On the Use of a Cash-Flow Time-Series to Measure Property Performance

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Abstract. **Modern portfolio theory is increasingly being used to guide real estate portfolio decisions. However, to obtain meaningful results from complex mathematical techniques, the input data must meet at least two conditions: property values must be measured accurately, and the process by which property valuations change over time must be known. Neither of these conditions are satisfied by data currently available.**

This paper closely examines how value is measured and reported for commercial property. Commonly used time-series from NREI, NCREIF and ACLI are found wanting. An index of value using the popular "repeat sales" method is derived using data from Freddie Mac's multifamily portfolio.

The focus of this paper is on developing an alternative measure of property performance based on property net operating income. Two cash flow indices are constructed from publicly available data and evaluated. It is recommended that the methodology developed here be used to create cash flow indices that can supplement or replace existing value indices in property analysis. The cash flow indices have much to offer researchers applying option-based models to real estate.

Introduction

Modern portfolio theory has been applied to real estate since the late-1970s (see, for example the Fall 1984 special issue of the *AREUEA Journal*). However, as data quality has improved, and as Wall Street investment houses have become interested in real estate, there has been an explosion of rigorous analysis that was until recently reserved for equities and bonds. To utilize the latest financial theories, particularly the application of option pricing theory, requires an accurate determination of property values and a knowledge of the process by which property valuations change over time.

In this paper I examine how value is measured and reported for commercial properties—specifically for apartment buildings. It is suggested that the currently available valuation time-series are of limited utility for understanding real estate performance over time. As in the work of Geltner (1990), and Geltner and Mei (1994), I find cash flow risk much more susceptible to rigorous analysis than total expected property returns.[1] Unlike that theoretical work, however, the discussion below presents several methodologies for actually deriving indices of apartment building cash flow.

The first section reviews trends in multifamily property values, pointing out that published indices are contradictory and hence not useful. The second section reviews the fundamentals of how value is created in order to identify the fundamental problems that arise when measuring it. The discussion underscores the attraction of cash flow as a

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meaningful substitute for value in rigorous theoretical analysis. Two new indices for measuring local market performance, both based on property net operating income, are proposed in the third section. The conclusion summarizes the arguments for a cash flow-based measure of market performance and suggests directions for future research.

Current Indices of Value

Knowledge of the time-series behavior of property values is essential for virtually any kind of real estate analysis: from the evaluation of portfolio manager performance to the creation of complex option pricing models. Unfortunately, currently available estimates of value trends are of limited value for most uses: they have a very short history, do not exhibit intuitively plausible behavior, and suffer from methodological problems. Two published, readily available indices of value are from the National Real Estate Index (NREI), and the National Council of Real Estate Investment Fiduciaries with the Frank Russell Company (NCREIF). The national series of each is shown in Exhibit 1, with the fourth quarter-to-fourth-quarter growth rates going as far back in time as each index permits.

The NREI index measures changes in the price per square foot in apartment building transactions reported by some 250 contributors. The building value is calculated as an "all cash equivalent," with future cash flows discounted at 12%. For geographic areas that report a large number of deals, a value-weighted average change is used to update the previous level. As the number of observations decreases, an increasing amount of judgment is used to control for characteristic differences across properties. Over time, the number of quarterly observations has grown to 400–500 properties per quarter. The numbers show values increasing from 1986 to 1990, before falling 7.4% during 1991 and 1992. (The 1986 and 1987 values are not directly comparable to later data because of sample changes.)

Exhibit 1
Alternative Measures of Growth in U.S. Multifamily Property Values
(percent change)

	NREI	NCREIF	Freddie Mac–WRS
1985			−4.4
1986	2.8		8.1
1987	2.9		6.7
1988	2.9	0.4	12.1
1989	3.1	−0.9	5.4
1990	2.4	−1.6	−21.1
1991	−3.1	−9.0	−7.0
1992	−4.5	−5.9	−7.7
1993		2.0	−4.4

NREI and NCREIF indices are 4th quarter-to-4th quarter growth rates. The WRS index is year-over-year. The Freddie Mac series uses 1993 observations through December 15, 1993.

The NCREIF index tracks the values of up to 250 apartment buildings that are included in pension fund portfolios. Some appraisals are updated quarterly, while others are revised only annually. Transactions are included as they occur. This index shows a slight gain in 1988, followed by four successive years of declines cumulating in a 16.5% loss in value through the end of 1992.

Each index has its problems. Concern over the NREI's reliance upon transactions diminishes as the sample increases in size, but the heterogeneity of properties is always a concern. The qualities of the properties vary, with subjective adjustments made to standardize the property valuations. NCREIF controls for heterogeneity by taking a large sample and tracking individual properties. But as shown in Giliberto (1992) and discussed in the section that follows, appraisers have been slow to recognize market valuations, which brings into question both the timing and magnitude of changes in the NCREIF index. Even were the appraisals individually correct, Giliberto (1988) points out that their use in the creation of an aggregate performance time-series creates errors of unknown magnitude. Methodological limitations would be less problematic were the two indices to agree at least in pattern or magnitude. Since they are in fact conflicting, the analyst is left without a reliable national index of value.

The "repeat sales" methodology that is achieving widespread acceptance for creating single-family house price indices provides some promise for creating future apartment valuation indices. The raw data for this technique are individual property valuations at two points in time, which are obtained from any two of a transaction, appraisal, or broker's price opinion. A sample of these property-specific appreciation rates, typically with overlapping time periods, can be combined in a linear regression to create a 'constant quality' appreciation measure. For a description of the technique see Stephens, Li, Abraham, Lekkas, Calhoun, and Kimner (1993), Case and Shiller (1989), or the early work of Bailey, Muth and Nourse (1963). (A simplified discussion is given by Abraham and Schauman, 1990/91.)

