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TOWARD MEASURES OF
REAL ESTATE VALUE,
RETURN, AND RISK

by

James W. Hoag

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TOWARD MEASURES OF REAL ESTATE VALUE, RETURN, AND RISK

1. Introduction

The purpose of this paper is to contribute to the analysis of risk and return of equity investment in real estate. The construction of an index of value and return for nonowner-occupied industrial property is chronicled. Although real estate is an important investment vehicle (aggregate value is large in comparison to the stock market), relatively little is known of the historical holding period risk and return for equity owners of real property. In Section 2, the current literature on real estate returns is summarized. The conclusion of that review suggests that available published empirical results on investment real estate risk and return are meager. Practically, there are no available indexes that attempt to measure price appreciation, cash flow, or return from real estate. Actually, many observers question the existence of one national real estate market. With no easily observable market transaction prices, it is little wonder there is a paucity of index numbers. Worse yet, with no information available on investment returns it is very difficult to utilize currently available quantitative investment management technology to estimate the risk inherent in a real estate investment.
In Section 3, a conceptual framework for estimating real estate value and return is developed and related to methods currently utilized in common stock risk/return analysis. The method of analysis expounded herein leads naturally to a consideration of a property valuation function based on a vector of fundamental microeconomic and macroeconomic variables which affect property value.

Section 4 develops the construction of the return index from interpolated fundamental property valuation functions. With certain reasonable approximations, the valuation model leads directly to an estimate of the market rate of return on real estate, the risk and return associated with each property, and the market risk. In this paper, the analysis focuses on time series properties of risk and return estimates for real estate. Coefficients of responsiveness to the fundamental valuation characteristics which are analogous to a multifactor analysis of common stock risk and return can be computed. The responsiveness coefficients are analyzed further in a complementary paper (Hoag [1979]).

This technique is specialized to one particular property classification in Section 5: Industrial real estate (consisting primarily of warehouses with some light manufacturing and distribution). The valuation factors relevant to these properties are detailed and the sample is discussed in Section 6. Section 7 presents the estimated valuation function and the returns on a subsample of carefully verified observations. The estimates of the valuation function are performed using pooled, cross-section, time-series regressions with generalized least squares estimators.
Many measurement and errors-in-variables problems are alleviated using these techniques, which allow unbiased, consistent and efficient estimates of the market return. The results in Section 8 indicate that equity investment in industrial real estate over a short period in the recent past had risk and return comparable to the stock market.

A discussion of future development finishes this paper in Section 9. Both the methodology and the empirical results will improve as additional data items on a wider class of properties become available. These developments should begin to fill the vacuum of knowledge and paucity of empirical investigation with respect to investment in real estate.

2. Previous Research on Real Estate Returns

Previous work on real estate returns is fragmented and tends to be flawed for many reasons. Analysis of historical common stock returns typically calculates before-tax holding period returns using transaction prices and actual cash disbursals for uniquely identifiable assets. These analyses usually include discussions of sample size and representativeness, the relevant holding period, techniques for aggregating or averaging returns across time or cross sectionally, and techniques for weighting of individual sample returns.

Calculations of returns in real estate inevitably use appraisals (subjective judgment of property values) instead of transaction prices. Examine, for instance, the studies of Friedman [1971], Ricks [1969], and Wendt and Wong [1965] where terminal price is either an appraised value
or identically equal (by assertion) to the initial price (which is sometimes also an appraisal). These early studies on apartment buildings (Wendt and Wong [1965]) and a single life insurance company's real estate portfolio (Friedman [1971] and Ricks [1969]) found that common stock returns and real estate returns were comparable, but real estate was much less risky than common stock. This result can be easily seen to relate to the smoothing tendencies of appraisal (relative to actual transaction prices) which in the extreme, set price appreciation to zero. Thus, these studies provide little guidance concerning risk and return in real estate.

Another recent example of the use of partial appraisal data appears in Warner and Aldrich [1978] where similar conclusions are obtained. That this view of risk and return is commonly held among real estate people can be seen quite clearly in the following quote from Roulac and King [1977]:

Scholarly research shows that real estate returns and stock market returns have been comparable over time but that, for given levels of return, the risk characteristics of real estate are superior.

This is indeed an interesting empirical point, if it were true, but as can be shown, it is one artifact of the risk/return calculation using appraised value.

Another difficulty of the current literature is the lack of breadth of statistical properties of returns across property classes and time periods. The narrow sample selection and general paucity of results leads practitioners to overgeneralize particular results to all classes of investment real estate. In particular, a number of researchers have
looked at rates of return computed from industry and U.S. government indexes (Boech, Department of Commerce, Department of Agriculture, and Bureau of Labor Statistics) for housing and farmland (Fama and Schwert [1977]; Robichek, Cohn, and Pringle [1972]; and Sprinkel and Genetski [1977]). Without analyzing the construction of these indexes with respect to the previously mentioned problems (sample selection, weighting, rebalancing, averaging), it is difficult to assess the potential usefulness of their results, but it is very unlikely that these results generalize to investment real estate held by institutional investors.

