most markets in apparent excess supply and a few in excess demand. For example, in 1987, downtown office buildings in Denver and Houston had vacancy rates greater than 20%, while those in Philadelphia and Boston were less than 10%. At the current time, 1995, the office market in Los Angeles is experiencing a vacancy rate that has risen to a level of about 20%, while to the north in San Francisco, the vacancy rate has been falling and is at a relatively low level of 13%. Unfortunately, the appearance of "abnormally" high vacancy rates, imploding market values, plummeting rents and mushrooming mortgage delinquencies and defaults is by no means a new phenomenon.

While the magnitude of the current downturn in real estate markets, on average nationally, appears to be the worst since the Great Depression, market episodes of the 1960's and 1970's are by no means dissimilar. Surprisingly, the analysis of the cyclical behavior of real estate markets has been relatively sparse; and, with rare exceptions², virtually no formal, systematic theory has evolved to explain the interrelationships among economic, real estate income and real estate value cycles. The objective of this paper is to develop a theory of real estate cycles that traces the

² For example, see Grenadier (1992) and references contained therein for the few analytically based studies of real estate cycles.

interrelationships among the economic cycle, real estate rental rates and property value cycles, and is consistent with empirically observed real estate market behavior.

Our paper is subdivided into three subsequent sections. The next section will review key real estate cycle articles. In brief, there exists an interesting and suggestive empirical real estate cycle literature, but a scant theoretical literature. The subsequent section, the prime focus of this paper, develops a theoretical model of real estate market cycles. Our theory generates real estate cycle outcomes that engender a sequence of results consistent with observed real estate market behavior. We utilize our theoretical model as a benchmark for evaluating and testing real estate cycle behavior. Finally, in the last section, we suggest a strategy for future research for real estate cycles.

II. A Review of the Real Estate Cycle Literature

Real Estate Cycle Identification

Real estate cycle research has linked the real estate cycle to the general economic cycle. This relationship has been well-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. The residential construction cycles tended to be counter-cyclical, while the commercial construction cycles tended to be co-incident with the macroeconomic cycle.

Hekman (1985) finds that the office construction sector, for fourteen MSA's, 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 MSA's, find 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 outcomes for local real estate markets.

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. For the office market, Wheaton (1987) identifies a twelve year recurring national cycle for construction and vacancy. Torto and Wheaton (1988) find a clear indication that the peaks and troughs of the office real rent cycle lag the troughs and peaks, respectively, of the vacancy cycle by about one year.

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.

Real Estate Cyclical Explanations

Several commonly espoused explanations for the boom-bust real estate construction and stock cycles hone in on the alleged "inept" and/or "greedy" developer and the "bumbling" lender. Using the logic of those views, the developer faces a long lag from start to finish in commercial real estate project construction, and is unable to forecast the future state of the marketplace accurately. Development might commence when the market indicators appear to be favorable, only to have space constructed and available when market conditions are much less sanguine. Hence, vacancies increase

above and rents decline below what they might have been because of the poorly timed additions to the stock of space, and so forth.

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 for prolonged periods of time.

However, the construction lag explanation, while at most partially true, is unsatisfactory by itself as the prime cause of cycles for several reasons. Since developers must recognize the existence of lags in construction as well as their own limited abilities to forecast "uncertain" markets, 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 less than a year. The lag-forecast argument would not seem to explain the boom-bust cycle for this type of industrial real estate market.

An alternative explanation highlights lender behavior and nonrecourse financings as the culprits to cyclical real estate markets. According to this view, the developer is "greedy" and if you provide nonrecourse project financing (or fees for construction), he will build. This argument depends upon lenders making recurrent bad lending decisions, and failing to learn from prior history (i.e., past lending mistakes). A variant on the theme attributes lender behavior to regulatory or profitability constraints. 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 partially contributing to observed cycles, inadequately explain the full extent of observed real estate cycles.

More 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 earlier explanations. Grenadier (1992) 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"³.

In sum, while each of the above explanation has a kernel of truth, there is less than universal agreement on what are the determinants of real estate cycles.

The Typical Regional Real Estate Cycle

Several research efforts have been devoted to examining the interrelationships between regional economic cycles and real estate market cycles. For examples, see, among others, Phyr, et.al., (1990, a, b), Pritchett (1977), Voith and Crone (1988). Two conclusions emerge from these studies. First, observed real estate cycles are a combination of several cycles produced by different underlying forces. Second, the typical real estate cycle usually follows a pattern. This pattern can be stylized as follows: as the cycle declines to the trough, demand and supply engender 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

³ Similarly, and consistent with Grenadier's (1992) analysis, Meese and Wallace (1993) show that fundamental economic variables determine residential values, but with a significant adjustment lag.

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 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.⁴

III. The Theory of Real Estate Value Cycles

Our strategy is to develop a theory of real estate value cycles that depends upon and interplays with economic income cycles. The theory will focus 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, equation 1 represents the relationship between the value of a real estate parcel and the true expected stabilized net operating income at time t.

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

Where, V = the fair market value of a parcel at time t.

C_v = a constant

Y_s^* = "true" expected stabilized net operating income at time t

δ = is the point elasticity of fair market value with respect to Y_s^* .

Equation (1) is a characterization of the income approach from appraisal theory. δ is the proportionality constant between value and 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.

⁴ 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.

Demand lags are usually the resultant of unanticipated changes in market economic fundamentals. Typically, because the short run demand elasticity with respect to price changes is relatively low for physical space, substantial rental price changes are required for demand to adjust solely from price changes. Hence, embedded in δ (among other factors) are both secular and cyclical effects of expected future vacancy and rent changes.

