A Multiple Index Analysis of Real Estate Cycles and Structural Change

Abstract. This article explores real estate cycles and structural change at an overall industry level, focusing on three key questions. First, are real estate cycle stages distinct and observable? Second, can the cycle stages be modeled using variables and relationships that hold for extended periods? Third, can the impact of exogenous shocks that cause structural changes in the market be monitored and modeled? The results of the research are generally positive, suggesting that indeed the variables and relationships that distinguish various real estate cycle stages can be isolated, and are sufficiently stable to help model cyclical changes. Furthermore, the research suggests it is possible to track key exogenous shocks that trigger structural changes that affect cycle models.

Introduction

In the late 1980s, institutional real estate investment had moved into the early maturity stage of its life cycle and gained acceptance as an asset class. Indeed, with the exception of smaller investors with limited appetites for lumpy real estate investments, most investors had established direct, private real estate allocations in the 5%–10% range. Despite these targets, institutional investors remained under-weighted to the asset class, with the overall industry average increasing gradually to the 4%–5% range. This trend toward increased real estate exposures was reversed by the collapse of most segments of the domestic real estate market in the early 1990s. The pronounced and prolonged decline in commercial real estate values, coupled with the illiquidity of investment positions in commingled funds caused most investors to step back and take a hard look at real estate. When the industry began to recover in 1993–1995, many traditional investors stayed on the sidelines, waiting for compelling signals that the real estate cycle had turned, and that the unexpected, painful downturn would not be repeated. The resultant capital shortage associated with the withdrawal of traditional capital opened the door to Wall Street-sponsored opportunity funds and other investors seeking high returns. These early investors were able to rely on pure market timing to achieve high returns, rather than having to tap into the expensive and somewhat cumbersome infrastructure and expertise necessary to harvest long-term performance from the asset class. While many traditional institutional investors

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returned to the asset class in 1996, most of them pursued opportunistic strategies, seeking higher returns from real estate to compensate for the uncertainty and the fear of a new market collapse.

By 1998, institutional investors recognized that although market timing plays were drying up, real estate still offered attractive adjusted returns for more moderate risk, core strategies. Despite renewed use of the term “core,” investors approached the asset class more cautiously than in the past. This caution manifested itself in two ways. First, institutional investors abandoned the old “buy and hold” model, turning toward a more proactive “buy and sell” model. Second, investors focused more attention on market cycles, hoping to avoid losses in the event of another deep, prolonged market downturn. The purpose of this study is to help expand the body of knowledge into real estate cycles to provide investors and other market participants better decision support. The research explores three fundamental questions. First, are the various phases of real estate market cycles distinguishable? Second, can market cycles be modeled in a valid and reliable manner? Third, can real estate investors ever be market timers at a broad strategic level and how they can approach real estate allocations in a more disciplined, systematic manner? While the models developed herein are not used to predict cycles, they do provide insights into how investors should approach the asset class in a “cycle” framework.

Organization

The inefficiency in the private real estate market, coupled with its diversity in terms of property types, markets and investment vehicles, makes applied research into cycles inherently complicated. The challenge is made even more demanding by the absence of consistent and reliable performance data that can test for cycles across sectors and markets. These limitations make it particularly difficult to develop robust conclusions that can help investors deal with the range of decisions that they must make in managing large institutional portfolios. Before getting into the issues emanating from data limitations, the discussion begins with a review of previous literature into real estate cycles. This secondary research is intended to identify the major conclusions that researchers have discovered using disparate sources of data and research designs. Once this foundation has been revealed, the discussion then turns to the pragmatic data issues that must be resolved in cycle research. Rather than seeking a single solution, however, the research is extended to each of the major indices that could be used in exploring real estate cycles. The emphasis in this discussion is to understand the similarities and differences in the return series in terms of time frame, composition, mechanics and other key distinguishing features. Exhibit 1 plots the performance of the direct real estate return series that are used in this study.

To avoid confusion that would be introduced by analyzing real estate cycles with an array of diverse, inconsistent data series, the initial phase of the empirical research relies on a single time series. The Ibbotson Data, the longest return series, is used to establish the cycle phases and relevant causal variables. The analysis tests whether the observed patterns of returns represent cyclical stages and whether turning points that indicate peaks and troughs in real estate cycles can be predicted at a macro level.
A MULTIPLE INDEX ANALYSIS OF REAL ESTATE CYCLES AND STRUCTURAL CHANGE

Exhibit 1
Comparison of Direct Real Estate Return Series

Where: I&A is Ibbotson & Associates, NCREIF is the National Council of Real Estate Investment Fiduciaries, ACLI is the American Council of Life Insurers, NREI is the National Real Estate Index, KYI is Korpacz & Associates, and RERC is the Real Estate Research Corporation.

The analysis also tests whether such models are stable on an intertemporal basis or whether changing return predictions are attributable to structural changes caused by non-recurring, and thus non-predictable, changes in market fundamentals. The existence of such structural changes are tested via regime switching, a statistical technique that tests whether the underlying forces that affect performance have changed. Once the validity and efficacy of cycle research based on the single Ibbotson series is determined, the techniques are extended to the other available data series to establish the robustness of the results.

Background Literature and Multiple Data Series Review

As might be expected, interest in cycles is not unique to the real estate asset class. Indeed, there is a rich tradition of cycle literature in which authors have explored overall business cycles, as well as investment cycles for various asset classes. Furthermore, real estate cycles have been the topic of a number of academic papers over the years, especially during the 1990s where market timing became more important to institutional investors. Over the past twenty years, the real estate market has undergone dramatic changes, some of which were cyclical in nature and some of which represented longer-term structural changes. These changes have dramatically
affected the occurrence, amplitude and frequency of real estate market cycles. The existing body of real estate cycle research can be grouped into several major classes depending on the emphasis of the researcher:


- **Investment Variables:** Specific industry or market performance and alternative investment return measures—Rubens, Bond and Webb (1989), Pyhrr, Webb and Born (1990), Liu and Mei (1992), Born and Pyhrr (1994) and Gyourko and Siegel (1994).


- **Structural Change:** Regime switches and the dynamics of structural change—Giaccotio and Clapp (1992) and Khoo, Hartzell and Hoesli (1993).

The diversity of approaches and the mixed results obtained in prior real estate cycle research is a testimony to the complexity of the issue as well as the challenges posed by the absence of clear, consistent data that can be used to model real estate markets. This point was dramatized by prior research producing differing findings depending on the return series employed (see Firstenberg, Ross and Zisler, 1988; Liu, Hartzell, Greig and Grissom, 1990a, b; Geltner, 1991; and Liang, McIntosh and Webb, 1995). Thus, while the existing literature provides anecdotal evidence that distinct real estate cycles exist and can be predicted, it fails to produce any substantial empirical support and a consensus as to how cycles should be modeled and what implications they have for investors. However, prior research suggests that by exploring the influence of physical and financial market variables over time, and selectively introducing exogenous decision variables, a better understanding of the causal factors can be developed. This study tests that assumption by focusing on investment performance, which is the ultimate output of the interaction of the physical and financial sides of the equation.
Empirical Return Series

The fact that many institutional investors have treated real estate as a distinct asset class for over twenty-five years, would imply that there must be some unambiguous benchmark of institutional real estate performance. However, the reality is that there is no dominant index of returns. This data void forced early researchers to generate synthetic return series that could be used for such research. As might be expected, researchers used a diverse array of investment/cash flow models and quantitative techniques to generate return series and their risk measures as developed by Ricks (1969), Hoag (1980), Sirmans and Webb (1980), Nourse (1987), Sirmans and Sirmans (1987), Geltner (1989, 1993), Liu, Grissom and Hartzell (1990), Liu and Mei (1992), Mei and Liu (1994) and Norman, Sirmans and Benjamin (1995). Since there was no standard definition of what constituted valid return series, a number of approaches were explored including:

- **Cap Rates**: Roulac (1978), Nourse (1987) and Ambrose and Nourse (1993)—the latter two papers empirically link to the Ellwood model (Ellwood, 1970).
- **Value-weighted Equations to Construct Yield Series**: Liu, Grissom and Hartzell (1990) and Mei and Liu (1994).
- **Band of Investment Models**: Ricks (1969) and Guntermann and Smith (1987).
- **Industry Specific Return Series**: American Council of Life Insurance (ACLI) data has also been used to represent industry specific returns as developed by Liu and Mei (1992); National Association of Real Estate Investment Trusts (NAREIT) data has been used to quantify real estate investment trust (REIT) performance, National Council of Real Estate Investment Fiduciaries (NCREIF) is the accepted industry benchmark for privately held institutional quality real estate.

Use of Multiple Return Series

While an additional set of proprietary return series that would satisfy the desire for consistent, reliable data, could be developed, such an approach would only add to the ambiguity surrounding real estate cycle research. Rather than further complicating the literature, this analysis is extended to each of the competing empirical performance series that are commercially available. While the various series each has limitations,
they are included to eliminate the position that the results based on any one series are data-dependent and cannot be extended to the asset class as a whole. Thus, by employing multiple indices the robustness of the results can be tested to determine whether the findings can be generalized beyond the immediate project. Further, by testing multiple data sets, significant insights can be derived to offset any lost observations and thus prohibit the need to develop a hold out sample within a single—and extremely limited—data set. Finally, the application of multiple data sets and the resultant “preponderance of the results” helps offset some of the concerns over data validity that cannot be empirically tested within the scope of this study.