A strength of this technique is its modest data requirements, while still controlling for property heterogeneity; and property heterogeneity is an even more significant issue with commercial property than single-family houses. A limitation of the repeat sales method is potential statistical biases from sample selection, property depreciation, weak appraisals, etc. The biases are discussed at length in Stephens et al. (1993).

The repeat sales method was applied to a dataset of apartment properties in the Freddie Mac portfolio. After data cleaning, the sample contained 15,000 matched observations spanning the last ten years. Almost all first observations are purchase valuations from 1984 to 1989; the second observations are from property inspections performed in 1990–93. The derived annual series is reported in the last column of Exhibit 1. This time-series provides yet a third pattern of price movements, and shows robust increases in the late-1980s, a sharp drop in 1990, and continued weakness through 1992. The absence of a decline in 1986–87 when tax reform occurred is curious, as is the magnitude of the 1990 drop.

Freddie Mac's problems with its 1980s multifamily portfolio are well known. Problems with over-valuations and exposure to particularly weak properties may explain the more extreme increase and subsequent large decrease relative to other indices. This series is not being proposed as a true alternative to the other indices. However, this technique will be shown to be of value in the subsequent analysis.

Behind the Value Concept

Many of the limitations with published price indices are a result of the inherent heterogeneity of commercial property. As noted above, heterogeneity creates special problems regarding the sampling method and sample size for these indices, exacerbating the need to minimize any error that might arise from the theory underlying the index's construction. It is therefore useful to return to the 'first principles' of property valuation.

Ownership of an asset means access to a stream of expected future income. This is captured in the discounted cash flow model:

$$Value = \mathrm{E}_O\left[\sum_{t=1}^{\infty}\frac{I_O \prod_{s=1}^{t}(1+\xi_s) - E_o \prod_{s=1}^{t}(1+\delta_s)}{\prod_{s=1}^{t}(1+k_s)}\right], \tag{1}$$

Where E_o is the expectations operator at time 0, I_o and E_o are the initial gross income and expense levels for time 0, ξ_s and δ_s their respective growth rates during each period in the future, and k_s a time-varying risk-adjusted rate of return. Three broad assumptions make it possible to condense the discounted cash flow model into the simple representation above:

(a) It is assumed the asset is held through its entire useful life, eliminating the need to consider residual value.

(b) Tax issues are ignored, permitting equation (1) to be written in terms of pre-tax earnings, not post-tax cash flow. That leaves out the effect on valuation of any differences between tax and economic depreciation. The treatment of capital gains upon disposition is also not present.

(c) Following Follain, Hendershott and Ling (1987), property value is assumed to be independent of the debt/equity financing mix.

It would be straightforward to relax these assumptions but at the cost of much greater, and unnecessary, complexity. Equation (1) can be further simplified by making the appreciation and discount rates invariant over time:

$$Value = \mathrm{E}_O\left[\sum_{t=1}^{\infty}\frac{I_O(1+\xi)^t - E_o(1+\delta)^t}{(1+k)^t}\right]. \tag{2}$$

Finally, if income and expenses grow at the same rate over time, *g,* then (2) condenses even further to:

$$Value = \frac{NOI_1}{k-g}, \text{ for } NOI_1 = \frac{(I_o - E_o)(1+g)}{(1+k)}. \tag{3}$$

In this familiar formula, value equals the first year net operating income (income less expenses at time 1), divided by a 'capitalization rate' (cap rate) equal to the internal rate of return less the rate of NOI growth.

One cannot arrive at a given property's value merely from dividing its projected NOI by a theoretically derived value of (k–g). That would imply acceptance of all the assumptions necessary to get to equation (3). The sensitivity of the equivalence of the discounted cash flow and capitalization rate methods to the various assumptions enumerated above has been explored in numerous recent articles in *The Appraisal Journal*, particularly Bradley (1989) and Eppli (1993).

Equations (1)–(3) illustrate that a natural expansion of the notion of market performance that goes beyond the single measure of property value—which has already been shown to be inadequately empirically captured by existing sources—would be to the dual concepts of property cash flow and market capitalization: the numerator and denominator of the right-hand side of equation (3). It is then an empirical question of whether these two individual concepts are easier than value to capture in an index, and which is the source of greater volatility in market value. A cash flow index is straightforward to compute and is discussed at length in the next section. In contrast, as discussed below, market capitalization shows little volatility in reported measures and is quite difficult to accurately characterize even in the best of circumstances.

The difficulty with measuring trends in capitalization rates is reflected in the published data. Two publicly available sources for cap rates by property type (which also provide detail by loan size and with some regional disaggregation), are the NREI survey described above, and the American Council of Life Insurance (ACLI). This second survey covers commitments for apartment lending by life insurers who hold over two-thirds of all life company commercial mortgages. The quarterly sample can be based upon anywhere from thirty to eighty individual properties.

The patterns of these two series, shown in Exhibit 2, appear to coincide much more than the price series in Exhibit 1, but that is only because there is so little total variation. The NREI series is essentially constant from 1987 through 1990, followed by an increase in cap rates. The ACLI series shows a slight decrease in late 1989–90, before a subsequent increase. During this time, the ten-year constant maturity Treasury yield has moved by 200 basis points, or by twice as much as cap rates, and in the opposite direction!