Abstracting from the trend for stabilized net operating income over time, which is assumed to grow secularly at a rate of β , equation (2) represents the de-trended stabilized NOI. β translates the trend for economic growth in the general economy into real estate property income.

$$\ln Y_s = \ln Y_s^* - \beta t - C_Y \quad (2)$$

Where Y_s = de-trended expected stabilized NOI.

C_Y = a constant.

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

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

where, in Equation (3), C^* is a generalized constant.

Taking the time derivative of equation (3), one can create the relationship between the rate of change of value as a function of the rate of change in de-trended expected stabilized net operating income, equation (4):

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

Unfortunately, one does 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. We assume that the relationship between observed, actual net

operating income and expected de-trended stabilized NOI is represented by equation (5):

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

We hypothesize that there is a rational economic partial adjustment process for de-trended stabilized NOI based upon the actual level of NOI (Y) and the expected de-trended stabilized NOI, and ω , the partial adjustment coefficient. Equation (5) can be more conveniently written as:

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

In essence, errors between actual NOI and expected de-trended stabilized NOI are deviations from expectations, and require adjustments in our future expectations for de-trended stabilized NOI. The partial adjustment coefficient, ω , is typically thought to be less than unity⁵.

Using equations (3) and (5) to express expected de-trended stabilized net operating income in terms of property values and equation (4) to express the rate of change in stabilized net operating income in terms of a change in value yield equation

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

Where $C^{**} = -C^*/\delta$.

Finally, taking the time derivative of equation (6), we obtain:

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

g_v is the instantaneous rate of change in fair market value. \dot{g}_v is, therefore, the instantaneous rate of change of the rate of change of fair market value, or an

⁵ The value of the parameters ω and δ in this model determine the "dynamic path" of the model.

"acceleration" variable. 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 and property fair market values. 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, a simple smooth de-trended sine function cycle for income (presumably, for convenience, reflecting a smooth function for the underlying economic cycle). Figures 1 and 2 translate equation (7) and our assumed cycle into a graphical presentation⁶.

In figure 1, the second term on the right hand side of equation (7) is represented by the oblique straight line intercepting the g_v axis at $\delta\beta$. To understand this, consider if the observed de-trended stabilized NOI growth rate were zero (i.e., $\dot{Y}/Y=0$), then, the change in the rate of growth in value (i.e., the acceleration) would be zero and the

⁶ Our results are robust with respect to different underlying cycles. Our analysis can incorporate stochastic-cyclical NOI functions and can be solved for 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 $V = e^c Y^\delta$, which implies that $V = g(Y)$.

Then, by applying Ito's Lemma: $dV = g_v dY + g_t dt + (1/2)g_{vv} dY^2 = e^c \delta Y^{\delta-1} dY + (1/2)e^c \delta(\delta-1)Y^{\delta-2} dY^2 = e^c Y^\delta \{Y\mu[\bullet]dt + Y\sigma[\bullet]dz\} + (1/2)e^c \delta(\delta-1)Y^{\delta-2} Y^2 \sigma^2[\bullet]dt$.

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

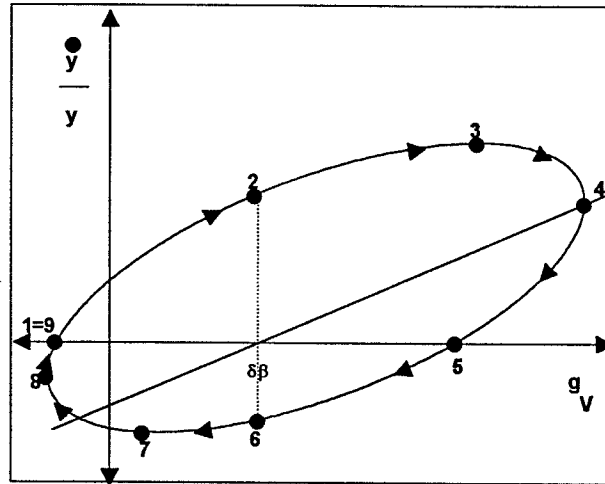
$(dV/V) = \delta (dY/Y) + (1/2)\delta(\delta-1)dt$.

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 find that

$\ln V = C(V) + \delta \ln Y + A(\delta, \omega, \beta)$, which is a second order PDE such that with the appropriate initial conditions for value and the instantaneous rate of change for value and NOI will generate the non-linear interrelated path followed by Y and V .

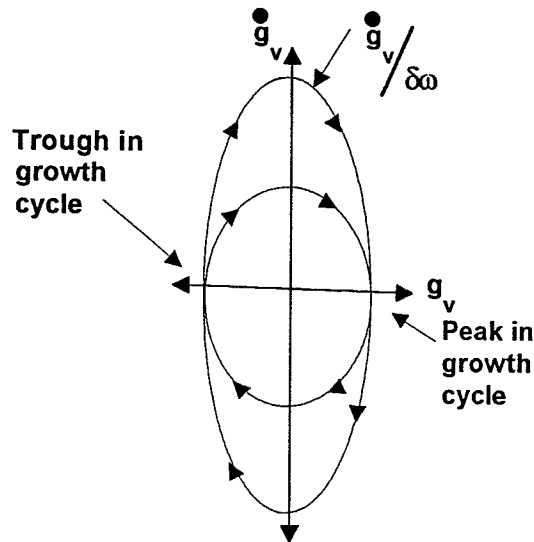
growth rate in property values would need to be constant at $\delta\beta$ in order to remove the trend β . As the cycle in NOI growth oscillates, the growth rate in value will oscillate along this line with slope of $1/\delta$, the income capitalization rate from equation (1).

Figure 1. The Cyclical Relationship Between NOI and Property Value



In figure 2, 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 2, 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 1.

Figure 2. 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 1 and 2, over the cycle, we would expect NOI changes to occur in advance (lead) of value changes. This will be the result, in the upturn, of a combination of both vacancies declining and rental rate increases.