The “multiple indices approach” used in the study is supported by the works of Liu, Hartzell, Greig and Grissom (1990), Liu, Grissom and Hartzell (1990) and Fisher, Geltner and Webb (1994). However, to help interpret the results, it is still necessary to understand the idiosyncrasies and sampling biases in each of the benchmark series. As might be expected, differences run the gamut from studies relying on cap rates, IRRs and other holding period returns, to differences in time period and periodicity, with index providers choosing among monthly, quarterly and annual returns. The distinguishing features of each index include:

- **Ibbotson and Associates (Ibbotson):** Longest available series of real estate returns; underlying data somewhat inconsistent over time since early portion of series was assembled by piecing together series for residential real estate, farm land returns and business real estate returns; more recent returns fairly consistent, reflecting an all equity composite return series; coverage extends from 1947-current (see Ibbotson and Siegel, 1984); reports annual total, income and capital returns; since 1994, the Ibbotson return series effectively employs the NCREIF data as a measure of total real estate return.²

- **NCREIF:** The most frequently cited series used over the last two decades; aggregation of property asset data contributed by members; consists of unleveraged properties; quarterly returns based on current income and appraised values, modified by actual transactions; some use of accrual accounting.

- **ACLI:** Capitalization rate series developed quarterly from insurance companies’ mortgage commitment reports on new mortgage activity; returns based on property level data, representing stabilized current income divided by an estimated value amount; value measure can be based either on cost or appraisal. This return series was most frequently employed prior to the development of the NCREIF series; the data consists entirely of leveraged properties supporting loan commitments with the input based on appraisals, transactions and/or loans; series is available from 1951 to current period.³

- **NREI (National Real Estate Index):** Initially published by the Liquidity Fund and Standard and Poor, is a data series developed from aggregated transaction data; the data series area not limited to institutional or investment grade properties;⁴ some concern over limited
control over standards of the data and methods of calculation developed by multiple contributors since reported rates are derived from transactions sent-in by correspondents to the index analysts; diversity of contributors is offset in part since prior periods are modified as additional transactions are included in the relevant time frames.

- **Korpacz Yield (KYI) Index**: return series derived from a quarterly mail survey of professionals concerning office, industrial, retail, apartment and hotel returns. It offers a national series for some property types, but limits its regional data to Dallas, Washington, New York, Los Angeles and Chicago. The survey inquiries are sent to a broad array of professionals, most being institutional investors. The KYI series began in 1988 and reports IRRs, cap rates (going-in and out) and other income related data. As a survey, it reflects desired or expected returns (i.e., ex ante). The series is considered at a fundamental level of real estate investment analysis, since it samples participants’ expectations of specific property types in specific geographic markets. The aggregated KYI yield measure is developed by equally weighting returns for each property type and market.

- **RERC (Real Estate Research Corporation)**: In conjunction with Equitable Real Estate Investment periodically conducts an extensive and detailed personal interview survey of market participants regarding their acquisition pricing parameters for real estate. Since 1992, approximately thirty participants are interviewed each year. Quarterly updates are developed in-house based on company databases and expertise. As a survey, the cap rates and yields in this series are for expected or desired (ex ante) ratio/yield relationships. A longer-term series from RERC exists prior to 1992 and is based on both transaction returns and appraised data developed in-house. Thus, this historic segment of the RERC data has an ex post perspective and calculations are similar to the NCREIF returns.

- **NAREIT**: The industry level total return measure of all REIT returns between 1972 and 1998. This index of returns represents an indirect investment performance measure for real estate. The return is for the operating concern or enterprise that deals with real estate assets. The NAREIT return series is included since several studies have presented REIT returns as a market/transaction based measure of real estate investment and a proxy for indirect returns in real estate.

### Issues in Selected Return Series

Exhibit 2 compares and contrasts the key elements of the various return series incorporated in this analysis. As suggested in the table, a number of key features distinguish the various series. In particular, it is useful to review some of the main issues and explore how they have been treated in the literature:

- **Appraisal Smoothing**: This issue is based on the belief that appraisal-based return series do not reflect true values, due to the existence of
### Exhibit 2: Comparison of Alternative Return Series

<table>
<thead>
<tr>
<th></th>
<th>Ibbotson</th>
<th>NCREIF</th>
<th>ACLI</th>
<th>NREI</th>
<th>Korpacz</th>
<th>RERC</th>
<th>NAREIT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nature of Date</strong></td>
<td>Composite</td>
<td>Sample</td>
<td>Mortgage Commitments</td>
<td>Transactions</td>
<td>Survey</td>
<td>Survey</td>
<td>Market</td>
</tr>
<tr>
<td><strong>Type of Assets</strong></td>
<td>Institutional Bias</td>
<td>Institutional</td>
<td>Institutional</td>
<td>Broad-based</td>
<td>Institutional Bias</td>
<td>Institutional</td>
<td>Mixed</td>
</tr>
<tr>
<td><strong>Sponsor Bias</strong></td>
<td>Unleveraged</td>
<td>Tax-exempt</td>
<td>Insurance Co</td>
<td>Diverse</td>
<td>Institutional</td>
<td>Institutional</td>
<td>REIT</td>
</tr>
<tr>
<td><strong>Periodicity</strong></td>
<td>Quarterly</td>
<td>Quarterly</td>
<td>Quarterly</td>
<td>Quarterly</td>
<td>Quarterly</td>
<td>Quarterly</td>
<td>Quarterly</td>
</tr>
<tr>
<td><strong>Type of Return</strong></td>
<td>Appreciation</td>
<td>NOI</td>
<td>NOI</td>
<td>Calculated</td>
<td>Expected NI</td>
<td>Expected NI</td>
<td>FFO Multiples</td>
</tr>
<tr>
<td><strong>Appreciation</strong></td>
<td>Appraisal</td>
<td>Appraisal</td>
<td>Imputed</td>
<td>Cash Flow</td>
<td>Expected</td>
<td>Expected</td>
<td>Stock Price</td>
</tr>
<tr>
<td><strong>Income</strong></td>
<td>NOI</td>
<td>NOI</td>
<td>NOI</td>
<td>Transactions</td>
<td>Expected</td>
<td>Expected</td>
<td>Reinvest Div.</td>
</tr>
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<td><strong>Cap Rates</strong></td>
<td>Derived</td>
<td>Derived</td>
<td>Appraisals</td>
<td>Desired</td>
<td>Desired</td>
<td>Desired</td>
<td>FFO</td>
</tr>
<tr>
<td><strong>Issues</strong></td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Survivorship</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Reviewed</strong></td>
<td>Indirectly</td>
<td>Yes</td>
<td>Appraisal</td>
<td>Indirect</td>
<td>Perceptions</td>
<td>Pre/post ’92</td>
<td>Indirect, Price &amp; Dividend</td>
</tr>
<tr>
<td><strong>Other Issues</strong></td>
<td>Source</td>
<td>Appraisal</td>
<td>Indirect</td>
<td>Validity and Consistency</td>
<td>vs. Reality</td>
<td>Consistency</td>
<td></td>
</tr>
<tr>
<td>Discontinuity</td>
<td>Smoothing</td>
<td>Smoothing</td>
<td>Smoothing</td>
<td>Smoothing</td>
<td>Smoothing</td>
<td>Smoothing</td>
<td>Smoothing</td>
</tr>
</tbody>
</table>

- **Survivor Bias:** This issue, which recognizes changes in composition of a sample over time, is common to return analysis across industry sectors. Within real estate, the issue is more pervasive when dealing with property-based returns, since ownership changes with respect to individual assets, and entity growth via acquisitions, by definition, change the composition of the underlying assets (Sagalyn, 1990).

- **Sponsor Bias:** In this instance, the various sources of data introduce sponsorship bias that limits how results can be extended to other research. For example, the annual total return measures furnished to the NAREIT organization by members, consist of the price appreciation plus the actual dividends paid, plus dividends reinvested on a monthly basis, during the year for companies that have been included in the index for the entire period. According to Sagalyn (1990) the changing data set indicates a survivorship problem, possibly amplified by the weighted impact of the reinvestment dividends of long-term assets.

- **Periodicity:** Unfortunately, although some of the alternative return series could be analyzed on a daily or monthly basis due to greater reporting frequency than the Ibbotson returns, they have shorter overall time frames. Despite the desirability of increased data frequency offered by the alternative rate series, to allow comparisons of the results applied to the various series they have been converted to quarterly data. In the actual modeling, the data are further aggregated to annual observations in a tradeoff that could soften the statistical results by artificially smoothing the tradeoff is achieved by using multiple indices based on several distinct data series.5

- **Data Consistency:** This category affects both intra-source and inter-source variations. In terms of intra-source, changing sampling methods, sources, investment structures and ownership can confound the creation of reliable time series. On an inter-source basis, different methodologies, nature of data (e.g., actual vs. expected), inclusiveness and other factors preclude any useful pooling of data to produce a composite set and make it difficult to compare and contrast results.