Exhibit 2
Alternative Measures of U.S. Average Market Capitalization Rates (percent)

	NREI	ACLI	Treasury Ten-Year Constant Maturity Yield
1987:2	8.8	8.9	8.3
:4	8.7	8.9	9.1
1988:2	8.7	8.8	8.9
:4	8.6	8.9	9.0
1989:2	8.6	9.0	8.3
:4	8.7	8.6	7.9
1990:2	8.7	8.7	8.7
:4	8.9	8.7	8.4
1991:2	9.1	9.1	8.1
:4	9.2	9.1	7.4
1992:2	9.5	9.6	7.4
:4	9.7	9.1	6.7
1993:2	9.6	8.9	6.9

The relative insensitivity of cap rates to inflation is explained in Bradley (1989). Still, real estate has been buffeted by several adverse forces over the last six years: tax changes (Follain, Hendershott and Ling, 1987), a credit crunch (Peek and Rosengren, 1993), and a protracted economic recession. It is possible that ACLI contributors have simply tightened their standards and changed their geographic distribution as the market has deteriorated, giving them an increasingly higher quality of properties for the same cap rate. However, the NREI data show a similar national pattern, and they rely on a broad base of recent transactions, with constant property stock weights.

The reasonableness of stable or rising cap rates during this tumultuous period in real estate markets is challenged in Giliberto (1992). He compares the real estate multiples (the reciprocal of the cap rate) implicit in the NCREIF series and in publicly traded equity REITs. (Both include all commercial structures, and are not limited to apartments.) He finds appraisal-based multiples far exceeded 'stock market' multiples from tax reform in 1987 through 1992; see Exhibit 3. Valuations in the NCREIF series were still some 10%–15% 'too high' in mid-1992. Instructively, in late 1993, the series show that the earnings multiples in REITs appear vastly out of line. Still, the extreme gap that opened up between 1987 and 1992 suggests that much of the valuation decline in commercial property reported in the value indices starting in 1990, actually occurred much earlier in time.

The relative stability of reported average cap rates raises serious doubts about the usefulness of market average valuation numbers, and by implication, property-specific cap rates. NREI cap rates do show a modicum of variability—a roughly 200-basis-point spread—cross-sectionally at a single point in time, and over time for small individual geographic areas. Nonetheless, we know little about the reasons why cap rates change and are therefore unable to project them into the future.[2] I conclude that modeling of the time-series of the valuation process necessarily must rely upon the net operating income process, and not the capitalization rate component of value.[3]

A NOI Index of Market Strength

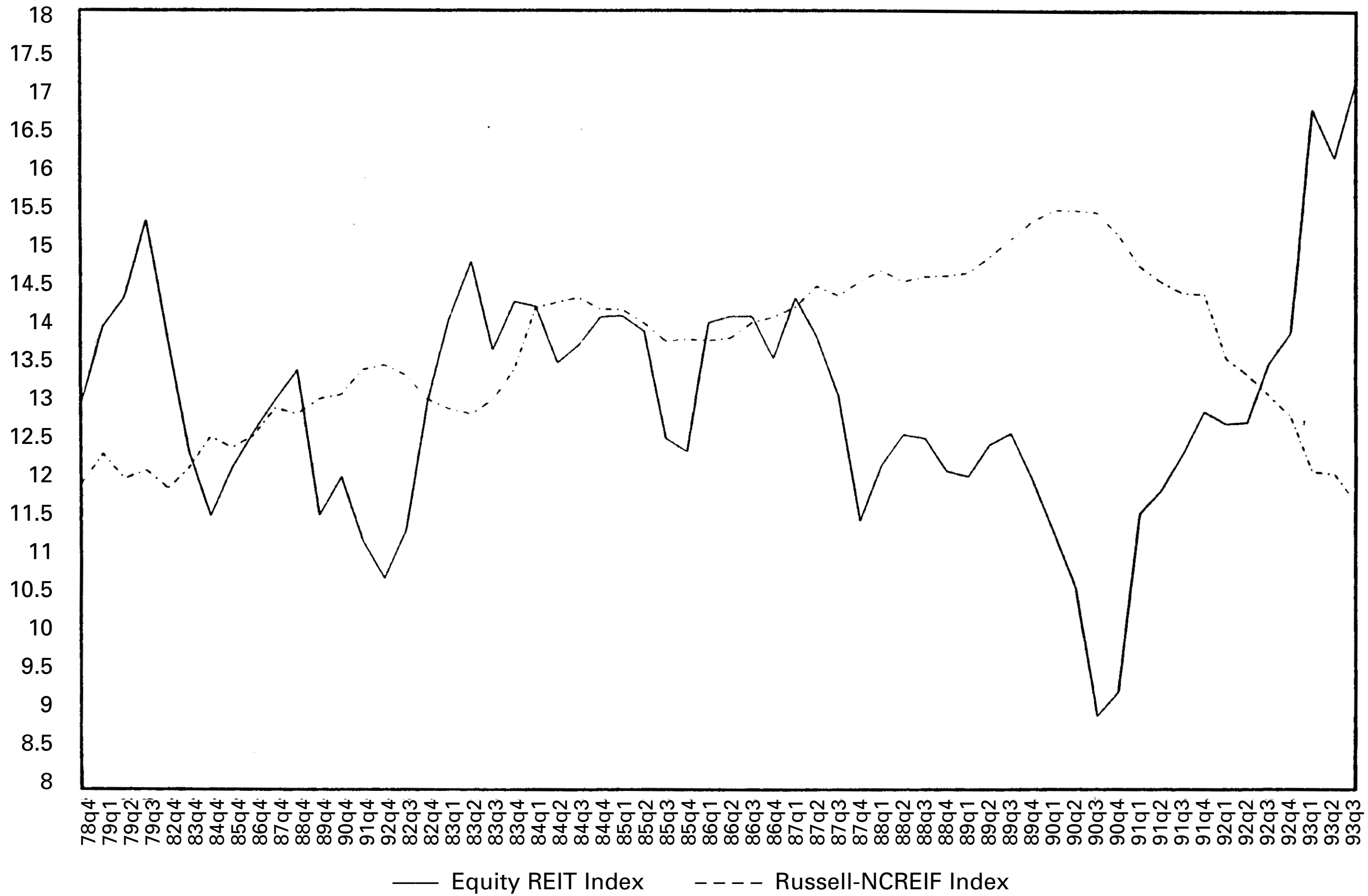
From equation (1) it is clear that property values change because of variation in current and expected future cash flow, and through the discount rate's effect on the present value of future cash flows. Each of these components will vary over time because of changing underlying economic trends or measurement error. The previous section demonstrated that the measurement error in market capitalization is substantial. There is also potential for uncertainty in the measurement of net operating income; see Kachadurian (1993) and Danter (1993). However, one can be precise about the definition of net operating income.