In contrast, when the real estate market peaks, we expect vacancies to peak before rents, 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 our model is delineated in Table 1, with corresponding numbered positions in figure 1.

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

The cap rate derived from the model's cycle pattern would be counter-cyclical, with cap rates rising as the real estate market declines (because NOI declines, and leads value declines), 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.

IV. Empirical Results

The Statistical Model and Data Set

We employ statistical equation (8) to estimate and test the model from section III as specified in equation (6):

$$(8) \ln Y = a_0 + a_2 \left(\dot{V} / V \right) + a_1 (\ln V) - a_3 t, \text{ where } \beta = -a_3, \delta = 1/a_1, \text{ and } \omega = a_1 / a_2.$$

That is, equation (8) is the empirical analog to equation (6).

A system of twenty equations, one for each of the twenty largest metropolitan office markets for which all necessary data are available⁷, is estimated. By using three stage least squares (3SLS) as an estimation procedure, we jointly estimate the parameters for equation (8), over time, for all 20 MSA's. The 3SLS procedure has the capability of taking into account the effect of underlying structural variables --supply and demand instruments subsumed in the closed form equation (6)-- as well as correcting for many classical statistical complications related to the structure of the error terms in the 20-equation system.

Table 2 summarizes all of the quarterly time series for NOI, growth in NOI and Market Value from 1985:4 to 1992:4 that are available for each MSA. It also specifies the sixty four variables that were used as instruments in the twenty equation system.

Table 2. All Variables Used in Estimation

<i>Number of Variables</i>	<i>Variables Employed in 3SLS Estimation</i>	<i>Source</i>
1	U.S. GDP Growth	NIPA
1	U.S. Employment Growth	U.S. BLS
1	U.S. Real Interest Rate (10-yr. t-rate - infl.)	FRB
1	U.S. Inflation Rate	U.S. BLS
20	Office Vacancy Rates for 20 MSAs	CB Commercial
20	NOI/sf and Price/sf	NREI
20	Office Absorption Rates for 20 MSAs	CREUE
20	Office Construction Permitted for 20 MSAs	F.W. Dodge

The estimated parameters, t-statistics and the implied cyclic-parameters β , δ , and ω , for the 20 MSAs are reported in table 3. Table 4 reports the results of the unit root tests performed.

⁷ All necessary data for Atlanta (ATL), Baltimore (BAL), Boston (BOS), Charlotte (CHR), Chicago (CHI), Dallas (DAL), Denver (DEN), Houston (HOU), Los Angeles (LA), Miami (MIA), Minneapolis (MIN), Orlando (ORL), Philadelphia (PHI), Phoenix (PHO), Sacramento (SAC), San Diego (SD), San Francisco (SF), Seattle (SEA), Tampa (TPA), and Washington D.C. (DC), are available at the MSA level.

Statistical Findings

As the results in table 3 indicate, all of the estimated equation (8) parameters for the 20 MSAs are significant at the 95% level per the computed t-statistics. The estimated parameter values for equation (8) are employed to compute the cyclical parameters from the theoretical model, equation (6), β , δ , and ω , and are also reported in table 3. Only three of the implied sixty cyclic parameters contain values outside the theoretical model ranges. The three parameters are ω 's with magnitudes exceeding 100% for Dallas, Sacramento and Baltimore. For all other MSAs, all parameters are consistent with the theoretical model assumptions and follow well defined cycles with trends, as described in section III.

Following the methodology developed by Leybourne (1994), the unit root tests reported in table 4 reject higher order integration than unity for the statistical model specification for all 20 MSAs. The unit root procedure and critical value table are presented in appendix A.

Figure 3 contains graphs of actual and fitted log NOI's for each of the 20 office markets used in the estimation of model parameters. A close examination of figure 3 suggests three major conclusions about our model of real estate cycles. First, the estimated values of log NOI by office market (MSA) derived from our model closely replicate the observed cycle data. Second, office market cycles vary significantly across MSAs with respect to cycle phase timing and amplitudes. Third, given the diversity of cycle timing and amplitudes, it is remarkable and encouraging how well this simple model traces office-MSA real estate cycles.