- **Data Representativeness:** In almost all cases, the data included in the various indices are collected via convenience sampling (i.e., assets controlled by data contributors and qualifying under various guidelines). As such, the results of any research findings cannot be blindly extended to the industry or sector at large.

Given the differences on these key issues, the mixed results that researchers have found are somewhat understandable when exploring the same phenomenon across industry/index lines. While we expect to find some differences when we extend our
research to the multiple indices, since the returns are ultimately dependent on underlying real estate market fundamentals, we expect to find similar patterns albeit with different weightings and lags. Further, since the research approaches the issue from an economic perspective, the affect of these idiosyncrasies and issues will be dampened in this study.

**Real Estate vs. Business Cycles via Multiple Return Series**

The differences among the selected return series coupled with the underlying data issues that several of them share, suggest that there would be differences in the observed patterns of returns. Further, these differences would translate to comparisons against the broader business cycle phases. As noted in Exhibit 3, there are a number of differences in the direction of the major return series compared to the broader business cycle. These differences are most pronounced for the ACLI return series, which is based on expected yields rather than actual performance. The time periods indicated in the table consist of the traditional business cycle phases of expansion-contraction and recession-prosperity reflected in the cycle literature since World War II, (see Prior, 1976; and Stoken, 1993). Despite some differences, there is a generally consistent relationship among the series and the overall economy.

As noted in Exhibit 3, real estate return cycles were relatively consistent with the business cycles from 1949 through the 1960s. During the early 1970s, real estate was a leading indicator of the impending downturn in overall economy. In the mid-1970s, real estate helped lead the economy out of the doldrums, although the rally was short-lived. In the latter 1970s, the real estate market lagged the economy on the expansion, and then dramatically turned down in 1979. During the post-recession period from 1982 to 1985, real estate lead the recovery although the asset class exhibited lower returns at the end of the period due to pent-up demand for real estate from investors chasing early 1980s returns that drove down cap rates and stimulated new construction. By the latter 1980s, real estate was in a clear contraction period in terms

<table>
<thead>
<tr>
<th>Period</th>
<th>Business Cycle</th>
<th>Ibbotson</th>
<th>NCREIF</th>
<th>ACLI</th>
<th>NREI</th>
<th>Korpacz</th>
</tr>
</thead>
<tbody>
<tr>
<td>1949–53</td>
<td>Increase-Dec.</td>
<td>Increase-Dec.</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>1954–60</td>
<td>Increase</td>
<td>Increase</td>
<td>na</td>
<td>na</td>
<td>Increase</td>
<td>na</td>
</tr>
<tr>
<td>1961–69</td>
<td>Increase</td>
<td>na</td>
<td>Decrease</td>
<td>na</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>1970–74</td>
<td>Increase-Dec.</td>
<td>na</td>
<td>Decrease</td>
<td>na</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>1974–76</td>
<td>Decrease</td>
<td>Increase</td>
<td>na</td>
<td>Decrease</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>1976–81</td>
<td>Decrease-Dec.</td>
<td>Decrease</td>
<td>Decrease</td>
<td>na</td>
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<td>na</td>
</tr>
<tr>
<td>1982–85</td>
<td>Increase</td>
<td>Increase</td>
<td>Increase</td>
<td>na</td>
<td>Na</td>
<td>Level</td>
</tr>
<tr>
<td>1985–91</td>
<td>Decrease-Inc.</td>
<td>Decrease</td>
<td>Increase</td>
<td>Increase</td>
<td>Level</td>
<td></td>
</tr>
<tr>
<td>1992–97</td>
<td>Increase</td>
<td>Increase</td>
<td>Increase</td>
<td>Increase</td>
<td>Level</td>
<td></td>
</tr>
</tbody>
</table>
of returns, although some of the expectation series (e.g., ACLI, NREI and Korpacz) continued to indicate stable returns. Despite a consistency in the pattern of the returns relative to the business cycles for these periods, from the mid-1970s through 1996 there was an increase in the divergence between the business cycles and the return series. Further, the relationship was unstable, with the returns sometimes lagging and sometimes leading the business cycle’s movement.

**Exploratory Single Series Time Segmentation**

*Research Design*

The fifty-year term of the Ibbotson series provides sufficient observations to develop test models over complete business cycles, which are subsequently tested against the other six return series. Exhibit 4 superimposes the Ibbotson return series on a graph that indicates the periods of economic recession, which are depicted as shaded columns. The pattern of returns in the exhibit suggests that real estate performance is indeed cyclical, with rather long periods of rising and declining yields. The functional significance of the trend will be discussed in detail in the methodology section. Interestingly, over the shorter-term real estate investment performance also reflects a pattern of smaller oscillations fluctuating along a longer-term cycle. The changes in the long-term trends and the differences among the alternative return series suggested that it would be prudent to focus the more advanced exploratory econometric analysis.
on this single series rather than automatically extending them to each of the series. This design decision enables us to explore a number of complicated issues that would be impractical to check against each of the multiple series. Further, such analysis would be inherently confusing due to the idiosyncrasies among the various series and the different time frames over which they are available would automatically result in inconsistent results.

Several methodological issues are explored in this exploratory phase of the research that concentrates on the Ibbotson series. First, the research explores the relationship between real estate cycles as measured by actual performance and broad macroeconomic variables. With the use of actual returns rather than expected returns generated by cash flow modeling or other approaches based on discount models, cycle stages can be more easily isolated since the data series are not dampened by the moving average calculations. Second, the research explores the appropriate time segments over which the various cycle phases operate, as well as helps quantify the turning points that indicate when the return series changes direction. This approach differs from much of the literature that has been based on observing the pattern of the selected data series to help delineate cycle phases, exploring the question from an econometric perspective to quantitatively determine that a change has occurred. This long-term time trend is then compared to phased segments suggested by the cyclical periods based on the inflection points recommended by Poirier’s (1976) econometrics procedure. Piece-wise regression is employed to test if consideration of inflection points and segmented trends improve the explanatory or associative powers of the exogenous variables. The Chow test, a Chow Forecast test, recursive residual analysis (sequential Chow test) and CUSUM tests are used to verify the turning points. A broad intervention analysis procedure is conducted from several perspectives to test the timing and validity of the turning points and gather insights to variation in returns relative to phases of structural change. Finally, spline analysis is used to determine when structural changes (e.g., GNP production levels, tax code revisions) modify the identity and nature of relationships among the independent variables.

The extension of spline analysis to real estate performance cycles offers explanatory insights not available by relying on dummy variables as a measure of intervention analysis with time series data. In particular, the use of dummy variables alone will result in a stepwise pattern, as variables are loaded into the model. This approach also differs from time-series analysis, which is typically conducted over rather arbitrary periods. That is, spline analysis quantitatively identifies the appropriate time frame or cycle trend over which a particular model should be applied. For example, if a model is extended too far past the turning points, then the $R^2$’s will decline since the model will no longer accurately predict the dependent variable. Thus, by observing changes in predictive power, analysts can systematically check whether a model’s period is optimal or whether it has been extended too long. Furthermore, with the construction of splines, the changes in the impacts of the independent variables can be tested within discrete regimes. This approach is superior to the alternative of assuming that the relationships stay constant over time and helps eliminate the smoothing effect of a moving average calculation on the expected return measures caused by extending a model across regimes when structural changes have occurred.
Thus, the analysis can help answer the fundamental question of whether the observed cycles can be statistically segmented.

**Segmentation Results Using Time Trend Analysis**

A common approach to analyzing real estate cycles is to visually select inflection points by plotting out vacancy rates or other dependent variables that serve as a proxy for market conditions. Although this approach has some intuitive appeal, it fails to indicate when some structural changes have occurred that cause the dependent variable (i.e., total returns) to move in a cyclical pattern, but driven by different forces. Examples of such forces include changing macroeconomic conditions or tax policies that have significant indirect effects on the real estate market. For example, referring back to the time series presented in Exhibit 4, the first turning point after World War II was the decline from the peak returns observed during the Korean War in 1950–51. The second turning point was at the end of a general growth phase beginning in 1955 and expanding to a peak in 1979, the era of stagflation. Real estate performance during this period was generally consistent with the predominant phase in both the investment and business cycles. The next inflection point began with the decline from the 1979 peak to the 1981–82 recession. Real estate performance in this segment diverges from the business cycle, suggesting some structural change has occurred that distorts the established relationships. The final segment begins at the recession of 1991 and includes the more recent investment expansion into the latter-1990s.