Three different ways of calculating an index of net operating income are proposed below. Which technique is appropriate in a given instance will depend upon the data available and the application to which the NOI index will be put. More research on each approach is needed.

NOI Index: Version 1

The repeat transaction methodology discussed above for a valuation index could equally well be applied to creating a NOI index. All this method requires is a sample of data with matching NOI observations on individual properties at two points in time. A simple

Exhibit 3
Real Estate Multiples – Public versus Private Market 4Q78–3Q93



Source: Salomon Brothers Inc.

regression model can be used to derive the average period-by-period change in NOI that best explains the sample dataset.

Of the three methods discussed here, this is the most theoretically attractive and conceptually straightforward way to create an index. It also requires the least number of heroic assumptions. Its drawback is that one must have a large sample of quality information for the geographic area of interest.

A national NOI index was calculated from the Freddie Mac sample cited above. This is reported in the first column in Exhibit 4. The pattern is quite different from the repeat transaction value index in Exhibit 1, and does not appear intuitively reasonable: the declines in 1986–87, followed by the large 1988 increase, seem implausible given both actual market behavior during that period and the indices developed below. The information collected at underwriting in this dataset may well suffer from the common problems of trended rents, understated vacancies, and uneven reserve treatment; the more recent inspection reports that provide data for the last few years have a much higher degree of consistency.

NOI Index: Version 2

An alternative to the repeat transaction approach is to create an index of net operating income from publicly available component series. To start a NOI series requires initial income and expense levels. After the first period, the levels of each of income and expense can be updated with information on their respective growth rates. Subsequent NOI levels can then be calculated as the level difference of the updated income and expense levels.

Clearly it matters for NOI growth whether the initial income level is two times or three times the expense level. As shown in the equations below, both the expense ratio and the vacancy rate (since expenses are calculated as a fraction of potential income gross of vacancies) must be known in the initial period to identify the income and expense levels.

Exhibit 4
Growth in U.S. Net Operating Income from Freddie Mac Repeat Observations (percent change)

	NOI	Consumer Prices
1985	0.9	3.6
1986	−3.1	1.9
1987	−3.0	3.6
1988	15.2	4.1
1989	−0.1	4.8
1990	−5.7	5.4
1991	−2.6	4.2
1992	−3.9	3.0
1993	−5.8	

Sources: Author's calculations and The Bureau of Labor Statistics

$$Income_o = \frac{(1 - vacancy_o)}{(1 - vacancy_o - expense\,ratio)}, \tag{4}$$

$$Expense_o = \frac{expense\,ratio}{(1 - vacancy_o - expense\,ratio)}.$$

The relative levels of income and expense as calculated here are sufficient to get the calculations started; an absolute dollar measure is unnecessary. The income level in period 1 is simply the level in period *o*, updated by period one income growth; the expense level changes with the first period expense growth. The difference between the two levels yields the level of net operating income in period 1. This process can be repeated in every period, yielding an index of NOI levels and, implicitly, NOI growth rates.

An unfortunate consequence of the initial level depending upon the specific vacancy rate and expense ratio in the initializing period is that the choice of initial period affects the NOI index. Fortunately, the vacancy rate is usually not too volatile and has a relatively small effect on the final series. As for the expense ratio, historical shares reported in IREM (1992) show relative stability, so an assumption of constant expense weights, even though components inflate at different rates, is not too unreasonable.

Time-series for the growth rates of income and expense are not published by either the government or industry, but they can be proxied reasonably well.

Changes in gross income (characterized as total collections in industry discussions) can be captured by the sum of the change in the natural log of the residential rent component of the consumer price index, and the log change in the national occupancy rate of apartment buildings (as reported in the Census H-111 publication).[4]

For a growth index of property expenses, one needs to know the components of expense, the weights to assign to different components, and the best way to represent each component. The expense 'production function' used here is styled after annual survey data of the Institute of Real Estate Management (1992).[5] The various expense line items were aggregated into four categories: labor costs, utilities, insurance and taxes, and construction materials, with the final 'production shares' being: 52.8% labor costs, 22.1% fuel (utilities), 18.9% taxes and insurance, and 6.2% construction materials.