One finding indicates that farmland and common stock are negatively correlated (−.13) (Robichek, Cohn, and Pringle [1972]) with farmland returns (9.5%) slightly below those of common stock (11.6%) over long holding periods (1949-1969) and standard deviations (4.5%) which are one-quarter of those realized on common stocks (17.6%). Were this truly the case, a fixed proportion strategy of half stocks and half farmland would have realized a return of 10.5 percent with a standard deviation of 8.8 percent! Clearly, one wonders why everyone is not investing in farmland. On the other hand, while Sprinkel and Genetski [1977] get the same result for average returns over a longer period (1929-1975), they point out that, according to their calculations, farmland had a negative rate of return for thirteen years straight (1920-1933). Again, it is hard to estimate the intrinsic value of these numbers, but their transferability and generality is clearly suspect.

One recent study by Smith and Shulman [1976] examines the returns on common stock of equity real estate investment trusts (EREIT). Although
this study purports to measure equity returns, most of these funds were leveraged, so the results are not directly transferable. In addition, these results necessarily include management fees and transactions costs which were not computed. Thus the returns are net of these costs and cannot be corrected to indicate gross returns. These securities (nine stocks, 1963-1974) had a beta with the stock market of .8 and a gross security selection figure of -2.17 percent relative to their risk. Perhaps the results are dependent upon the short study period, the small sample of EREITS, EREIT leverage or mismanagement, but there is some indication here that investment real estate was not being properly compensated for systematic risk (relative to a diversified stock portfolio). Thus, these "results" do not look as rosy as those presented above.

It must be clear by now that the available empirical literature on real estate risk and return can not be relied upon to provide practical information for portfolio management. It is empirically inconsistent and replete with conceptual inaccuracies. With this perspective on the obvious difficulties, we launch into an attempt to provide reasonable estimates of the rate of return and risk for investment real estate.

3. Conceptual Framework for Index Construction from Property Valuation

Methodological issues in construction of market return indexes usually involve discussions of sample size and representativeness, appropriate holding periods relative to investor horizons, policies for rebalancing, techniques for aggregating or averaging returns across time or
cross-sectionally, and rules for weighting individual sample returns (see, for instance, Fisher [1966]). There are a wide variety of indexes available for the stock and bond markets. Most of these indexes are based on transactions and many are calculated at daily and sometimes hourly intervals. The same situation does not exist in real estate. Individual transactions are infrequent and information on their number is unavailable. The investment holding period is purported to be very long (on the order of several years, at minimum).

The rapidly growing presence of more institutional investors in the real estate market coincides with other evidence that suggests that a national market has developed in investment real estate. This development motivates the construction of a real estate index.

The focus is on the holding period returns for investment real estate. One often hears the contrary argument suggesting that if the investment horizon is long, then intermediate fluctuations in value are not very important. Perhaps this holds true for investors who do not sell frequently, have complete discretion in timing their sales, and match the maturity structure of their liabilities to these long-lived assets. Alternatively, consider any intermediary which sells participations in pooled real estate funds. The effective holding period is the (typically) quarterly period for reporting to investors. Since investors can increase or decrease positions at this time, they are interested in quarterly values and hence quarterly holding period returns.

Initially, return computations are estimated before tax as returns to tax-free investors. Later the nontaxable and taxable portions can be
broken out analogously to unrealized capital gains and dividends in common stocks. Thus, the intention is to calculate quarterly before tax holding period compound rates of return. Given that the holding period and investment horizon are not known with certainty, compound returns are robust with respect to the relative lengths of these intervals (see Rosenberg and Marache [1979]).

Note carefully that a real estate investment fund still has grave difficulties at the quarterly valuation point. A stock fund can easily value their assets, unless the stocks are infrequently traded. Real estate funds faced with this valuation problem hire an appraiser who provides a (subjective) estimate of value, and thus a subjective estimate of return.

The technique proposed here uses fundamental characteristics to (objectively) estimate the value for a property at any point in time. The techniques used herein have been thoroughly developed for common stocks and have proved both useful and intuitively understandable for market participants. The technique outlined in Figure 1 requires fundamental valuation characteristics (such as location, property type, size, and age), economic and demographic variables (such as business inventories, construction costs, transportation access, and population), transaction prices and cash flows. This information is used to estimate a valuation function which is composed of weights for the value of each fundamental characteristic, that is, the responsiveness of property value to changes in the fundamental factors.
CONCEPTUAL FRAMEWORK FOR INDEX CONSTRUCTION FROM A PROPERTY VALUATION FUNCTION

Before Tax Equity Cash Flows

Income Expenses Tax Related Flows

Property Specific or Microeconomic
Location Physical Characteristics Lease Characteristics Financing Characteristics Appraised Value

Regional
growth, population, population changes External land value and zoning Regional transportation spending Available space/vacancies Business inventories Building starts, value of new construction and construction costs Mortgage interest rates, availability, commitments and investment by major market participants

National

Transaction Characteristics Purchase Date

Transaction Prices

Fundamental Characteristics

Valuation Function

Estimated Prices

Total Return Index

Market Risk Measures

Individual Risk Measures

Responsiveness to Fundamental Characteristics

Macroeconomic Climate
A real estate appraiser would call this the market comparison technique (see, for instance, Wendt and Cerf [1979]). But the technique is actually much broader than pure market comparison. Since the fundamental descriptors include cash flows, property type, and location, all the raw elements are available for the equivalent of an income capitalization appraisal. Since construction cost indexes are included, the data for a replacement cost appraisal are also provided. Clearly, then, a sufficient amount of information is available for an appraiser to make a judgment of value. The objective judgment of the valuation model simply supplants the subjective judgment of the appraiser.