Table 3. Equation 8: 3SLS Estimated Values, t-Statistics and Implied Parameters

Estimated Parameter	Estimate Value	t-stat	implied	parameter value	Estimated Parameter	Estimate Value	t-stat	implied	parameter value
A_ATL_0	1.2458	34.22	β	0.0091	A_MIN_0	-3.185	-142.57	β	-0.0024
A_ATL_1	0.1937	28.25	δ	5.1626	A_MIN_1	1.3685	124.35	δ	0.7307
A_ATL_2	-0.0368	-6.86	ω	-0.0526	A_MIN_2	-0.3725	-20.93	ω	-0.0367
A_ATL_3	-0.0091	-14.25			A_MIN_3	0.0024	21.42		
A_BAL_0	-1.0253	-67.24	β	-0.0017	A_ORL_0	-0.7684	-7.66	β	-0.0014
A_BAL_1	0.6523	254.65	δ	1.533	A_ORL_1	0.5687	94.72	δ	1.7584
A_BAL_2	0.0015	-36.45	ω^{**}	4.3487	A_ORL_2	-0.2631	-42.39	ω	-0.0216
A_BAL_3	0.0017	6.78			A_ORL_3	0.0014	0.61		
A_BOS_0	-2.0135	-223.21	β	-0.0245	A_PHI_0	-0.2849	-28.66	β	-0.1245
A_BOS_1	0.7614	571.54	δ	1.3134	A_PHI_1	0.6543	141.27	δ	1.5284
A_BOS_2	0.2387	113.51	ω	0.0319	A_PHI_2	0.2292	44.13	ω	0.0285
A_BOS_3	0.0245	58.39			A_PHI_3	0.1245	30.45		
A_CHR_0	-1.6127	-142.24	β	-0.0035	A_PHO_0	0.3591	3.62	β	0.002
A_CHR_1	0.4805	222.35	δ	2.0812	A_PHO_1	0.6928	75.64	δ	1.4434
A_CHR_2	-0.0714	-75.64	ω	-0.0673	A_PHO_2	-0.0943	-43.21	ω	-0.0735
A_CHR_3	0.0035	8.54			A_PHO_3	-0.002	-8.97		
A_CHI_0	-0.3846	-18.63	β	0.0035	A_SAC_0	-0.4221	-23.21	β	-0.0014
A_CHI_1	0.4218	147.34	δ	2.3708	A_SAC_1	0.5624	104.25	δ	1.7781
A_CHI_2	-0.0823	-25.36	ω	-0.0513	A_SAC_2	0.0031	0.91	ω^{**}	1.8142
A_CHI_3	-0.0035	-18.76			A_SAC_3	0.0014	6.84		
A_DAL_0	-1.3458	-46.54	β	-0.0063	A_SD_0	-1.4758	-178.62	β	-0.0061
A_DAL_1	0.6218	246.45	δ	1.6082	A_SD_1	0.7412	105.25	δ	1.3492
A_DAL_2	-0.0028	-1.7	ω^{**}	-2.2207	A_SD_2	0.2176	17.58	ω	0.0341
A_DAL_3	0.0063	15.43			A_SD_3	0.0061	14.21		
A_DEN_0	0.2759	31.65	β	0.0031	A_SF_0	1.4789	23.51	β	-0.0214
A_DEN_1	0.4267	84.65	δ	2.3436	A_SF_1	0.1358	16.84	δ	7.3638
A_DEN_2	-0.0521	-24.54	ω	-0.0819	A_SF_2	0.6258	45.27	ω	0.0022
A_DEN_3	-0.0031	-18.67			A_SF_3	0.0214	15.27		
A_HOU_0	-0.5963	-31.38	β	0.0021	A_SEA_0	-1.1475	-84.51	β	-0.0018
A_HOU_1	0.6853	246.61	δ	1.4592	A_SEA_1	0.6839	114.57	δ	1.4622
A_HOU_2	-0.4257	-184.54	ω	-0.0161	A_SEA_2	-0.1495	-83.26	ω	-0.0457
A_HOU_3	-0.0021	-4.58			A_SEA_3	0.0018	11.24		
A_LA_0	0.3274	20.64	β	0.0034	A_TPA_0	1.345	46.74	β	0.0042
A_LA_1	0.4128	84.13	δ	2.4225	A_TPA_1	0.1955	42.81	δ	5.1151
A_LA_2	-0.1266	-12.54	ω	-0.0326	A_TPA_2	0.2387	56.84	ω	0.0082
A_LA_3	-0.0034	-7.46			A_TPA_3	-0.0042	-24.67		
A_MIA_0	0.4275	21.24	β	-0.0016	A_DC_0	-0.3427	-42.16	β	0.0004
A_MIA_1	0.4125	42.15	δ	2.4242	A_DC_1	0.5817	24.54	δ	1.7191
A_MIA_2	0.1217	35.32	ω	0.0339	A_DC_2	-0.1257	-46.63	ω	-0.0463
A_MIA_3	0.0016	2.58			A_DC_3	-0.0004	-4.67		

Table 4. Unit Root Testing Procedure Results: Equation by Equation

OFFICE MARKET	ORDER OF INTEGRATION = 1	CRITICAL VALUE*	REJECT UNIT ROOT?
ATLANTA	0.0008	0.009	Yes
BALTIMORE	0.0003	0.009	Yes
BOSTON	0.0005	0.009	Yes
CHARLOTTE	0.0004	0.009	Yes
CHICAGO	0.0004	0.009	Yes
DALLAS	0.0007	0.009	Yes
DENVER	0.0004	0.009	Yes
HOUSTON	0.0008	0.009	Yes
LOS ANGELES	0.0007	0.009	Yes
MIAMI	0.0024	0.009	Yes
MINNEAPOLIS	0.0016	0.009	Yes
ORLANDO	0.0009	0.009	Yes
PHILADELPHIA	0.0002	0.009	Yes
PHOENIX	0.0004	0.009	Yes
SACRAMENTO	0.0008	0.009	Yes
SAN DIEGO	0.0008	0.009	Yes
SAN FRANCISCO	0.0078	0.009	Yes
SEATTLE	0.0004	0.009	Yes
TAMPA	0.0009	0.009	Yes
D.C.	0.0002	0.009	Yes

**95% Confidence, d.f.=23*

V. A Closing Perspective: What is next?

In this paper, we develop a theoretical model to examine the interrelationships among the economic cycle and the real estate income and real estate value cycles. Our theoretical model generates a sequence of events that has been empirically observed in previous real estate cycle research. We then develop and statistically test an empirical model that is the analog for our theory. To our knowledge, based upon our statistical analysis, our paper represents one of the first theoretical models for real

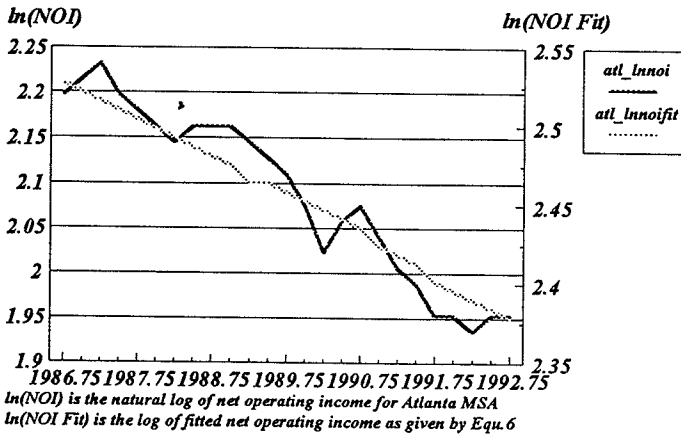
estate cycles that, once transformed into an empirically testable statistical model, is able to "replicate" the observed property income and value real estate cycles⁸.