The time-series used to represent trends for each of those components are the following. Labour costs are captured by non-farm business compensation per hour; utility costs are represented by the producer price index for processed fuels and lubricants; taxes and insurance are represented by property tax trends, calculated by using National Income Accounts State and Local Property Tax payments, divided by the nominal value of owner-occupied real estate (from the Federal Reserve Board Flow of Funds data), times the trend in value per real estate unit found by combining the Freddie Mac repeat sales house price index (reported in Stephens et al., 1993) with the Census' constant quality house price index for some early years; construction material price changes are represented by the producer price index for capital goods.

An advantage of the selected series is that with a little coaching they go back to 1963, so that NOI growth rates can be calculated since 1964.[6] That permits testing of the derived NOI series through several real estate cycles, as well as a thorough examination of the time-series properties of the income and expense series, which is necessary for Abraham (1993).

Exhibit 5
Estimated NOI Growth from Income and Expense Trends
(percent change)

			Net Operating Income		
	Income	Expense	ER=.492 VR=.075	ER=.492 VR=.114	ER=.432 VR=.075
1985	4.6	3.0	6.2	6.4	5.8
1986	3.9	−1.1	9.2	9.7	8.0
1987	3.1	3.3	2.7	2.7	2.8
1988	3.5	3.0	4.0	4.1	3.9
1989	5.3	5.5	5.3	5.3	5.3
1990	4.8	7.9	1.7	1.4	2.4
1991	2.5	4.3	0.4	0.2	0.8
1992	2.8	4.0	1.9	1.8	2.2

ER=Expense Ratio: VR=Vacancy Rate.
Source: Author's calculations. See text.

Exhibit 5 reports the income, expense and NOI series calculated in the way just described, using a 49.2% expense ratio and the 1984 average vacancy of 7.5% for the initial level.[7] The sensitivity of the NOI series to alternative initial vacancy rate and expense ratio figures is shown in the two right columns of the exhibit.[8] Since the expense ratio is close to 50%, one should expect NOI to change by roughly twice the income change minus the expense change. The NOI pattern in Exhibit 5 reasonably shows strong growth in the late-1980s, followed by a sharp deceleration in 1990.

An attraction of using this constructured NOI index to assess property performance is its ability to be customized for geographic areas that have different income and expense histories. Additionally, the sensitivity of the index to explicit future counterfactuals (such as a doubling of tax expenses) can be precisely determined. A sense of cross-sectional historical variability is provided in Exhibit 6, which uses the same expense series as above, but combines it with city-specific rent changes and occupancy rates for the last five years. The troubled market of Atlanta is shown to have experienced sharply declining NOI, while Dallas has been improving since 1988. Anaheim started seeing average NOI declines in 1991. The healthy Portland market has performed quite well.

NOI Index: Version 3

The index calculated earlier gives the change in net operating income for a property receiving the mean income change and mean expense change in every period. In the real world, however, there is volatility around mean changes across properties and across time: average NOI growth of 5% may reflect one property with growth of 2.5% and another at 7.5%.[9]

Version 3 is a NOI index that goes beyond the Version 2 mean growth rate, capturing the true richness of the distribution of property-level outcomes using simulated data. A

Exhibit 6
Estimated NOI Using City-Specific Income Trends
(percent change)

	Anaheim VR=.038		Atlanta VR=.064		Dallas VR=.162		Portland VR=.053	
	Income	NOI	Income	NOI	Income	NOI	Income	NOI
1988	1.0	−1.1	−0.1	−3.5	−4.5	−15.2	4.3	5.7
1989	5.5	5.5	−1.7	−10.2	3.7	0.6	6.8	8.2
1990	6.2	4.4	2.3	−5.5	6.1	2.8	4.8	1.6
1991	1.8	−1.0	−0.6	−8.4	6.0	9.2	3.1	1.8
1992	0.1	−4.5	3.4	2.3	6.8	11.9	3.7	7.6

VR=Vacancy Rate.
Source: Author's calculations. Income is calculated as the sum of the log change in occupancy (according to the Census H-111 report) and local rent component of the consumer price index (according to the Bureau of Labor Statistics). The expense series comes from Exhibit 5.

benefit of this more complex approach is that it creates knowledge of the distribution of NOI growth at the property level, which is essential for the option-based model of Abraham (1993) that depends upon knowing the behavior of the 'tails' of the NOI distribution.

To derive the distribution of NOI changes around the mean growth rate, we need to know three more pieces of information: the cross-sectional property variance of income changes, the cross-sectional variance of expense changes, and the property-specific covariance of income/expense changes. Market measures for property volatilities were found from analysis of Freddie Mac's inspection reports, which provide annual property data on income, expenses and value since 1990. The analysis was limited to properties for which there are three successive years of data, creating one set of 461 observations for 1990–92, and a second dataset of 1058 observations for 1991–93. Mean growth rates and standard deviations for one- or two-year intervals for each dataset are shown in Exhibit 7.[10] The sample sizes are small (for nationwide data), so the standard deviations move around a bit from year to year.[11] Relying more on the larger second sample, a reasonable figure for an annual income standard deviation is 9%, while the expense deviation is about 20%, with a correlation of 35%.

A striking feature of Exhibit 7 is the high volatility in the expense process; it would be truly surprising if operating expenses varied by such a great amount from one year to the next. Some measure of capital expenditures—which are highly variable from one year to the next—is likely included in these numbers. For example, if a maintenance setaside averages 12% of operating expenses, and is spent in every third year, that alone could account for a 17% volatility.