The time trend analysis summarized in Exhibit 5 provides a statistical test of the cycle stages visually extracted from the pattern of returns. The results are drawn from a series of time trend piece-wise regressions that were applied to these intuitively selected stages. The dependent time trend variable is based on a time trend variable. The time trend statistic depicted for each time segment include the coefficient measure, the coefficient’s $t$-Statistic, the equation’s $R^2$, Durbin Watson Statistic (DW) and the $F$-Statistic. Notably, only the early period from 1947 to 1953, appears insignificant based on a segmented or shorter-term time trend. Based on the $R^2$ and $F$-Statistics, the segmented trends show improved explanations of return variation over time when compared to the long-term trend. This improvement established a

### Exhibit 5

**Time Trend Analysis of Returns**

<table>
<thead>
<tr>
<th>Segment</th>
<th>Coeff.</th>
<th>Coeff. $t$-Stat</th>
<th>$R^2$ (%)</th>
<th>DW</th>
<th>$F$-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1947–95</td>
<td>0.0006</td>
<td>1.43</td>
<td>4.15</td>
<td>0.809</td>
<td>2.03</td>
</tr>
<tr>
<td>1947–53</td>
<td>−0.0079</td>
<td>−1.00</td>
<td>16.75</td>
<td>2.085</td>
<td>1.01</td>
</tr>
<tr>
<td>1954–79</td>
<td>0.0043</td>
<td>9.97</td>
<td>79.90</td>
<td>0.999</td>
<td>99.42</td>
</tr>
<tr>
<td>1980–90</td>
<td>−0.0097</td>
<td>−3.27</td>
<td>49.27</td>
<td>1.128</td>
<td>10.69</td>
</tr>
<tr>
<td>1991–95</td>
<td>0.0309</td>
<td>5.35</td>
<td>90.51</td>
<td>2.237</td>
<td>28.63</td>
</tr>
</tbody>
</table>

*Note: Returns are regressed over time only.*
foundation for exploring the time segmentation process in more detail as well as exploring the contribution of exogenous variables that had been suggested in the literature.

Despite the general improvement in modeling returns obtained by designating specific periods, the results were not stable across those periods. For example, the weakest of the selected periods is the 1947 to 1953 phase. Although relatively brief, this period was diverse, including the 1949 recession, a period of economic stimulation, the Korean War and the beginning of the 1954 recession. The relatively long temporal frame of the 1954 through 1979 period complies with long phase economic cycle discussions suggested by the research of Goldstein (1988), Stoken (1993) and Grenadier (1995) and is supported by the relatively high $R^2$ (79.9%). This period is characterized by a generally positive sloping trend in returns, although the volatility is amplified toward the end of the period. On the other hand, a negative sloping trend prevails over the full decade of the 1980s, although there was a brief upswing from 1982 to 1984 (refer to Exhibit 4). These weakening returns run counter to the popular characterization of the early to mid-1980s as an active, healthy real estate market. This inconsistency can be attributed in part to offsetting structural changes that permeated the period, including the stimulative impact of the 1981 Tax Recovery Act, expansive Reagonomics policies, lagging effects of the 1981–82 recession and the constraining impact of the 1986 Tax Reform Act. The inconsistencies reflected in these findings across time periods suggest that attempts to formally delineate the appropriate time periods and develop more precise, time-sensitive models is warranted.

**Segmentation Results Using Macroeconomic and Capital Market Parameters**

In order to better understand the observed segments and improve the explanatory power of the model based purely on time trend modeling presented in the previous section, the key exogenous economic parameters discussed in the return literature were added into the analysis. In this phase of the study, the decision as to the appropriate number of independent variables was based on accepted practice in econometrics theory, as well as concern for the limited degrees of freedom in the underlying data. Two distinct models were developed: a model based purely on macroeconomic factors shown in Equation (1); and, a model based on a combination of macroeconomic and tax factors shown in Equation (2). The key independent variables in the first model included economic productivity as proxied by GNP, interest rates as an indication of capital markets and unanticipated inflation. Control of the independent variable input improved model specification and prevented multicollinearity from distorting the results. Using these modeling criteria, the basic model was:

\[ R_t = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \epsilon_t, \]  

where:

- $X_1 = \text{GNP}$;
- $X_2 = \text{Interest rates}$; and
- $X_3 = \text{Unanticipated inflation}$. 

\[ \text{where:} \]

\[ X_1 = \text{GNP}; \]
\[ X_2 = \text{Interest rates}; \text{and} \]
\[ X_3 = \text{Unanticipated inflation}. \]
The explanatory power of the model based on macroeconomic variables blocked for the previously selected time periods is presented in Exhibit 6, which indicates the coefficient measures for $\beta_1$ (GNP), $\beta_2$ (interest), $\beta_3$ (unanticipated inflation), the coefficient’s $t$-Statistic (in parenthesis), the equation’s $R^2$, DW and $F$-Statistic. By comparing the results of Exhibits 5 and 6, the improvement obtained by adding macroeconomic variables over shear time trend analysis becomes apparent. As noted, the $R^2$ and other statistics improved for each time period, including the full period from 1947 to 1995. The most dramatic improvement was in the 1947–53 period, which experienced an increase in $R^2$ from 16.75% to 94.83%. An exception to this pattern of improvement was the period from 1980 through 1990 where the $R^2$ actually declined substantially, from 49.27% to 7.17%. Once again, the instability of results across time periods provides empirical evidence that structural changes that modify the relationships among real estate performance, macroeconomic variables, and capital market variables may indeed occur over time.

**Segmentation Results Adding Exogenous Tax Effects**

To explore the impact of structural changes in more detail, and to better understand the weaker results for the 1980s, the macroeconomic model was expanded to include key tax variables cited in the literature. This addition is consistent with Grendier’s research for the 1970s and 1980s that suggested a significant impact of tax regulation during this period. In the literature, the treatment of tax factors on real estate performance can be grouped into two highly relevant and interwoven approaches. The first category explored the impact of tax changes on optimal holding periods as developed by Ricks (1969), Friedman (1971) and Webb and Rubens (1988). The second category explored the impact of tax changes on time segmentation by treating tax variables as singular intervening events using dummy variables (Nourse, 1987). The fact that tax changes can trigger changes in holding periods, independent of

---

**Exhibit 6**

<table>
<thead>
<tr>
<th>Segment</th>
<th>$\beta_1$</th>
<th>$\beta_2$</th>
<th>$\beta_3$</th>
<th>$R^2$ (%)</th>
<th>DW</th>
<th>$F$-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1947–95</td>
<td>0.314</td>
<td>0.636</td>
<td>0.572</td>
<td>50.63</td>
<td>1.207</td>
<td>15.381</td>
</tr>
<tr>
<td></td>
<td>(2.04)</td>
<td>(3.88)</td>
<td>(2.93)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1947–53</td>
<td>0.713</td>
<td>–2.301</td>
<td>–0.011</td>
<td>94.83</td>
<td>1.530</td>
<td>18.349</td>
</tr>
<tr>
<td></td>
<td>(3.69)</td>
<td>(–1.38)</td>
<td>(–0.04)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1954–79</td>
<td>–0.012</td>
<td>1.184</td>
<td>0.730</td>
<td>89.37</td>
<td>1.725</td>
<td>61.642</td>
</tr>
<tr>
<td></td>
<td>(–0.11)</td>
<td>(5.99)</td>
<td>(3.19)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1980–90</td>
<td>0.517</td>
<td>–0.307</td>
<td>–0.105</td>
<td>7.17</td>
<td>1.292</td>
<td>0.180</td>
</tr>
<tr>
<td></td>
<td>(0.73)</td>
<td>(–0.47)</td>
<td>(–0.18)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991–95</td>
<td>0.703</td>
<td>–14.602</td>
<td>–14.683</td>
<td>99.21</td>
<td>1.906</td>
<td>42.162</td>
</tr>
<tr>
<td></td>
<td>(7.38)</td>
<td>(–7.42)</td>
<td>(–7.27)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: t-Statistics are in parenthesis.*
macroeconomic conditions, suggests the possibility of misspecification error in a model that combines the two types of variables. This potential confusion is amplified by the fact that holding period time frames for investors that materially affect investment performance may not be synonymous with the economic phases of the business cycle. To offset the potential specification error, this research incorporates both the tax shelter component of the income return and the capital gain. The conceptual basis for this modeling format is addressed by Gushee (1974), Fisher (1977) and Grissom and Diaz (1991). The addition of tax treatment to macroeconomic variables generated the following equation:

\[ R_t = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_4X_3 - \beta_4X_4 - \beta_5X_5 + \epsilon_t, \]  

where:

- \( X_1 = \text{GNP}; \)
- \( X_2 = \text{Interest rates}; \)
- \( X_3 = \text{Unanticipated inflation}; \)
- \( X_4 = \text{Tax shelter/benefits}; \)
- \( X_5 = \text{Capital gains}. \)

The statistical significance of time segmentation with the expanded model is demonstrated in Exhibit 7. The addition of tax variables to macroeconomic factors continued to improve the explanatory power over the shear time trend model over several time segments. However, over the long term the \( R^2 \) shows insignificant improvement while the \( F \)-Statistic and the DW were indeterminate given the sample

### Exhibit 7

**Return Trend Analysis Considering Tax Variables and Testing Coefficients for Change in GNP, Interest Rates and Unanticipated Inflation**