This type of fundamental analysis is accomplished on a daily basis by security analysts in the stock market. Macroeconomic variables plus firm specific data (such as leverage and industry) are used to estimate the value of the firm. Furthermore, it is possible to use similar techniques to those proposed below to establish the contribution to security risk and return of various common factors (see, for instance, King [1966], Rosenberg [1974], and Rosenberg and Marathe [1976]).

Thus, the analogy is complete. Appraisers and security analysts use fundamental information to establish the value of their respective investments: real estate properties and common stocks and bonds. Portfolio managers bid on these investments based on these individual assessments of value, establishing a marketwide consensus of value. If consensus expected returns reflect unbiased estimates of realized returns (rational expectations), then statistical techniques (such as those
proposed below) should discern the elements of fundamental characteristic values.

Consider one potential improvement for the valuation scheme. If subjective evaluations of property values are available, consider adding them as a fundamental characteristic for the valuation function. If appraisers can systematically estimate value, then these estimates will improve the valuation function.

The valuation function is estimated using a sample of actual transaction prices from individual assets (data are described in Section 6), and fundamental characteristics collected about these properties (see Figure 1, and Section 5 for a description of the fundamental characteristics).

At any point in time, a value for each nontransacting property is estimated from the valuation function applied to the fundamental characteristics at that time. From the valuation function, the individual compound rate of return can be estimated and the aggregate market value is estimated. From the aggregate market value and the cash flows, the total return index is calculated. With the return estimate also comes an estimate of the standard deviation of market return. Further, it is possible to calculate the responsiveness of an individual property's risk and return to the fundamental characteristics of property valuation.

In this section, the technique of fundamental valuation for properties has been compared to the same process in the stock market. The fundamental valuation process leads up to a market return estimate.
Utilizing techniques developed from risk estimation for stocks, the next section derives an estimator for the fundamental valuation function.

(For further details of the estimation process and extensions, see Hoag [1980].)

4. Construction of a Return Index from Interpolated Fundamental Property Valuation Functions

Since very little is known about real estate returns, an initial assumption concerning the choice of "return" definition must be made. Empirically, in the stock market, logarithmic returns more closely approximate the observed distribution of returns when predictable "nonstationarity" in variance is removed from the time series (see Rosenberg and Marathe [1979]). Defining the logarithmic return for an individual property \( i_{lt} \) gives:

\[
\begin{align*}
\tilde{P}_{it} & = \text{price of property } i \text{ at time } t, \ i = 1, \ldots , I \\
i_{ft} & = \text{risk-free rate at time } t \\
\tilde{C}_{it} & = \text{cash flow from property from time } t-1 \text{ through } t, \ i = 1, \ldots , I \\
\end{align*}
\]

(1) \[
\ln(1+i_{lt}) = \ln(\tilde{V}_{it}/P_{it-1}) = \ln \tilde{V}_{it} - \ln P_{t-1}
\]

where \( \tilde{V}_{it} = \tilde{P}_{it} + \tilde{C}_{it} \).

Define the excess return \( \tilde{r}_{it} \) as:

(2) \[
\tilde{r}_{it} = \ln(1+i_{lt}) - \ln(1+i_{ft}) = \ln \tilde{V}_{it} - \ln ((1+i_{ft})P_{it-1})
\]
Assuming that $\ln \tilde{V}_{it}$ is normally distributed (implying that $\tilde{F}_{it}$ is normally distributed for individual properties) has several benefits, but also several disbenefits. Logarithmic returns are less sensitive to the observation interval which is useful here since the observation interval is not constant and can be very long. Additionally, it can be shown that logarithmic returns have stable compounding properties which are important in a multiperiod smoothing process. Finally, logarithmic returns are less sensitive to uncertainties in the horizon of investors (partially due to the compounding property) when there is a lack of correspondence among the investment horizon, the price observation interval, and the valuation interval. On the other hand, empirical distributions of property returns are less likely to be positively skewed and therefore less likely to be closer to lognormally distributed. This occurs because property returns are not subject to limited liability, and $\tilde{C}_{it}$ can be negative. Furthermore, logarithmic returns cannot be aggregated linearly to market returns. Thus a difficult choice must be made.

Define the market excess return ($\tilde{F}_{mt}$) as:

\begin{equation}
\tilde{F}_{mt} = \ln(\sum_i W_{it} \exp(\tilde{F}_{it}))
\end{equation}

where: $W_{it} = \frac{P_{it-1}}{\sum_i P_{it-1}}$ represents market value weights.

Substituting for $\tilde{F}_{it}$ and the weights gives:

\begin{equation}
\tilde{F}_{mt} = \ln \sum_i \tilde{V}_{it} - \ln((1+\tilde{F}_{it}) \sum_i P_{it-1}).
\end{equation}
Defining the total market value and total market cash flow, rearrange the market return as:

\[ \tilde{M}_V = \sum_1^n \tilde{P}_i \]

\[ \tilde{M}_{CF} = \sum_1^n \tilde{C}_{F_i} \]

(4) \[ \tilde{r}_{mt} = \ln(\tilde{M}_V + \tilde{M}_{CF}) - \ln((1 + r_t)\tilde{M}_{V-1}) \]

Lintner [1975] shows that the distribution of a weighted sum of security returns can be approximated by means of a second order Taylor expansion and thus the market return may be approximately normally distributed.\[ \]

Perhaps the greatest benefit of using logarithmic returns is that the errors in the calculation of \[ \tilde{r}_{mt} \] will be additive rather than multiplicative. This simplifies the estimation of the standard deviation and its sampling variance.