It is our perspective that the profession has come of age and that we need to link theoretical models of the real estate cycle and recently created real estate pooled cross-section data bases by devising appropriate statistically testable models. Our paper serves to advance this position, and hopefully to stimulate others to commence rigorous research agendas which combine theory, available real estate data, and empirical techniques to study real estate cycles.

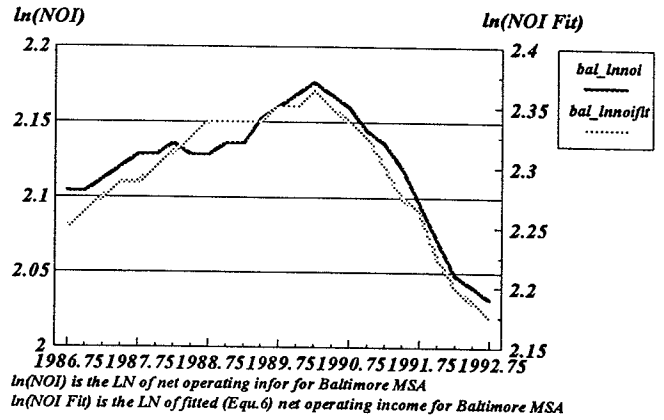
⁸ Our model of the real estate cycle is mechanical. On the theoretical side, additional efforts are needed to integrate micro-supply and micro-demand behavior with a more precise notion of the economic cycle. In this context, our model is suggestive of what needs to be done in those arenas.

Figure 3. Actual versus fitted log NOI

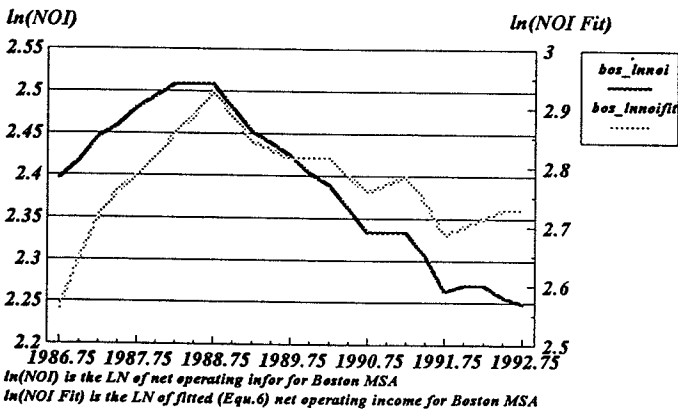
Atlanta



Baltimore



Boston



Charlotte

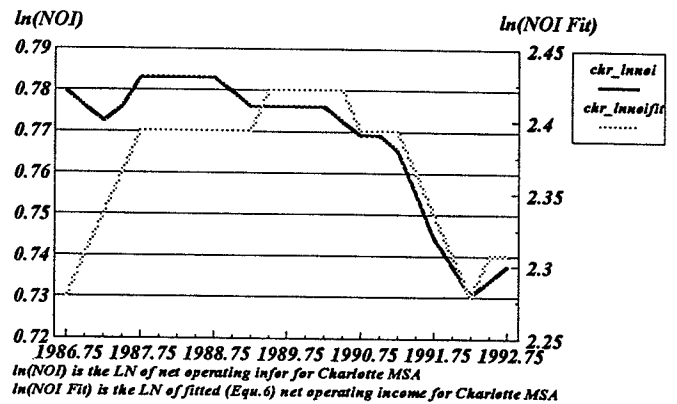
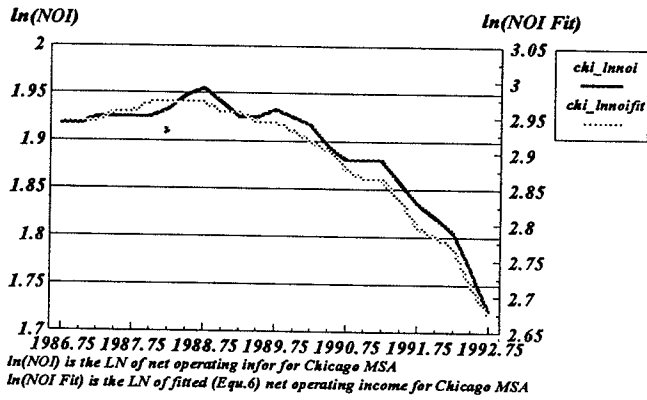
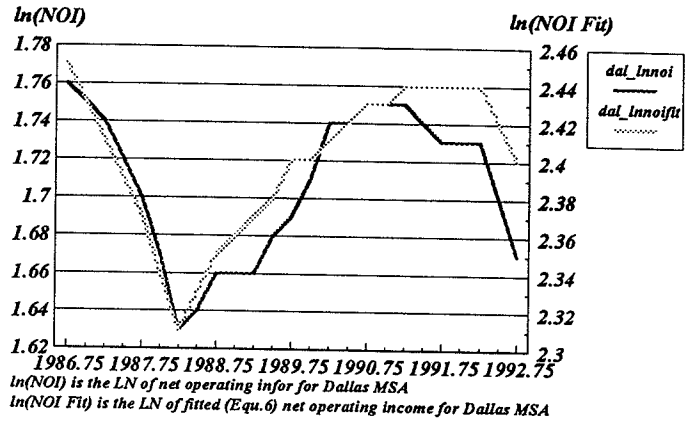