<table>
<thead>
<tr>
<th>Segment</th>
<th>( \beta_1 )</th>
<th>( \beta_2 )</th>
<th>( \beta_3 )</th>
<th>( \beta_4 )</th>
<th>( \beta_5 )</th>
<th>( R^2 ) (%)</th>
<th>DW</th>
<th>F-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1947–95</td>
<td>0.327</td>
<td>0.691</td>
<td>0.543</td>
<td>−0.353</td>
<td>−0.163</td>
<td>51.88</td>
<td>1.279</td>
<td>9.273</td>
</tr>
<tr>
<td>1947–53</td>
<td>0.713</td>
<td>−2.301</td>
<td>−0.011</td>
<td>na</td>
<td>na*</td>
<td>94.83</td>
<td>1.530</td>
<td>18.349</td>
</tr>
<tr>
<td>1954–79</td>
<td>−0.084</td>
<td>1.071</td>
<td>0.670</td>
<td>−1.336</td>
<td>0.068</td>
<td>91.40</td>
<td>1.735</td>
<td>42.535</td>
</tr>
<tr>
<td>1980–90</td>
<td>0.695</td>
<td>−0.496</td>
<td>−0.034</td>
<td>−12.657</td>
<td>−5.124</td>
<td>94.02</td>
<td>2.061</td>
<td>15.716</td>
</tr>
</tbody>
</table>

*Note: t-Statistics are in parenthesis.  
*A singular matrix was produced.*
size and the number of independent variables. As in the previous case the results differed over the selected time periods. The most dramatic improvement was during the 1980s, which experienced two major tax shocks and a series of smaller policy adjustments. Comparing the results of the base macroeconomic model (Equation (1)) and the expanded model with tax variables over the 1980–90 time segment shows a major shift in variable impacts. The significance of the interest rate or expected inflation is reduced and the tax factors greatly increased as noted by the \( t \)-Statistics. The \( R^2 \) for 1980–90 increases from 7.17% to 94.02%, with the Durbin Watson statistic showing no serial correlation in the latter calculations. Also, a high \( F \)-Statistic of 15.716 is calculated for the 1980–90 time segment. These statistical implications support the literature and common recollection of the period as one in which tax reform created a series of windfalls and wipeouts for investors. The results of the 1991–95 time segment are indicative of a period in which tax changes were inconsistent, with changes concentrated on capital gain regulations, while the income shelter position was fairly constant. These results are presented at the bottom of Exhibit 7 showing the separate analysis of tax factors over the 1991–95 period, with an \( R^2 \) of 75.47% due in large part to the significance of the capital gain variable.

**Single Series Structural Change and Regime-Switching Analysis**

The development of the econometrics models and the identification of relevant variables within the time periods visually extracted from the pattern of returns can now be extended to more rigorously determined time periods. In this section, an array of statistical techniques is used to test for significance and timing of structural changes. Specifically, the investigation employs the Chow Breakpoint test, the Chow Forecast Analysis, CUSUM and CUSUM of Squares tests to attempt to delineate when structural changes occur by testing the impact of the turning points (i.e., the periods over which such changes actually occurred). The recursive perspective is based on the expectation that the relationship between the pattern of real estate returns and independent variable residuals occur sequentially and not simultaneously. This allows a year by year test process that monitors changes in \( R^2 \)'s, helping to isolate the inflection points past which regime switching has occurred.

**Regime Switching: Chow Tests**

The implications of regime switching are reflected in the statistics displayed in Exhibit 8 using Equation (2). The Chow test first segments the time series into clusters of defined time periods and then tests the relationships between the two groups. As noted by the \( F \)-Statistics, the Chow Breakpoint tests are significant and suggest that 1979, 1981 and 1991 can be identified as possible inflection points or points of significant structural segmentation. Further information on structural change is developed with the Chow forecast test in support of the basic Chow test. The forecast uses a subsample of the data prior to the estimated date of change and forecasts the trend in the subsample across the remaining period up through year-to-date 1997. It should be noted that the period from 1947 to 1953 produced a singular matrix using the expanded tax model and thus could not be applied. Further, using the basic macroeconomic model (i.e., Equation (1)) for the period produced a highly linear
model, which was not consistent with the pattern of the actual data. This developed a misspecified forecast after 1953, reinforcing the possibility that an unexplainable structural change occurred.

The subsample from 1947 to 1978 was the basis for a forecast of the period 1979 through 1997. This forecast produced an $R^2$ of 83.84% and an $F$-Statistic of 26.97. The coefficients for the productivity measure of real economic growth (GNP), interest rate and unanticipated inflation variables all showed significant t-statistics. The 1991–97 segment, based on a forecast from the subset of 1947–90 generated a lower $R^2$ of 57.45%. The other statistics for this period indicate that the independent variables are still strong as predictors of returns. The decline in the specification of the longest data subset over a cyclical pattern suggests that the expanding time frame of the subsamples creates a trending problem for the analysis. However, problems arising in the development of an overall trend suggests that the impacts (e.g., slope or explanatory mix) of the independent variables are changing. The Chow tests are supported by a multiperiod recursive residual test. The recursive residual analysis is effectively a sequential Chow forecast (a year by year analysis of breakpoints) that test each year as a potential point of structural change. The 1981 year break point was also tested and is similar to the findings for 1979 with some moderate statistical significance. Based on the sequential residual Chow test, the switch point occurs in 1981, suggesting a lag relative to the Chow Breakpoint, CUSUM and Chow tests.

**Single Series Structural Change via Spline Analysis**

Dummy variables are employed in much of the econometrics literature to identify structural change or quantify the impact of significant economic events. However, concerns with dummy variables have been raised by a number of researchers including Chow (1960), Robb (1980) and Johnston (1984). In an attempt to determine whether dummy variables could add to the explanatory power of the modeling, Equation (2) was expanded to replicate the possible structural changes that occurred in 1953, 1979 and 1991. The $R^2$ of the expanded model improved modestly, suggesting that dummy variables made only a marginal addition to time segmentation. Because of this limited

---

**Exhibit 8**

**Structural Analysis Testing For Regime Switching**

<table>
<thead>
<tr>
<th>Year</th>
<th>Chow Break Point</th>
<th>Chow Forecast Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$F$-Stat./Prob</td>
<td>Log Likelihood/Prob</td>
</tr>
<tr>
<td>1953</td>
<td>1.069/0.405142</td>
<td>10.19/0.251857</td>
</tr>
<tr>
<td>1979</td>
<td>6.623/0.000081</td>
<td>35.74/0.000003</td>
</tr>
<tr>
<td>1981</td>
<td>9.229/0.000003</td>
<td>44.83/0.000000</td>
</tr>
<tr>
<td>1991</td>
<td>3.303/0.013702</td>
<td>16.93/0.004627</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Chow Break Point</th>
<th>Chow Forecast Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$F$-Stat./Prob</td>
<td>Log Likelihood/Prob</td>
</tr>
<tr>
<td></td>
<td>132.62/0.007510</td>
<td>389.84/0.000000</td>
</tr>
<tr>
<td></td>
<td>8.061/0.000002</td>
<td>89.95/0.000000</td>
</tr>
<tr>
<td></td>
<td>8.229/0.000001</td>
<td>82.71/0.000000</td>
</tr>
<tr>
<td></td>
<td>2.938/0.024452</td>
<td>16.01/0.006807</td>
</tr>
</tbody>
</table>


*Used basic model, because of the singular matrix produced by the expanded model.
improvement in model specification, the use of spline analysis—an alternative econometrics approach—was applied in an attempt to improve explanatory power in the study of structural change.

Spline analysis was particularly appropriate for this study since it identifies the slope change resulting from a regime-switch and overcomes the dependency of dummy analysis on a subset base, as discussed by Suits, Mason and Chan (1978) and Kennedy (1986). Also, spline analysis allows the extension of discontinuous piece-wise analysis to a continuous analytical model, as per Poirier (1976). Briefly stated, regime switches are dependent on “knots,” which help delineate the segments of the splines linked to specific turning points. Knot approximations of these turning points are determined by adjusting the actual variables in a time segment that follows a specific turning point (e.g., 1978). This differential change is then weighted by a dummy variable to isolate the slope change for a specified period of time. This provides a temporal weighting of each effective intercept as they are linked to the impact of the relevant variable. Exhibit 9 presents a graphical representation of the phases of regime switches (i.e., turning points) and dominant splines that were generated for the three regimes (i.e., 1953–79, 1979–91, 1991–97).

**Results of Spline Analysis**

As discussed, the most significant variables over the entire time interval have been the change in productivity level (GNP) and the interest rate, which reflects anticipated
inflation. In effect, these variables can be viewed as proxies of the aggregated supply and demand of capital, which is consistent with Ibbotson, Diermeier and Siegel’s (1984a,b) Net Equilibrium Theory (NET). Unfortunately, because of the limited number of observations within some of the temporal segments, the interest rate knots and productivity level knots modeled in Equations (3) and (4) could not be incorporated into the same equation without producing a singular matrix. Thus, spline analysis was applied to two separate models to determine whether the GNP or interest rate-based splines dominated the other in terms of explanatory power.