'*Utilizing a twist on the approach instituted by King [1966] and extended and clarified by Sharpe [1973], Rosenberg [1974], and Rosenberg and Marathe [1976], express the individual property values in a multiple factor model:

(5) \[ \tilde{s}_{it} = \ln(\tilde{V}_{it}) = \sum_{j=1}^J b_{ij} f_j + \tilde{s}_i \]

\[ i = 1, \ldots, I \]

where: \[ b_{ij} \] = the weight for factor \( j \) and property \( i \)

\[ f_j \] = the \( j \)th value factor—perhaps unobservable, \( j = 1, \ldots, J \)

\[ \tilde{s}_i \] = a component of specific value for property \( i \) and let

\[ \sigma_i^2 = \text{var}(\tilde{s}_i). \]
Assume that $\text{cov}(\tilde{\sigma}_i, \tilde{\eta}_j) = 0, \ i \neq j,$ and $\text{cov}(\tilde{\sigma}_i, \tilde{f}_j) = 0$. For the moment, drop the time subscript on all variables and define the column vectors for $\tilde{\sigma}_i, \ b_{ij}, \ f_j,$ and $\tilde{\eta}_i$

\[
\begin{bmatrix}
\tilde{\sigma}_1 \\
\vdots \\
\tilde{\sigma}_I \end{bmatrix} = 
\begin{bmatrix}
b_{11} \\
\vdots \\
b_{jI} \end{bmatrix} \quad 
\begin{bmatrix}
f_1 \\
\vdots \\
f_J \end{bmatrix}
\]

\[
\tilde{\eta} = 
\begin{bmatrix}
\tilde{\eta}_1 \\
\vdots \\
\tilde{\eta}_I \end{bmatrix}
\]

and $\bar{B} = \begin{bmatrix} b_{1j} \\ \vdots \\ b_{Ij} \end{bmatrix}$ the $I \times J$ matrix of weights.

\[ (6) \quad \tilde{\sigma} = \bar{B} f + \tilde{\eta}. \]

Thus the values on all $I$ individual properties are expressed as linear functions of the $J$ factors which have ideal stochastic properties for estimation purposes. Unfortunately, it is likely that the observable characteristics of property valuation are not uncorrelated with the specific components of value for each property. Thus define
Let \( d_{ik} \) be the \( k \)th known characteristic of value for property \( i \), \( i = 1, \ldots, K \) and let \( d_{ll} = 1 \) ∀ \( l \).

Assume that the specific value risk and the factor weights are linear functions of the characteristics, then:

\[
(7) \quad \sigma_i^2 = \mathbf{v}'d_i + \bar{\varepsilon}_i
\]

and

\[
(8) \quad \beta_i = \bar{\mathbf{n}}_i d_i + \bar{\bar{\varepsilon}}_i
\]

where

\[
\begin{aligned}
\mathbf{d}_i &= \begin{bmatrix} d_{1l} \\
\vdots \\
d_{ik} \end{bmatrix}, \quad \mathbf{v} = \begin{bmatrix} v_1 \\
\vdots \\
v_k \end{bmatrix}, \\
\bar{\varepsilon}_i &= \begin{bmatrix} \bar{\varepsilon}_{i1} \\
\vdots \\
\bar{\varepsilon}_{ij} \end{bmatrix}
\end{aligned}
\]

\[
\begin{aligned}
\mathbf{d}_i &= \begin{bmatrix} d_{1l} \\
\vdots \\
d_{ik} \end{bmatrix}, \\
\bar{\varepsilon}_i &= \begin{bmatrix} \bar{\varepsilon}_{i1} \\
\vdots \\
\bar{\varepsilon}_{ij} \end{bmatrix}
\end{aligned}
\]

and

\[ E(\bar{\varepsilon}_i) = 0 \quad \text{and} \quad \text{cov}(\bar{\varepsilon}_i, d_{ik}) = 0 \quad \forall k \]

\[ E(\bar{\bar{\varepsilon}}_{ij}) = 0 \quad \text{and} \quad \text{cov}(\bar{\bar{\varepsilon}}_{ij}, d_{ik}) = 0 \quad \forall i, j, k \]

and \( \bar{\mathbf{n}}_i \) is a \( J \times K \) matrix of coefficients.

Substituting the observable characteristics into the multifactor value equation (5) gives:

\[
(9) \quad \bar{\bar{\varepsilon}}_i = d_i \mathbf{w} + \bar{\mathbf{h}}_i
\]
where: \( \mathbf{f}^* = \mathbf{R}' \mathbf{f} \) are the transformed ideal factors, and
\[
\mathbf{h}_i = \mathbf{g}_i \mathbf{f} + \mathbf{s}_i
\]
are the specific components of value.

Thus (9) expresses the values in terms of the known characteristics \( d_{ik} \) and the weights for each characteristic are unknown. Notice that the residuals \( \mathbf{h}_i \) no longer have the desired properties of homoscedasticity or lack of correlation with the factor weights \( t_k^* \).