Figure 3. Actual versus fitted log NOI

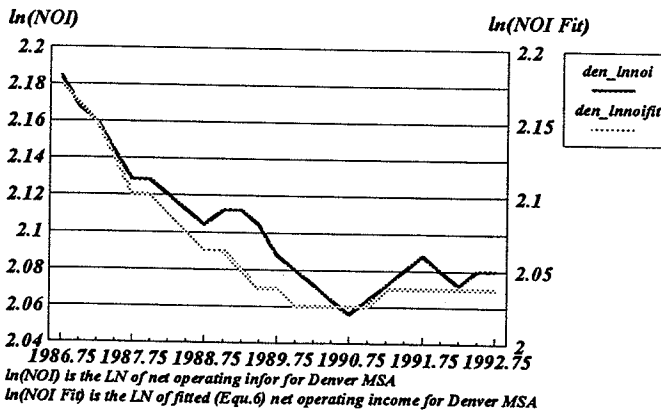
Chicago



Dallas



Denver



Houston

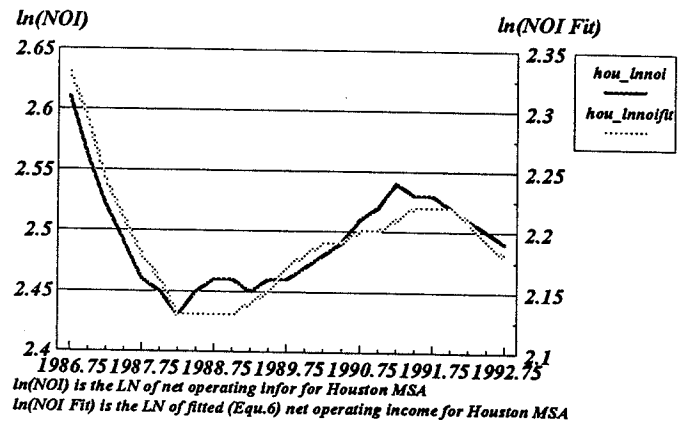
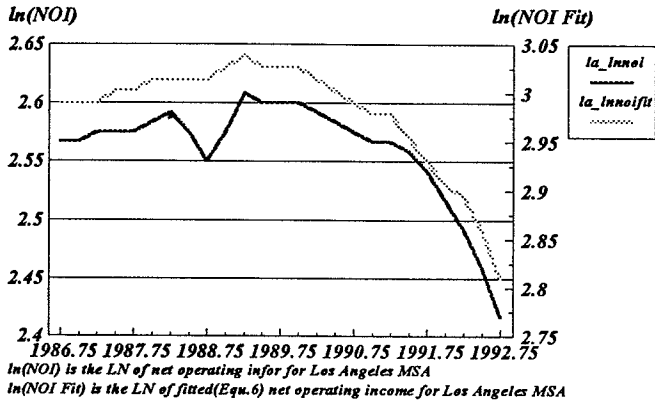
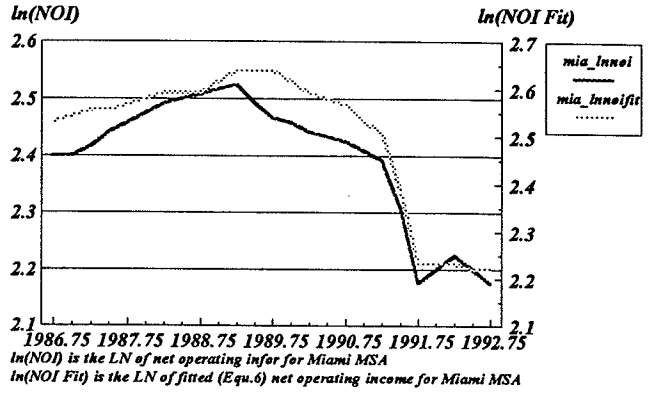