The two matched-property samples, each with three successive years, were created to provide some guidance on the time-series properties of property-specific income and expense deviations. The two-year standard deviations are slightly smaller than the implied deviation were the annual changes uncorrelated. This suggests there is some mean reversion, or negative serial correlation, in individual property deviations from the mean. However, for simplicity, the simulations below will assume that individual property shocks are serially uncorrelated, and randomly distributed around the mean. Therefore

Exhibit 7
Property-Specific Mean Growth Rates and Volatilities
(percent)

	Annual Change			Biannual Change	
	1990/91	1991/92	1992/93	1990/92	1991/93
1990/92 Dataset					
Income Growth					
Mean	3.3	3.4		6.6	
Standard Deviation	8.2	7.4		9.4	
Expense Growth					
Mean	9.3	5.8		14.2	
Standard Deviation	22.7	18.3		24.3	
Correlation	24.8	16.8		27.8	
1991/93 Dataset					
Income Growth					
Mean		3.6	2.9		6.3
Standard Deviation		9.7	8.2		11.5
Expense Growth					
Mean		7.3	8.9		15.4
Standard Deviation		20.7	18.7		22.8
Correlation		33.7	16.7		35.1

Source: Author's calculations

the standard deviations used in the work below should be somewhat lower than were the Exhibit 7 values taken at face value. The standard deviations are assumed to be 8% for income growth (rather than 9%) and 16% for expense growth (rather than 20%). The income/expense correlation for these new standard deviation values is 49%, found by holding the observed covariance constant and solving for the appropriate correlation with the new lower standard deviations.[12]

Using the mean paths for income and expenses described earlier, and the stochastic processes just described, historical property-specific performance was simulated for 1000 properties. Updated income, expense and NOI levels for each property were calculated. Then, net operating income times-series were estimated using the 'repeat sales' regression method of Version 1. The results are reported in Exhibit 8. The simulations use an expense ratio of .492 and start with the 1984 vacancy rate of 7.5%. The first column shows the result with zero volatility and matches the growth rates in Exhibit 5. The second column uses the favored values for the income and expense processes and shows somewhat lower growth rates. As shown in the last two columns, the results are sensitive to the volatilities and the degree of correlation between shocks, but not in an obvious manner. In general, permitting a positive correlation between income and expense tightens the NOI distribution, while those years with higher income volatility because of high vacancies have fatter tails in the NOI distribution.

Exhibit 8
Alternative Measures of NOI Growth
(percent)

Expense Volatility	.0	16.0	20.0	16.0
Income/Expense Covariance	.0	.630	.630	.315
1985	6.2	5.6	4.6	4.9
1986	9.3	8.2	6.8	7.1
1987	2.7	−1.0	−1.9	−1.9
1988	4.1	2.2	2.2	2.2
1989	5.4	2.3	4.4	2.2
1990	1.6	0.1	1.5	0.9
1991	.4	−0.7	1.5	−0.3
1992	1.5	.6	4.0	1.7

Source: Author's calculations

Conclusion

The existing data series that permit systematic comparisons of real estate performance across geographic markets are inadequate. Available measures of property value trends are used by practitioners only because the need for *some* data is so great. The available time-series certainly cannot withstand the much more rigorous requirements of the mathematical models that researchers would like to employ in real estate analysis. This paper recommends the development of new indices to address this need, with suggestions on how they might be calculated.

A technique with great promise, and one that could be easily employed by many market players, is the 'repeat sales' (matched observation) regression. This would go a long way to addressing the problem of controlling for heterogeneity when measuring value changes across properties. A repeat sales regression using Freddie Mac data on value is reported, but does not seem to give reasonable values.

The focus of the paper, however, is on net operating income indices, which are proposed as an alternative to value indices as a way to evaluate market strength. Given the subdued volatility in market aggregate cap rates, much of the changes in value are likely to come from changes in cash flow. One possible approach, therefore, is simply to perform a 'repeat sales' regression with property-specific NOI data. However, that requires access to a database with detailed, property-specific information. Two alternative methods for constructing NOI indices from publicly available data sources have been motivated and reported in great detail. The ultimate test will be whether market practitioners find them useful and more reliable than current value indices.

Appendix 1

The annual growth rates (log-changes) in income, expense, and in their components, are reported below from 1963 to 1992. The vacancy rate is for buildings with 5+ units from the Census H-111 series. Published data go back to 1977; earlier data is found by using a constant 1.42 multiple of 2+ unit vacancies reported in *Historical Statistics of the United*

States from the Census Bureau. The rent index comes from the consumer price index. Labor costs are compensation per hour of the non-farm business sector, as reported in the *Economic Report of the President (ER),* 1993. Fuel costs are captured by the producer price index for processed fuels and lubricants, also from the *ER*. Tax costs are constructed as represented in the text. Materials costs are the producer price index for construction materials and components from the *ER*.