Defining the relevant vector
\[
\mathbf{h} = \begin{bmatrix}
\mathbf{h}_1 \\
\vdots \\
\mathbf{h}_I
\end{bmatrix} \quad \mathbf{d} = \begin{bmatrix}
\mathbf{d}_1 \\
\vdots \\
\mathbf{d}_I
\end{bmatrix}
\]
the matrix representation of the valuation equation is:

\[
\tilde{\mathbf{d}} = \mathbf{D} \mathbf{f}^* + \mathbf{h}
\]

Alternatively, the model can be written with a market component of value and a characteristic component of value paralleling developments in the stock market (see, for instance, Rosenberg [1974]). If a market index were observable, a single factor model (like those in Sharpe [1974] orLintner [1965]) can be written. An analysis of the characteristic and specific components of value is simple (see Hoag [1979]).

It is possible to estimate the factor weights cross sectionally from equation (10) using generalized least squares estimates to insulate against the undesirable residual properties. These estimates for \( \mathbf{f}^* \)
can be used to provide estimated logarithmic values for each property \( i \) in the sample at that time. Define the variance covariance matrix for the residuals as:

\[
H = E[hh']
\]

then

\[
\hat{\mathbf{f}}^* = (D'H^{-1}D)^{-1}D'H^{-1}\mathbf{p}
\]

and

\[
\text{var}(\hat{\mathbf{f}}^*) = (D'H^{-1}D)^{-1}
\]

and

\[
\mathbf{e} = \mathbf{p} - D\hat{\mathbf{f}}^*.
\]

Then define the estimate of logarithmic value at time \( t \) for all properties \( i \) as a function of the predetermined characteristics and the vector weight estimates as:

\[
\hat{\mathbf{c}} = D\hat{\mathbf{f}}^*.
\]

Using the estimate \( \hat{\mathbf{c}} \), the market rate of return and standard deviation can be estimated at that point in time. Unfortunately, these estimators have substantial pointwise error due to the fact that in any cross section all weight is placed on prices which were present. To alleviate this problem, a pooled cross section time-series regression can be run on the
entire ensemble of observations. Let \( I_t \) equal the number of observations at time \( t \) and define the time subscripted variables as before:

\[
\hat{\beta}_{it} = \hat{d}_{it} \hat{\epsilon}^* + \hat{h}_{it}, \quad i = 1, \ldots, I_t
\]

\[
t = 1, \ldots, T.
\]

Essentially, estimation of this equation implies a stationary valuation function. It is relatively simple to decide on the validity of this procedure. If there are significant differences and the data cannot be pooled, then with sufficient data it is possible to estimate \( \hat{f}^* \) as a time-varying vector (see, for instance, Cooley, Rosenberg, and Wall [1977], and Rosenberg [1977]), a stochastically convergent parameter vector (Rosenberg [1973]), or a random parameter vector (for a survey, see Rosenberg [1973]). Experience with similar stock market regressions (see, for instance, Rosenberg and McKibben [1973]) suggests that random parameter regressions are excessive. The estimator of choice with sufficient data would be a stochastically convergent smoothed generalized least squares estimate of the valuation factor \( \hat{f}^* \).

Given the estimate in (11) for the value at time \( t \), a (biased) estimate of the market rate of excess return for real estate is:

\[
\hat{r}_{mt} = \ln \prod_t \hat{\beta}_{it} - \ln((1+\hat{r}_{mt})^{\sum_t \hat{\beta}_{it-1} - CF_{it-1}})
\]

and the variance of the market return can be estimated as \( \hat{\text{var}}(\hat{r}_m) = E_t(\hat{r}_{mt} - E_t(\hat{r}_{mt})) \).
In the next section, a brief description of the fundamental characteristics provides insight into the valuation process. These characteristics, the actual transactions, and the interpolated property valuation function provide the required estimates of risk and return for the real estate market.

5. Construction of an Industrial Real Estate Return Index

The success of the estimation of market return depends upon the choice of valuation characteristics. Any variable which estimates industrial real estate value should improve the efficiency of the estimation procedure. Indeed, econometric parsimony is not required here unless the model is unstable. Furthermore, intuitively understandable value measures should be preferred to technical value measures. Initially, the list of valuation characteristics should be very broad, but as experience grows, many candidate characteristics will be cast aside. Figure 1 lists a number of important characteristics for industrial properties.13

One broad class of variables describes the general economic climate. These values fluctuate through time and provide a texture of time variation in the market rates of return for real estate (in conjunction with transaction prices). These variables attempt to capture the supply and demand for warehouse services, replacements costs and potential profits of warehouse ownership.

For industrial real estate, a number of specific or microeconomic characteristics can be examined. The physical characteristics literally
describe the building, its surroundings and location. Notice that the location interacts with specific regional macroeconomic variables (such as transportation spending) to provide a context for regional valuation if it is warranted.

Next, the actual transaction price and any qualifications are analyzed. The qualifications are used to screen out any swaps or any partial transactions which are not reflective of the price paid for the property. At least initially, swaps and joint purchases (or packages) are avoided so that pure valuation characteristics for industrials can be identified. In addition, any transaction costs paid to locate or purchase this property are included as part of the fundamental characteristics.