As noted in Exhibit 9, the GNP splines had an upward sloping line for each of the time periods, although the slope varied significantly after the knots or breakpoints. Over the full time period, the GNP spline model represented by Equation (3) produced an $R^2$ of 60.64%. The use of dummy variables in this context differs from that of dummy variable regression models in the sense that the procedure tests whether the indicated spline segment is significant, as opposed to whether an individual independent variable is significant. Some of the improvement in the model over dummy variable regression models is based on the fact that the knots for the 1979 and 1991 segmental changes were statistically significant in the Spline model as measured by the $t$-Statistics. Improvement over dummy regression models was also apparent in the Durbin-Watson statistics and the $F$-Statistics.

$$R_i = \alpha + [\alpha_1 + \beta i_i (X_{it} - X_{1953})D_{53}] + [\alpha_2 + \beta i_i (X_{it} - X_{1979})D_{79}]$$
$$+ [\alpha_3 + \beta i_i (X_{it} - X_{1991})D_{91}] + \beta i_i X_2 + \beta i_i X_3 - \beta i_i X_4 - \beta i_i X_5 + \epsilon i,$$  (3)

where:

- $X_{it} = GNP_t$, productivity measure altered by 1953, 1979 and 1991 changes;
- $D_{53} = $ Dummy variable signifying period from 1953 through 1979;
- $D_{79} = $ Dummy variable signifying period from 1979 through 1990;
- $D_{91} = $ Dummy variable signifying period from 1991 through 1995;
- $X_2 = $ Interest, anticipated inflation;
- $X_3 = $ Unanticipated inflation;
- $X_4 = $ Tax shelter; and
- $X_5 = $ Capital gains.

Equation (4) presents the Interest spline model. As noted, the model differs from the GNP model via the substitution of the dummy variable for the time periods, with the Interest variable altered by the 1953, 1979 and 1991 changes. In general, the Interest rate driven spline analysis did not explain as well as the GNP spline. The $R^2$ for the interest rate spline model dropped to 57.86%. However, it should be noted that this is still an improvement, though moderate over Equation 2 at 51.42% and equivalent to the dummy variable model at a 57.31% $R^2$. Interestingly, the Interest splines changed both direction and slope across the time segments (see Exhibit 9), indicating that interest rate and inflationary impacts on performance can dramatically differ over time.
\[ R_i = \alpha + \beta_i X_1 + [\alpha_1 + \beta_i (X_{2t} - X_{1953})D_{33}] + \alpha_2 + \beta_i (X_{2t} - X_{1979})D_{79} + \alpha_3 + \beta_i (X_{2t} - X_{1991})D_{91} + \beta_i X_3 + \beta_i X_4 - \beta_i X_5 + \epsilon_i, \]

where:

- \( X_1 \) = GNP, productivity measure;
- \( D_{33} \) = Dummy variable signifying period from 1953 through 1979;
- \( D_{79} \) = Dummy variable signifying period from 1979 through 1990;
- \( D_{91} \) = Dummy variable signifying period from 1991 through 1995;
- \( X_{it} \) = Interest rate altered by 1953, 1979, and 1991 changes;
- \( X_3 \) = Unanticipated inflation;
- \( X_4 \) = Tax shelter; and
- \( X_5 \) = Capital gains.

The predominance of the GNP spline model is intuitively acceptable given the regulatory control over the interest rates up to 1979 and hence an expectation of autocorrelation. These findings help characterize the 1953–79 period as an expansionary phase in which real estate performance was highly associated with and driven by the GNP productivity variable. On the other hand, the 1979–90 period was driven by the financial markets uncoupled from the real product markets (Drucker, 1990). As the piece-wise trend and recursive analyses indicated, the predominant economic trend in the 1980s was negative. Intuitively, this period should have been characterized a positive economic environment. However, the real estate return pattern in the 1980s generally declines with the Interest spline and is in contrast to the GNP spline. The most current period (1991–97) calculations show the productivity measures of GNP to be a key impact, while the significance of the interest rate is lower. This may be a rational outcome of the combination of deregulating interest rates and the changing structure of capital markets associated with the trend toward securitization. It may also show that in different phases, the variables shift between exogenous and endogenous impacts. It is expected that as the time series data is extended, the ability to combine the impacts of the GNP and Interest spline models may help adjust for misspecifications and improve the \( R^2 \) above the 70% level of association.

The consistency of the direction of the GNP spline and the interest spline in the 1953–79 period and the reversal of direction during the 1980s provides insight into how the real estate market functions in relationship to the general economy. For example, during an expansionary phase, the productivity level of the economy drives real estate performance with investors more concerned by growth than by capital costs. During more volatile times such as experienced in the 1980s, both capital and investment potential are factored into performance, with emphasis placed on the general level of economic productivity as the crucial value. During such periods, the imbalance of supply and demand that was in part initiated by the 1981 tax act and further distorted by the 1986 attempts at fiscal adjustment, disrupt long-term relationships and capital flows to the asset class.
Extension of Single Series to Multiple Series Analysis

As noted in the literature review and the discussion of the major return series, researchers exploring real estate cycles have struggled with a scarcity of data and inconsistent measures of performance or market conditions. However, each of the data series can provide insight into how certain aspects of the real estate market perform over time. Thus, to develop a better understanding of the dynamics of real estate cycles, the econometric models developed with the Ibbotson series were applied to each of the return series using the same time periods. This extension addressed several key questions. First, would the improvement of the spline models over the basic time series models reflected in the Ibbotson data hold up against the other series or was it an artifact of the data? Second, regardless of the underlying drivers behind the competing series, could they be modeled over time in a meaningful way? Finally, are the competing time series related, or do they appear to measure different phenomena?

Exhibit 10 summarizes the results of the extension of the Ibbotson analysis to the other performance data. As suggested in the table, the basic model (i.e., Equation (1), the macroeconomic model) was applied to each data series as an initial attempt to identify the appropriate specification for each index. The findings for each index’s basic model were then compared to the statistics of the expanded model (i.e., Equation (2), which added tax variables to the macroeconomic variables) to see if there was a meaningful change in the relevant variables in the varying time periods covered by each data series. Finally, the econometrics spline models are applied to see if the specification of the structural change is consistent for each data series. This analysis included Equation (3), the GNP spline model; and, Equation (4), the tax spline model.

As noted in the exhibit, the spline models generally improved the $R^2$s for the respective return series. The tests for each of the return series indicates support for the overall structural change models and inclusion of both the macroeconomic and tax variables. The ACLI returns show a weaker basic model in application than that developed with the Ibbotson data. However, with the introduction of the tax and structural change variables, the model reflects more significant statistics than the initial model using the

### Exhibit 10

**Coefficient of Determination ($R^2$) of Models for the Alternative Return Series**

<table>
<thead>
<tr>
<th>Series</th>
<th>Basic Model Equation 1 (%)</th>
<th>Expanded Model Equation 2 (%)</th>
<th>GNP Spline Equation 3 (%)</th>
<th>Interest Spline Equation 4 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ibbotson</td>
<td>49.21</td>
<td>51.42</td>
<td>60.64</td>
<td>57.86</td>
</tr>
<tr>
<td>ACLI</td>
<td>42.79</td>
<td>54.24</td>
<td>71.50</td>
<td>85.40</td>
</tr>
<tr>
<td>NAREIT</td>
<td>8.19</td>
<td>22.95</td>
<td>29.42</td>
<td>22.04</td>
</tr>
<tr>
<td>NCREIF</td>
<td>65.95</td>
<td>83.55</td>
<td>86.07</td>
<td>91.63</td>
</tr>
<tr>
<td>RERC</td>
<td>54.61</td>
<td>82.48</td>
<td>84.68</td>
<td>87.88</td>
</tr>
<tr>
<td>NREI</td>
<td>65.85</td>
<td>77.75</td>
<td>79.26</td>
<td>92.81</td>
</tr>
<tr>
<td>KYI</td>
<td>55.05</td>
<td>89.70</td>
<td>99.99</td>
<td>99.93</td>
</tr>
</tbody>
</table>

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Ibbotson returns. Major specification improvements in modeling occur with the introduction of variable splines, when the ACLI data is used. The NCREIF, RERC, NREI and KYI series all show improved statistics over the initial Ibbotson data tests. However, it should be noted that these series were not available for the full time period over which the Ibbotson statistics were calculated and thus were not tested with as many market cycles and structural shifts. Furthermore, due to their even more limited time series of data availability, the implications developed from the analysis of the NREI and KYI return series should be viewed somewhat skeptically. Interestingly, extension of the models to the NAREIT return series revealed a limited association with any of the private market real estate return series. However, application of the expanded model and the GNP spline model to the NAREIT series still offered improvement over the basic model. Thus, although the public real estate market cannot be explained as easily as the private market by fundamental economic variables, there is evidence that they do go through distinct cycles and experience structural change. This lack of model association suggests that NAREIT return models depict public security pricing more than real estate asset performance, and may be more directly linked to expectation theory than the direct real estate investment indices.