Figure 3. Actual versus fitted log NOI

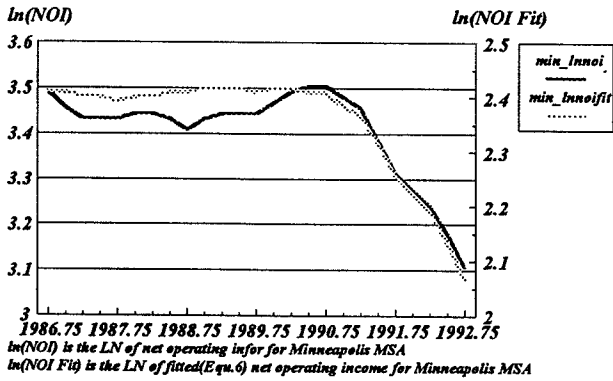
Los Angeles



Miami



Minneapolis



Orlando

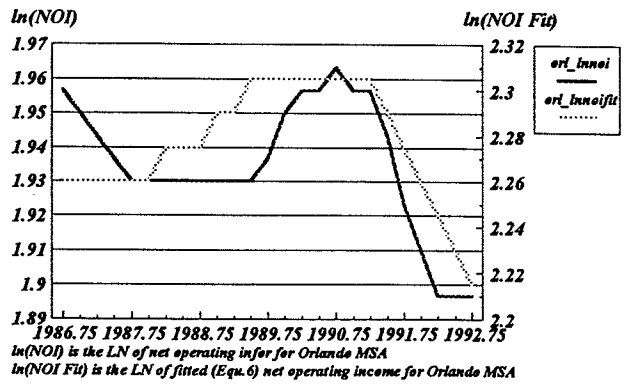
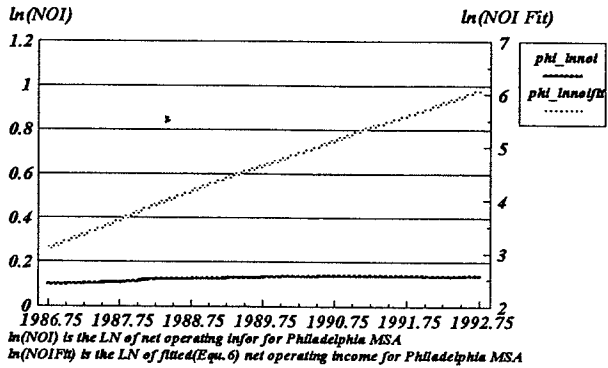
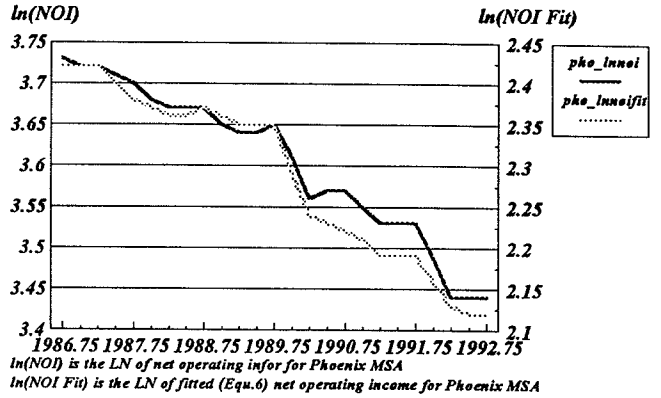


Figure 3. Actual versus fitted log NOI

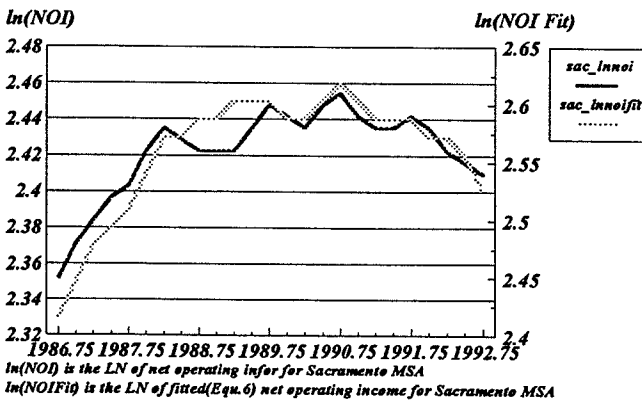
Philadelphia



Phoenix



Sacramento



San Diego

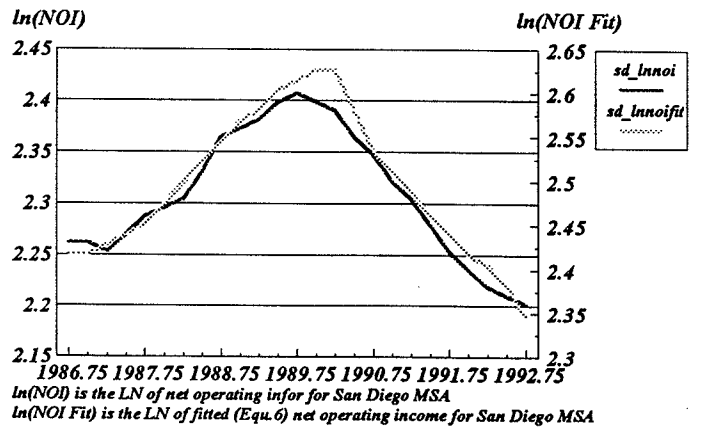
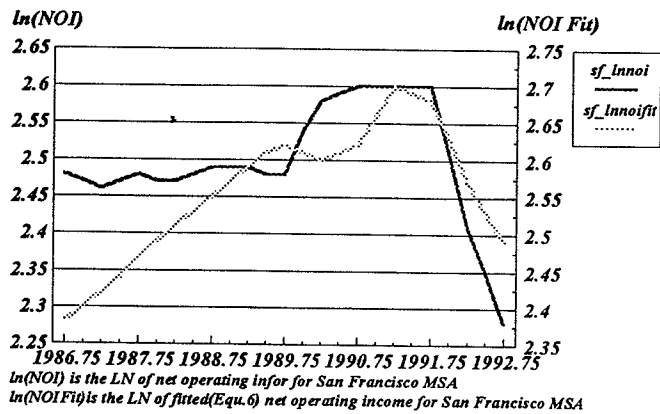
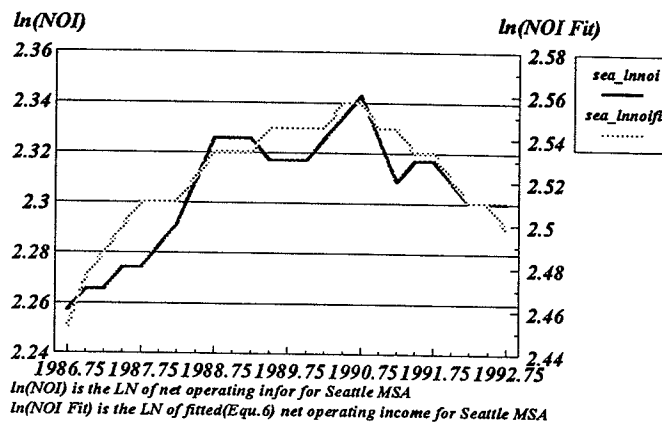