If financing exists, a number of variables which are fundamental to the valuation process can be examined. Although leveraging for tax purposes is not common among institutional investors, these investors participate in a market which may include taxable investors. Therefore, it is possible that tax effects, credit availability, and borrowing restrictions have an influence on the valuation of real estate properties. Another area where these effects are apparent (and potentially useful in valuation) is in the depreciation and amortization schedules. Although the main concern is with before-tax rates of return, it is very possible that overall value is affected by the participation of individuals and institutions with diverse marginal tax rates.

The cash flow stream is a very important part of the valuation process. Not only is the cash flow included directly in return
calculations, but its components are potentially useful in the valuation function itself. For instance, a building with large maintenance expenses may be in need of massive repairs. Finally, it is necessary to examine the stability and variability of the cash flow stream. Crude measures of maturity and lessee credit ratings potentially provide useful valuation information.

The purpose of examining the fundamental characteristics of property valuation is to provide insight into the underlying valuation process. Many of the characteristics which seem to be intimately related to the valuation process may have no empirical importance whatsoever.

6. Industrial Property Subindex: Sample Selection and Characteristics

The need to concentrate on one homogeneous property type is apparent when the number of potential real estate investments is considered. Of the many property types, industrial properties seem to be the most homogeneous and their valuation characteristics seem readily discernible. It is difficult to check this sample for representativeness. Any extrapolation to population parameters should be made with great care and attention must be paid to the problem of retrospective inclusion and survivorship bias. These problems tend to inflate the values of return estimated from a sample, and it is likely that our sample suffers from these biases to some (currently unknown) degree.

The sample used for calculations in this next section consists of 463 properties with transaction prices at some time during the twenty-four
quarter interval from the first quarter of 1973 (1Q73) through the fourth quarter of 1978 (4Q78). This subsample was chosen because only these observations have been verified for accuracy and completeness. Only those locations and time periods where sufficient data existed could be used in the estimation process. As more information on industrial properties becomes available, the estimates of return and risk will change—perhaps dramatically at first. As the sample size increases, further changes should be small. From the little information analyzed from the *Site Selection Handbook* and *Western Real Estate News* (see Sand [1978]), the sample does not look wholly unrepresentative, but the results must be treated with care. A complete description of the sample appears in Table 1.

7. The Fundamental Valuation Function for Industrial Properties

To alleviate problems of substantial pointwise error in any cross section, pooled cross section time-series regressions can be estimated over the entire ensemble of observations of transaction prices. Essentially, estimation of the pooled data implies a stationary valuation function. It is relatively simple to decide on the validity of this procedure for any particular sample.

In Table 2 estimates of the parameters of a simple linear valuation function for industrial properties appear. The sign and magnitude of most of the coefficients in this model are reasonable. In particular, a great deal of importance is attached to the income capitalization rate which
TABLE 1

INDUSTRIAL PROPERTY SAMPLE CHARACTERISTICS*

\[ \bar{P}_{it} = \$1,167,000 \]
\[ \sigma(P_{it}) = \$1,039,000 \]
\[ \text{Max}(P_{it}) = \$8,241,000 \]

where \( P_{it} \) = the price paid for an industrial property at time \( t \), \( i=1, \ldots, 463 \)

Temporal Distribution of Transactions

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</tr>
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<td>2</td>
<td>6</td>
<td>24</td>
<td>35</td>
<td>5</td>
<td>14</td>
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<tr>
<td>3</td>
<td>13</td>
<td>23</td>
<td>22</td>
<td>9</td>
<td>39</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>14</td>
<td>34</td>
<td>9</td>
<td>55</td>
<td>9</td>
</tr>
<tr>
<td>Annual</td>
<td>49</td>
<td>74</td>
<td>109</td>
<td>37</td>
<td>124</td>
<td>70</td>
</tr>
</tbody>
</table>

Geographic Distribution of Transactions

- North East: 40
- Central: 59
- South: 168
- Mountain: 13
- West: 183
- Total: 463

*The Industrial Property Sample at the University of California, Berkeley currently has information on 800 industrial properties with at least one transaction each over a period from 1970 through today. Institutional donors of this data have been especially generous with their time and information. This data base will be expanded and updated in future years.
### Table 2

**Relative Asset Valuation Function for Industrial Properties**

\[
P_{it} = \alpha_0 + \alpha_{f1} f_1 + \alpha_{n1} n_1 + \alpha_{r2} r_2 + \alpha_{q4} q_4 + \epsilon_{it}
\]

\[
R^2 = .89 \quad S(\epsilon) = 352. \quad F(33,429) = 108.6
\]