	Vacancy Rate	Rent Growth	Income Growth	Labor Costs	Fuel Costs	Tax Costs	Materials Cost	Expense Growth
1963	11.8	1.0		3.3	−.6	3.1	.3	
1964	11.8	1.0	1.0	4.4	−2.4	2.0	.9	2.2
1965	11.8	1.0	1.0	3.4	1.8	3.0	.9	2.8
1966	10.9	1.5	2.5	5.8	1.8	2.1	2.4	4.0
1967	9.7	1.7	3.0	5.5	.6	6.2	1.2	4.3
1968	8.4	2.6	4.0	7.7	−2.4	5.0	4.9	4.8
1969	7.8	3.2	3.8	6.6	.6	7.0	5.5	5.3
1970	7.1	3.9	4.7	7.0	6.4	8.0	1.6	6.7
1971	7.9	4.6	3.8	6.3	9.7	5.5	6.3	6.9
1972	8.3	3.4	3.0	6.2	3.0	.2	5.3	4.3
1973	8.1	4.1	4.3	8.0	9.9	.5	7.9	7.0
1974	8.8	5.0	4.3	9.5	41.4	1.6	16.8	15.5
1975	8.3	4.9	5.5	9.4	15.9	7.7	8.9	10.5
1976	7.8	5.2	5.8	8.2	7.1	1.0	6.4	6.5
1977	7.1	5.9	6.6	7.8	12.0	9.4	7.8	9.0
1978	6.7	6.7	7.1	8.5	4.5	−.9	9.9	5.9
1979	6.6	7.0	7.1	9.1	21.1	−1.5	9.6	9.8
1980	7.1	8.5	8.0	10.2	32.2	2.1	8.1	13.4
1981	6.4	8.3	9.0	9.1	16.9	4.9	7.0	9.9
1982	6.5	7.3	7.2	7.3	−.6	8.7	2.1	5.5
1983	7.1	5.7	5.0	3.8	−4.7	7.3	2.8	2.5
1984	7.5	5.1	4.6	9.0	.3	5.8	2.7	3.4
1985	8.8	6.0	4.6	4.1	−3.1	7.3	1.6	3.0
1986	10.4	5.7	3.9	4.8	−24.4	9.2	.7	−1.1
1987	11.2	4.0	3.1	3.3	.8	6.5	1.6	3.3
1988	11.4	3.7	3.5	4.1	−2.9	6.0	5.6	3.0
1989	10.1	3.8	5.3	3.2	7.0	10.6	4.4	5.5
1990	9.5	4.1	4.8	5.3	11.7	12.8	1.3	7.9
1991	10.4	3.5	2.5	4.9	−.7	9.5	1.3	4.3
1992	10.1	2.5	2.8	3.6	−.7	11.2	1.6	4.0

Appendix 2

This appendix motivates permitting income volatility and the income/expense correlation to change over time in the calculation of Version 3 NOI indices. This added complexity is, at best, an obscure enhancement to imposing constant standard deviations over an entire sample period. The enhancement was pursued because in Monte Carlo simulations of the income/expense/NOI process for the model described in Abraham (1993), greater volatility in NOI outcomes was needed. The changes described below have the effect of ‘thickening the bottom tail’ of the NOI distribution in simulations by making adverse income growth realizations even worse.

Income risk can be considered to come from three sources: the market, the owner/manager, and the property. Market risk would include macroeconomic trends and tax policy, as well as fluctuations in local occupancy and city regulations. Strategic decisions by management add risk to the investment project. And finally, the property itself may have some features that make it unique even in the local market, like location, environmental hazards, or even design obsolescence. The magnitude of manager and property risk is specific to each individual property. Market risk, on the other hand, is more systematic and predictable, and should be able to be measured with available data.

It is assumed that the three risks are additive and uncorrelated. Manager and property risks are invariant over time, with only the magnitude of market risk changing from one period to the next. Market risk is assumed to account for two-thirds of the total volatility in the initialization period (calendar year 1990). Total risk will thus vary in magnitude between the extremely good markets in which market risk approaches zero, leaving only the irreducible manager and property risk remaining, and the bad markets in which market risk increases so much as to overwhelm anything even a good owner and property can do.

In a local market, rent growth and market vacancy rates should have a tight inverse correlation. Therefore 'market risk' from the volatility in income should be proportional to the vacancy rate volatility. In turn, the (cross-sectional) vacancy volatility will be related to the average vacancy level. This follows naturally from the observation that vacancies follow a log-normal distribution: when the national average vacancy falls, because there is limited improvement possible in already good areas (vacancies cannot reasonably go much lower than 2%–3%), areas with much higher vacancies must proportionately get a lot better. This is illustrated graphically in Exhibit 9, as the vacancies shift from distribution A to distribution B. A falling average vacancy therefore also means a reduced dispersion of vacancies, which implies much less dispersion around the mean rent increase. This works in the other direction as well.