Figure 3. Actual versus fitted log NOI

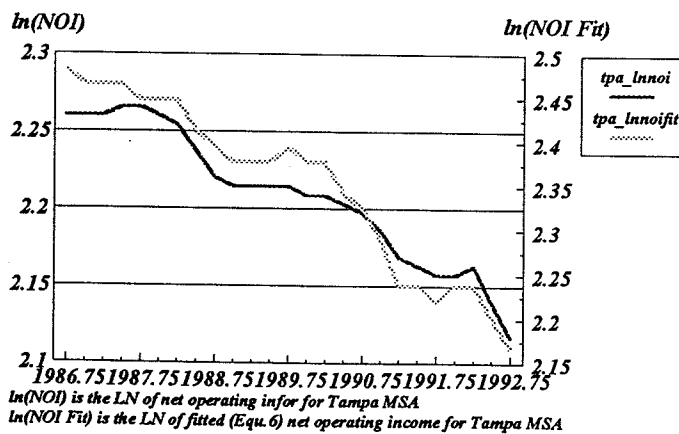
San Francisco



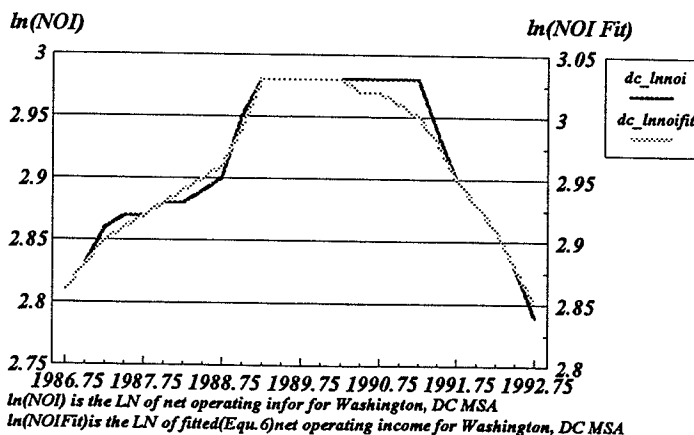
Seattle



Tampa



Washington, D.C.



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. 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.
4. 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.
5. 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.
6. 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.
7. Froland, Charles, "What Determines Cap Rates on Real Estate?" The Journal of Portfolio Management, (Summer, 1987), pp. 55-60.
8. Gatzlaff, Dean and Dogan Tirtiroglu, "Real Estate Market Efficiency: Issues and Evidence," Working Paper, (June, 1993).
9. 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.
10. Grenadier, Steven, "The Persistence of Real Estate Cycles," Journal of Real Estate Finance and Economics, Vol. 10, no. 2 (March 1995) pp. 95-119.
11. Harris, Jack and Waldo Born, "Timing Real Estate Acquisitions," Real Estate Review, (Summer, 1986) pp. 79-83.

12. 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.
13. 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.
14. 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.
15. Leybourne, S.J. "Testing for Unit Roots: A Simple Alternative to Dickey-Fuller," Applied Economics, vol. 26, no. 7, July, 1994, pp.721-729.
16. Meese, Richard and Nancy Wallace, "Testing the Present Value Relation for Housing Prices: Should I Leave my House in San Francisco?" Journal of Urban Economics, 1994 May, V35, no. 3: 245-266.
17. 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.
18. Peiser, Rick, "Capitalization Rates, Inflation and Investment Analysis in U.S. Real Estate," Appraisal Review Journal, (Spring/Summer, 1983) pp. 42-49.
19. Pritchett, Clayton, "Forecasting the Impact of Real Estate cycles on Investment," Real Estate Review, (Winter, 1984) pp. 85-89.
20. Pyhrr, Steven A., Waldo L. Borne 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.
21. Pyhrr, Steven A., James R. Webb and Waldo L. Borne, "Analyzing Real Estate Asset Performance During Periods of Market Disequilibrium Under Cyclical Economic Conditions: A Framework for Analysis," pp. 75-106 in Kapline, and Schwartz, editors, Research in Real Estate, Vol. 3, 1990.
22. 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.
23. 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.

24. 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.
25. 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 A

TESTING FOR PRESENCE OF UNIT ROOTS IN THE OFFICE MARKET MODEL

The general model specification is given by $Y(t) = a(t) + \beta't + u$ which is a time series system of equations where the error vector u is well behaved and follows an i.i.d. distribution $(0, \Omega)$.

The basic model for the unit root test is given by:

$Y(t) - a(t) + \beta't = \phi[Y(t-1) - a(t-1) + \beta'(t-1)] + v(t)$, where v is well behaved as u , $Y(0)$ is known. The null hypothesis corresponds to $\phi = 1$, the unit vector, which implies that the model collapses to $Y(t) = Y(t-1) + \beta + v(t)$, a random walk with drift. The alternative hypothesis is that $\phi < 1$, and thus the general model specification is then stationary around the function $a(t)$ plus trend term β .

Following Leybourne (1994), we can rewrite the basis model for the unit root test by unfolding the basis equation back in time until $t=0$. In doing so the lag- k residual autocorrelation for each equation is given by:

$$\hat{r}_k = \left(\sum_{s=k+1}^{T-1} (\hat{v}_s - \bar{v})(\hat{v}_{s-k} - \bar{v}) \right) / \left(\sum_{s=1}^{T-1} (\hat{v}_s - \bar{v})^2 \right)$$

and the integer, n is defined such that:

$$\hat{r}_k > 0, \text{ for } 1 \leq k \leq n \text{ and } \hat{r}_k \leq 0, \text{ for } k = n+1$$

The integer n is the maximum lag length for which the residual autocorrelations at all lower lag lengths are strictly positive and yields the test statistic $\lambda = n/T$, where T is the total number of quarters.

Up to two lags were tested and the null rejected in every instance. For $k=1$ (i.e. lag-1) autocorrelations are reported as Table 4 below. For brevity, the lag-2 results are not reported. The tests based on lag-1 autocorrelations reject the null; this is consistent with the hypothesis that no unit roots are present in our data series and that the model is correctly formulated as a non-integrated time series model.

To close, a table of the simulated distribution of the test statistic's critical values for 25 degrees of freedom is reported here:

x	T
0.04	0.001
0.045	0.006
0.05	0.009 ** (critical level employed in table 4)
0.055	0.014
0.06	0.019
0.065	0.023
0.07	0.025