Multiple Series Results: Relevant Decision Variables and Time Segments

Exhibit 11 illustrates the findings resulting from the application and testing of the econometric models on the seven return series. The findings present the most significant model for the particular series, along with the $t$-Statistics for the respective splines and independent variables. In each application, a spline model based on $R^2$ measures is specified as the most appropriate fit for each data series. The specifications appear to be evenly divided between GNP or interest spline models. Within the context of the most significant model specification, significant variables are indicated within relevant time segments. The relevant variables and time periods are identified by the magnitude of their $t$-Statistics relative to the number of observations and degrees of freedom available. As noted in the exhibit, all three GNP spline periods were significant for the Ibbotson series, while only the latter two were significant for KYI, and only one for NAREIT. In view of the KYI series, it should be noted that the lack of variation in the data relative to the historic returns, which reflects desired yields and makes it appear more predictable than the other series, which are based on actual performance. As noted in the exhibit, the interest spline periods were only significant for the ACLI and NCREIF series during the 1980s. The other series were explained by the other independent variables, with GNP contributing to each series with the exception of NREI, and capital gains relevant for all but the ACLI series. The differences in the signs of the $t$-Statistics across the series and spline models indicates that there are some significant differences in how the series can be explained over time.

Regardless of the index used and the diversity reflected in its data origins and the development of its performance measurement, each index quantitatively supports segmenting the return series into distinct time periods. Furthermore, the level of the general economic condition as measured by GNP is significant in six out of the seven
Exhibit 11  
Statistical Identification of Relevant Variables per Time Segment

<table>
<thead>
<tr>
<th>Series</th>
<th>Most Significant Model</th>
<th>Significant Variables</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ibbotson</td>
<td>GNP Spline</td>
<td>Interest</td>
<td>5.15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unanticipated Inflation</td>
<td>4.59</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GNP 1991–1997</td>
<td>2.90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1980–1990</td>
<td>−1.40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1954–1979</td>
<td>1.40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Capital Gains Rate</td>
<td>−1.15</td>
</tr>
<tr>
<td>ACLI</td>
<td>Interest Spline</td>
<td>Interest 1980–1990</td>
<td>−6.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GNP</td>
<td>−2.53</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tax Shelter</td>
<td>1.36</td>
</tr>
<tr>
<td>NAREIT</td>
<td>GNP Spline</td>
<td>Unanticipated Inflation</td>
<td>−1.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GNP 1991–1997</td>
<td>−1.28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Capital Gains Rate</td>
<td>−1.24</td>
</tr>
<tr>
<td>NCREIF</td>
<td>Interest Spline</td>
<td>Capital Gains Rate</td>
<td>−3.42</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GNP</td>
<td>2.53</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interest 1980–1990</td>
<td>1.21</td>
</tr>
<tr>
<td>RERC</td>
<td>Interest Spline</td>
<td>Capital Gains Rate</td>
<td>−3.30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GNP</td>
<td>2.44</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GNP Spline</td>
<td>2.19</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interest</td>
<td>2.16</td>
</tr>
<tr>
<td>NREI</td>
<td>Interest Spline</td>
<td>Capital Gains Rate</td>
<td>−2.68</td>
</tr>
<tr>
<td>KYI</td>
<td>GNP Spline</td>
<td>Tax Shelter</td>
<td>−212.17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Capital Gains Rate</td>
<td>102.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GNP 1980–1990</td>
<td>95.12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1991–1997</td>
<td>40.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interest</td>
<td>33.84</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unanticipated Inflation</td>
<td>51.69</td>
</tr>
<tr>
<td></td>
<td>Interest Spline</td>
<td>Tax Shelter</td>
<td>−19.97</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Capital Gains Rate</td>
<td>12.34</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unanticipated Inflation</td>
<td>8.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GNP</td>
<td>6.97</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interest 1991–1997</td>
<td>1.83</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1980–1990</td>
<td>−1.67</td>
</tr>
</tbody>
</table>

Note: The variables are ranked in order of highest to least significance. The significant t-Statistic varies with the sample size and degrees of freedom employed.

indices. Interest rates are significant in five of the seven scenarios, even though real estate returns and interest rates have not been highly correlated since the mid-1980s. The tax variables, both tax shelter and capital gain rates have been most cyclical in their significance. Indeed, only the 1980–90 time frame shows them as statistically relevant, despite the options of highly accelerated rates and recapture allowances prior to 1986.

The market segment from 1980 to 1990 has been delineated as a highly relevant time period. Further research is required to determine if this is because of the occurrence
of a major structural change during this era or if it is simply an economic anomaly. The results of this study tend to support the former conclusion. The temporal market segment from 1991 to 1997, year to date is also statistically recognized as a distinct, if not unique economic phase. It has been a period of good economic growth with moderate inflation. The latter period when compared to the long term volatility may suggest the need to start identifying future near term market corrections (as related to future structural changes).

The use of multiple indices supports the segmentation of economic time periods, reflecting distinct patterns and trends resulting from structural changes underlying the fluctuation of return and economic cycles. The other key findings revealed for the respective return series include:

- The Ibbotson series is best specified by a GNP spline model. It shows in order of $t$-Statistic ranking an emphasis on the interest rate, unanticipated inflation and the GNP. The GNP as an explanatory variable during the period of 1991–97. The 1980–90 period and the 1954–79 are marginally significant, such that the link to the change in GNP with a loading for anticipated inflation is consistent with the NET theory and the built up rate method developed by Ibbotson and others (see Ibbotson, Diermeier and Siegel, 1984a,b; Goetzmann and Ibbotson, 1990; and Ibbotson and Siegel, 1984).

- The ACLI Index is best specified by an interest spline model, heavily focusing on the interest variable during the 1980–90 market segment. This series shows a negative association with both the interest rate and the change in GNP. This is consistent with the database offered by ACLI, which is based on a mortgage portfolio and the underlying property collateral. Though an equity yield is developed, performance is influenced by debt levels that should be related to the key economic indicators.

- NAREIT returns as stated earlier, show weak associations under all model specifications. However, of the models, a GNP spline is most appropriate, with unanticipated inflation, GNP and capital gain rates being marginally relevant based on coefficient $t$-values. The GNP spline for 1991–97 is the most significant phase. This is consistent with the accelerated activity in REITs tied to the new wealth created by an active economy (as per NET theory), an the tax implications of the 1993 Ombudsman Tax Act, effectively changing the economic structure and operations of the REIT industry.

- NCREIF performance levels are linked to an interest rate spline, focusing on capital gain rates, changes in the GNP and interest, with the latter being most significant during the 1980–90 time frame. Though many of the NCREIF participants are tax free or deferred investors, the return levels are impacted by market competition. The competitors over time, especially in the current market phase, have been significantly influenced by capital gain rates. Note the appropriateness of the negative
t-Statistic sign for capital gains and other tax variables relative to return measures.

- RERC is equally specified by both an interest rate and a GNP spline model. This equation is based on similar $R^2$ measures. This dual specification foundation is rational given the shift in the data source from a historical series to a survey format. Under the interest spline model, the capital gains rate and the change in GNP are most relevant. The GNP spline indicates that the interest rate is most insightful in explaining RERC returns for the 1991–97 market phase. This would infer that those investors surveyed assign importance to the general level of the economy.

- The NREI return series is best specified by an interest rate spline model, with an emphasis on the capital gains rate. This focus on financial issues and tax variables linked to transactions is rational given that the NREI data is derived from transactions of a high concentration of non-institutional investors.

- The KYI return series as a survey of performance expectations is well specified by both a GNP and interest rate spline model. Under both model specifications, in ranking order, tax shelter is most significant in explaining return variation. Capital gain rates are next in order. Both specifications then vary with an emphasis on GNP with the 1980–90 and 1991–97 being significant periods. The interest rate is significant for the same periods, but in reverse order (1991–97 and then 1980–90). It is interesting to note that all variables are significantly integrated into the KYI return series. This may be attributed to the series being developed from a survey, with expectations incorporating rational expectations, rather than historically documented associations.

**Conclusion**

The emphasis on investment decision making in this study had a fundamental impact on the research design that made it distinctive in two respects. First, it directly investigated bottom line investment performance, moving away from the more traditional cycle research that focuses on real estate fundamentals related to market balance. Second, it operated at a more macro-scale than the bulk of cycle research to date. In the first stage of the study, cycle literature and available research series were explored. In the second stage, exploratory analysis was conducted on the longest return series to determine whether performance cycles existed and whether they could be modeled. This single series exploratory research also analyzed some of the major exogenous shocks that could trigger a change in the key drivers of real estate performance that render static models irrelevant over time. Based on the successful results of this exploratory single series research, the tests were extended to the multiple return series to establish the robustness of the results and ensure that they were more than an artifact of the selected data series.