<table>
<thead>
<tr>
<th>( f = {f_1} )</th>
<th>Fundamental Characteristics of Value</th>
<th>( \hat{\alpha}_{f1} )</th>
<th>( \hat{\sigma}<em>{\alpha</em>{f1}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( f_1 ): income in year of purchase</td>
<td>9.8</td>
<td>0.42</td>
<td></td>
</tr>
<tr>
<td>( f_2 ): expenses in year of purchase</td>
<td>-1.65</td>
<td>0.90</td>
<td></td>
</tr>
<tr>
<td>( f_3 ): net lease variable</td>
<td>79.3</td>
<td>41.8</td>
<td></td>
</tr>
<tr>
<td>( f_4 ): capital improvements in year of purchase</td>
<td>-0.58</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>( f_5 ): size measure</td>
<td>-0.0081</td>
<td>0.00086</td>
<td></td>
</tr>
<tr>
<td>( f_6 ): expense measure</td>
<td>0.013</td>
<td>0.00297</td>
<td></td>
</tr>
<tr>
<td>( f_7 ): lease attractiveness measure</td>
<td>0.0086</td>
<td>0.001</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>( n = {n_1} )</th>
<th>National Economic Concomitants of Value</th>
<th>( \hat{\alpha}_{n1} )</th>
<th>( \hat{\sigma}<em>{\alpha</em>{n1}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( n_1 ): business inventories in quarter of purchase</td>
<td>-3.1</td>
<td>0.43</td>
<td></td>
</tr>
<tr>
<td>( n_2 ): nationwide volume of sales of industrial properties</td>
<td>6.22</td>
<td>2.06</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>( z = {r_1} )</th>
<th>Regional Economic Concomitants of Value</th>
<th>( \hat{\alpha}_{r1} )</th>
<th>( \hat{\sigma}<em>{\alpha</em>{r1}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( r_1 ): $ value of loans committed in the region of the property</td>
<td>3.09</td>
<td>2.85</td>
<td></td>
</tr>
<tr>
<td>( r_2 ): measured capitalization rate on property in the region</td>
<td>-65.5</td>
<td>62.3</td>
<td></td>
</tr>
<tr>
<td>( r_3 ): capitalization rate dummy variable for credit availability</td>
<td>722.8</td>
<td>633.8</td>
<td></td>
</tr>
<tr>
<td>( r_4 ): regional volume of sales of industrial properties</td>
<td>-8.4</td>
<td>2.8</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>( i = {i_1} )</th>
<th>Locational Characteristics of Value **</th>
<th>( \hat{\alpha}_{i1} )</th>
<th>( \hat{\sigma}<em>{\alpha</em>{i1}} )</th>
</tr>
</thead>
</table>

| \( q = \{q_4\} \) | Temporal Characteristics of Value ** | \( \hat{\alpha}_{q4} \) | \( \hat{\sigma}_{\alpha_{q4}} \) |

*The micro and macroeconomic characteristics of value are described in more detail as is the estimation of the valuation function for industrial properties in Hoag [1979].

**See the discussion for a description of these variables and their effects on property value.
is also very significant (20 times its standard error) in our regressions. All of the fundamental financial characteristics add to the explanatory power of the model. Additionally, the macroeconomic (regional and national) variables add further to the model. The locational variables detracted somewhat from the regional economic concomitants since each represents essentially a localized measure of value. The existence of significant coefficients for the location variables can be attributed to a lack of strong regional concomitants for industrial properties in the model or segmentation in the real estate market.

The overall performance of the model is quite reasonable with an adjusted $R^2 = .89$. Quite a large portion of the variance in transaction price can be explained through the relationship in the model in Table 2. The goodness of fit of the fundamental valuation model improves the chances of providing reasonable estimates of the value and return of industrial real estate.

8. Historical Risk and Return Estimates for Industrial Real Estate

Results based on the sample described in Table 1 and the valuation function estimates in Table 2 indicate that the average compound return for the industrial real estate value weighted subindex over the period 1Q73 through 4Q78 was 3.38 percent/quarter with a quarterly standard deviation of 8.61 percent. The return is high and the risk is comparable to that obtainable on stocks and corporate bonds during that period, as
can be seen in Table 3. As is commonly observed in common stock portfolios, the equally weighted industrial real estate index has a larger variance than the value weighted industrial real estate index.

It appears from the cross-correlation evidence that real estate provides a sound basis for fulfilling the inflation hedge and diversification motives of investors. In Figure 2, the time series behavior of the total rate of return on industrial real estate is displayed. There appear to be sizeable fluctuations which are, of course, corroborated by the 17 percent annual standard deviation for industrial real estate over this period. It does not appear that real estate was substantially less risky than common stock. However, the sample period was one of relative uncertainty in the investment real estate industry due to the virtual collapse of a number of Real Estate Investment Trusts (REITS). More definitive results on real estate investment characteristics await further data collection and analysis.

9. Potential Applications and Future Developments

Perhaps the best indication of the importance of this work is the breadth of potential applications in the real estate investment management arena. The availability of an index of returns permits the evaluation of realized returns on individual properties on an objective basis. The fundamental valuation characteristics permit measurement of historical risk characteristics for each property. When properties are sold, it is possible to objectively evaluate performance compared to a broad-based sample of industrial properties.
<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation**</th>
</tr>
</thead>
<tbody>
<tr>
<td>( i_t )</td>
<td>.0196</td>
<td>.0061</td>
</tr>
<tr>
<td>( r_{ft} )</td>
<td>.0152</td>
<td>.0031</td>
</tr>
<tr>
<td>( r_{Bt} )</td>
<td>.0155</td>
<td>.0402</td>
</tr>
<tr>
<td>( r_{St} )</td>
<td>.0092</td>
<td>.1038</td>
</tr>
<tr>
<td>( r_{EW} )</td>
<td>.0211</td>
<td>.0953</td>
</tr>
<tr>
<td>( r_{RET} )</td>
<td>.0338</td>
<td>.0861</td>
</tr>
</tbody>
</table>