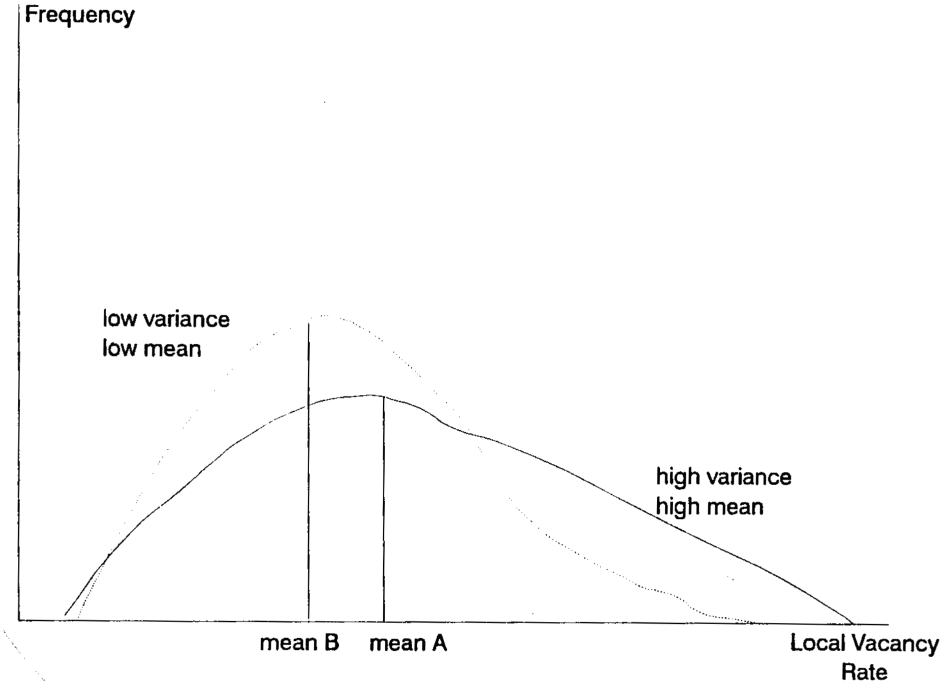
The relationship between vacancy level and volatility was examined with a time-series cross-sectional dataset on (2+) rental vacancies from the Census H-111 series. Both the simple mean and (cross-section) standard deviation of annual data on rental vacancies of sixty-one cities from 1986 to 1992 were derived. A regression of the log standard deviation on the log mean give a coefficient of 3.5; this was rounded up to 4 in equation (*) below since apartment (5+ buildings) vacancies are a little more volatile than for the whole rental stock.[13]

There is now enough information to calculate a time-varying formula for the standard deviation of income growth. Again, the train of logic is that: (1) income volatility can be decomposed into independent market and manager/property components; (2) market income volatility is proportional to vacancy volatility; and (3) there is a stable relationship between vacancy volatility and the average vacancy rate. This results in the following formula:

$$\sigma_{inc_t} = \left[\left[\frac{vacancy_t}{10.1} \right]^8 (.00427) + .00213 \right]^{0.5} . \qquad (*)$$

The exponent of 8 follows from the 'estimated' value of 4, which is then multiplied by 2 since the formula is in terms of the variance rather than the standard deviation. In equation (*) the 'observed' income standard deviation of 8% ($.08 = (.00427 + .00213)^{0.5}$) is

Exhibit 9
Example of the Correlation between Vacancy Rate Mean and Variance



assigned to calendar year 1990, which had a (5+) rental vacancy rate of 10.1%. The 2/3–1/3 split of the income variance follows the assumed split between market and manager/property risk.

Notes

[1]Within the appraisal discipline as described by Grissom and Smith (1990), this paper contributes to valuation theory.
[2]Ambrose and Nourse (1993) find a significant property-type fixed effect on cap rates, but little else.
[3]Of course, if capitalization rates are truely constant over time, then all the variability in value would arise from NOI.
[4]Log changes rather than percent changes are used to facilitate the simulation discussed later in the text.

There has historically been a concern with the accuracy of the CPI rent component. The CPI survey results were originally not corrected for quality improvements in the rental stock, leaving the reported rent changes with an upward bias. While the Census has made adjustments since 1988, Apgar, Masnick and McArdle (1991) suggest that earlier data might be prone to overstatement of rent changes by as much as 80 basis points per year. How and whether one should truly adjust the published data becomes less clear cut the deeper one gets into this issue; see Randolph (1988). In the end, no adjustment for depreciation was made.
[5]Similar data from the National Apartment Association (1992) was reviewed. Its component weights are very similar to IREM's, but its total expense ratio is a little higher, and it has a

somewhat higher share devoted to payroll and less to utilities compared to IREM's. The IREM expense ratio more closely matched the ratio in the Freddie Mac portfolio.

[6]Appendix 1 reports log changes for income and expense, and their components, back to 1963. The discussion in the text only uses the index since 1985.

[7]IREM reports data separately for four types of properties: those with elevators, low-rise 12–24 units, low-rise 25+ units, and garden apartments. Freddie Mac portfolio weights were used to average the component percentages, which came out to virtually a one-fourth weight on each property type.

The IREM numbers cover only operating expenses. After talking with industry professionals IREM's 43.2% was grossed up to 49.2% of potential income to account for maintenance setasides, which are merely smoothed capital expenditures. Roughly following Census Bureau input/output data, half of the additional (almost) 12% of expenses was assumed to be labor costs, and half construction materials.

[8]IREM (1992) reports time-series of median rents, total actual collections, total actual expenditures, and NOI for each of their property types. Separately, and as a weighted average, their movement is generally counterintuitive and quite volatile. So those figures are not recommended as a source for NOI trends.

[9]Ling (1993) provides an example of where the volatility of income and expense has a significant effect on property value.

[10]In addition to removing obvious coding errors, some scrubbing of the data was necessary. The observations were limited to annual inspections that include true property data, rather than stabilized estimates. To avoid distorting the results with poorly performing properties, the sample was limited to those with debt coverage of at least 1.10. This restriction brought slightly higher growth in NOI and slightly lower volatility. Finally, year-to-year changes in any of income, expense, or value was limited to a doubling or halving.

[11]The income changes are broadly consistent with the Version 2 series in Exhibit 5. Expense growth is somewhat higher.

[12]In the subsequent analysis, the income standard deviation and income/expense correlation are permitted to change over time. The reasoning behind this, and the mechanics of how that was done, are covered in Appendix 2.

[13]The restriction of the regression to only using a local vacancy rate is to permit inclusion of these results in a Monte Carlo simulation with very few state variables. Queries of the author are recommended should a lengthier explanation of the motivation be required.

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