The results of the research are generally positive, suggesting that the variables and relationships that distinguish real estate cycle stages can be isolated when looking at
returns and that they are sufficiently stable to help identify cyclical changes. The study also provided insight into the more strategic question of whether such fundamental, micro-research efforts can help investors make investment decisions regarding asset allocation and portfolio construction in a timing framework. That is, if the results were successful, this would suggest that the additional insights and understanding gleaned from indirect research into market fundamentals can help investors make strategic decisions regarding the role of real estate in mixed-asset portfolios. The research suggests that it is possible to track key exogenous shocks that indicate that structural changes have occurred. For example, with respect to structural changes, one of the key implications of this research based on several test techniques is that a major structural change occurred in the pattern and trend of real estate returns between 1979 and 1981. This structural impact intervened through 1991. Other periods of structural change in the long-term return cycle were observed around 1954, extending through 1979 and 1991 into 1997. Also, the time segment from 1980 through 1990 was unique relative to the other time segments, with tax shelter and capital gain rates representing more significant impacts on returns than witnessed in the periods prior to 1980 and after 1991. This isolation of significant tax implications between 1980 and 1991 is noteworthy because the tax regulations prior to 1980 that allowed for accelerated depreciation were significantly different from the moderate tax legislation after 1991. The radical shifts in the 1981 and 1986 tax acts were also key exogenous factors that changed the optimal performance models as the disaggregative spline analysis demonstrated. In particular, the prohibitive 1986 tax regulation appears to have had greater impact on performance than the stimulative actions of the 1981 legislation.

While the statistical results presented herein are not intended to suggest that real estate investors can, or should, focus on market timing, they do provide strategic insights that investors can use to proactively manage real estate portfolios. In particular, the institutional requirement to view real estate as a long-term asset rather than a current transaction, argues that investors should apply a cyclical perspective in making investment allocation decisions. The ability to identify the knots of structural change presented in this study and to isolate distinctive temporal market segments provides statistical support for this conclusion. Furthermore, the discrete segmentation of the cycles reveals that different variables are emphasized at different times and can have different impacts on real estate performance. Such insight should help investors associate the significant economic variables in distinct economic environments in terms of their timing and likely impact on returns. This suggests the importance of considering market cycles in real estate investment and the importance of applying both fundamental real estate expertise and portfolio management principles. In addition, a better understanding of market cycles and structural changes provides a foundation for identification and development of hedging strategies, timing of acquisitions and disposition, forecasting models, portfolio allocations and comparative investment decisions within a time domain consistent with long investment positions.

The insights into the changing nature of driving forces behind the real estate performance presented have a number of implications for researchers. First, the existence of a linkage between macroeconomic variables and overall asset class
performance suggests that a top-down view can be used in making the mixed-asset allocation to real estate. However, since investors must operate at a more tactical level once they have made an allocation to the asset class, fundamental research that focuses on cycles across property types or markets can help. Second, the models that are used to predict real estate fundamentals (e.g., vacancy, rent growth) should be revisited on a periodic basis, making indicated changes to improve their validity and reliability. Third, major exogenous shocks that might distort or modify how the market functions, should dictate how analysts model cycles. To recalibrate such models, researchers should consider extending some of the same econometric techniques used in this article.

Notes

1 Many of the macroeconomic variables used are consistent with the parameters considered in the arbitrage pricing literature (see Ross, 1976; Roll and Ross, 1980; and Grissom, Hartzell and Liu, 1987). Despite the broad array of literature cited, the relevant macro factors consistently identified are some measure of real/productive economic growth, capital market performance and varying measures of degrees of inflation.

2 The Ibbotson and Associates returns are effectively built-up yields (see Ibbotson and Siegel, 1984, 1988).

3 The yield calculation represents the mathematical differential between the cap rate and the nominal interest rate. Imputed in this quantitative differential is the conceptual allowance for the potential equity appreciation and the equity build-up through amortization or paydown of the mortgage, as well as a return of the investment. It effectively reflects the change in the equity position over the holding period as is implicit in the ratio rate of capitalization into perpetuity. The author has concern with the change in method employed by ACLI after 1990. The possible impact of a technical change can be witnessed from the steep increase in returns developed for 1990 through 1995. The yield calculation after this period may require a time variable or some other appropriate adjustment. Research on this issue is being studied for further insights. For more detail, see Grissom and DeLisle (1998).

4 The Koll publication has changed hands after the time series were extracted for this research. Although ownership change frequently introduces methodological changes, the transfer did not distort the observed time series. However, researchers going forward should test for sampling or other research/mechanical changes that could make the time series inconsistent. The term institutional/investment grade properties are usually high quality (e.g., Class A office), large scale facilities with prime locations.

5 Annualization of more frequent reporting periods may be relevant, because several of the appraisal based indices (NCREIF, ACLI and individual CREF databases) are appraised only each year by third parties. The quarterly valuations are conducted in-house as updates. As stated above, the validity of analysis on aggregated data is documented by Geltner (1993) and applied by Geltner, Rodriguez and O’Connor (1995). This approach is also supported by the investigations of Sirmans and Webb (1980), Ibbotson and Siegel (1984), Grissom and DeLisle (1996) and others.

6 Turning points reflect the change in the trends of the longer cycle phases, which correspond with economic structural changes and implied regime switches. Poirier’s (1976) econometric models refer to these structural shifts or turning points as inflection points, reflecting the change in the longer term trend of change (i.e., the second derivative).
7 Piece-wise regression is an econometric process of modeling the longer cycle trends and linear segments identified between the turning points based on a time trend variable. The turning points, which indicate a change in the inflection of the trends, are regressed against the independent economic variables discussed earlier. It should be noted that these independent economic variables are not time series variables, but are exogenous variables that significantly impact the dependent variable.

8 The series of Chow and CUSUM tests relate the dependent and independent data series to statistically determine when the turning point (or inflection point) of the cycle (or regime) changes. A regime change indicates a significant change in underlying economic fundamentals. The Chow test (Chow, 1960) establishes the turning point and uses past data to forecast. The CUSUM test indicates if the actual return data associated with the economic variables significantly differ from the overall trend. The point of variation indicates the actual turning point. The CUSUM Square Test verifies the turning point by testing whether the returns associated with the economic variables exceed a 5% confidence level of significance. For more details, see Brown, Durbin and Evans (1975).

9 Each of these is an objective, quantitative test of the turning points that indicate an intervention or change in structure, as opposed to subjective time segmentation analysis.

10 Segmented spline analysis as applied in this article is a combination of piece-wise regression and dummy variables. It differs from a simple dummy variable analysis that holds the effect constant over the indicated time period based on a discrete intervention. In particular, segmented spline analysis extends the turning point test across the entire phase of the structural shift. This allows analysts to isolate the differential impacts of the variable rather than limiting the impact to the indicated turning point. In effect, spline analysis allows a robust test of the turning effect by testing the significance of the change in slope (i.e., inflection) for its point of initiation until another intervention or structural change occurs and another turning point is indicated. For a more detailed discussion, see Poirier (1976).

11 Dummy variables employed in intervention analysis assumes that the intervening variable occurs in a stair stepping and/or disaggregated pattern. This recognizes the initial impact and its occurrence, but may misspecify the influence of the economic variable over the relevant term. On the other hand, knots used in the spline technique enable the measurement of the variables economic impact throughout its relevant period.

12 A regime is a phase over which the nature or impact of the underlying economic fundamentals on the dependent variable changes from prior, or future, periods. The change in economic regimes connotes the need to alter decision models and policies, for regime relationships shift when the structural foundation of the economic environment is altered. For more details, see Giaccotto and Clapp (1992) and Khoo, Hartzell and Hoesli (1993).

13 The returns as a dependent variable are associated with a time trend applied as an exogenous variable. In effect, the returns are regressed over time.

14 The income tax rate used is based on the maximum allowed depreciation in each of the respective years multiplied by the typical percentage of the depreciable component of the asset. This weighted factor is then multiplied by the maximum marginal tax rate in effect in each specific year. The capital gains tax is calculated in a similar fashion with an adjustment for the portion excluded under the tax law in effect in each respective year, as well as allowances for recapture, when appropriate.

15 GNP was used in this study because it included foreign expenditures in the U.S. economy. This productivity measure is consistent with the sources of investment capital in real estate—which includes foreign ownership—and impacts on the majority of the return series (see Ibbotson, Diermeier and Siegel, 1984a,b).
Control of independent variable input was achieved by limiting the variables to the general categories observed in the literature to assure adequate degrees of freedom. These categories included real/productive economic growth, capital market performance and varying measures of degrees of inflation.

In effect, this modeling approach converts the effects to a rate, using the tax rate, maximum depreciation method (i.e., 175% declining balance) and assuming an 80% depreciable asset.

For additional information to the explanation in the above text on interpreting the recursive residual test on the coefficients of the intercept and independent variables see the User’s Guide for E-Views (Micro-Views TSP®), Pyndick and Rubinfeld (1981) and Kennedy (1986).

Data is lost in simple dummy variable analysis since the analyst must choose between omitting the intercept or one of the base variables. Thus, the calculated coefficients measure marginal changes to the base, not to the overall model. For more details, see Kennedy (1986).

The knots in spline analyses are simply the quantitative measures of a span of a regime that extends from a turning or inflection point until a change in slope occurs that indicates another turning point.

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