**Cross Correlation Coefficients**

<table>
<thead>
<tr>
<th></th>
<th>( i_t )</th>
<th>( r_{ft} )</th>
<th>( r_{Bt} )</th>
<th>( r_{St} )</th>
<th>( r_{EW} )</th>
<th>( r_{VW} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( i_t )</td>
<td>1</td>
<td>.68</td>
<td>-.50</td>
<td>-.41</td>
<td>.79</td>
<td>.50</td>
</tr>
<tr>
<td>( r_{ft} )</td>
<td>.68</td>
<td>1</td>
<td>-.36</td>
<td>-.33</td>
<td>.39</td>
<td>.28</td>
</tr>
<tr>
<td>( r_{Bt} )</td>
<td>-.50</td>
<td>-.36</td>
<td>1</td>
<td>.64</td>
<td>-.49</td>
<td>-.31</td>
</tr>
<tr>
<td>( r_{St} )</td>
<td>-.41</td>
<td>-.33</td>
<td>.64</td>
<td>1</td>
<td>-.21</td>
<td>-.07</td>
</tr>
<tr>
<td>( r_{EW} )</td>
<td>.79</td>
<td>.39</td>
<td>-.49</td>
<td>-.21</td>
<td>1</td>
<td>.99</td>
</tr>
<tr>
<td>( r_{VW} )</td>
<td>.50</td>
<td>.28</td>
<td>-.31</td>
<td>-.07</td>
<td>.99</td>
<td>1</td>
</tr>
</tbody>
</table>

where

- \( i_t \): the rate of inflation as measured by changes in the Bureau of Labor Statistics Consumer Price Index
- \( r_{ft} \): the rate of return on U.S. Treasury Bills with 3-month maturity
- \( r_{Bt} \): the total rate of return on corporate bonds measured by the Salomon Brothers High Grade Long-Term Corporate Bond Index
- \( r_{St} \): the total rate of return on the Standard & Poor's 500 Stock Index
- \( r_{EW} \): estimated total rate of return on an equally weighted portfolio of industrial properties
- \( r_{VW} \): estimated total rate of return on a value weighted portfolio of industrial properties

*Historical returns for bonds, stocks, treasury bills and the rate of inflation were obtained from Ibbotson and Sinquefield [1979].

**The variances and covariances presented have been adjusted for serial correlation due to random pricing errors. For details, see Hoag [1980].
FIGURE 2

HISTORICAL MARKET VALUE WEIGHTED EQUITY RETURNS FOR INDUSTRIAL PROPERTIES

Time Series of Quarterly Returns

Wealth Index for a Market Value Weighted Investment
- One classic objection to previous market indexes has been the lack of real estate representation. With the inclusion of our real property indexes, major objections to missing assets in the "market" portfolio are alleviated. 17

Further, this new market index and its associated portfolio lead naturally to a redefinition of a passive investment strategy which would include market value weighted portions of all real estate assets. To say that this would be a change in investment strategy for institutions is an understatement. In addition to pursuing the passive strategy, it will be possible to analyze asset allocation strategies which differ from the passive strategy. Since industrial real estate appears to have a low correlation with stock returns, it should be a good diversifying asset. Once the matrix of covariances of returns between stocks, bonds, and all real estate is available, investment managers can rationally explore the efficient frontier.

Last, but not least, the availability of this technique and the fundamental valuation parameters permits investment managers to perform objective evaluations of properties in their portfolio. Thus, in addition to hiring an appraiser, the valuation function can provide a computer-based "appraisal." Clearly the fundamental valuation technique embraces all three commonly used appraisal strategies and combines these techniques with a broad data base for reference. It would only be natural to compare these two estimates of value to cross check and confirm the valuation. In fact, it would be interesting to look for appraisers who choose properties with positive abnormal returns, much as stock portfolio managers
attempt to identify security analysts who pick winners. Regardless of
the availability of superior selection ability in real estate, the index
and valuation techniques can help in the active management process.

Finally, the real estate indexes are an indispensable tool in
valuing contingent claims upon the equity returns of real property. For
instance, mortgages, mortgage bonds, mortgage-backed bonds, and pass-
through certificates all rely upon the cash flow from real estate invest-
ments. In the same way that it would be difficult to evaluate risky bonds
without the value of the underlying stock and company, it is harder to
value these mortgage-related instruments without knowing something about
equity real estate returns.

Thus, the real estate index is potentially useful throughout the
investment management process. Ongoing research in this area includes
the completion of the industrial property data base, installation of an
ongoing data collection mechanism, and continual updating and reestimation
(when necessary) of the industrial real estate subindex. Further develop-
ments include an expansion of the data base and indexes to the other main
areas of real estate returns and, finally, a link between all return sub-
indexes to create an overall market index for investment real estate.
Financial support for this research from Wells Fargo Bank and First National Bank of Chicago is gratefully acknowledged. The Institute of Business and Economic Research, University of California, Berkeley, assisted in preparing this manuscript. The author also appreciates the support of and very helpful discussions with William F. Sharpe and Barr Rosenberg. Of course, the sponsors and my colleagues are absolved of responsibility for the conclusions presented herein. Pieces of this work appear in the Proceedings of the Seminar on the Analysis of Security Prices and a forthcoming issue of the Journal of Finance. Comments are welcomed.

1 Sizable quantities of real estate are held in the portfolios of most large financial intermediaries including employee benefit trusts, commercial banks (trust departments and foreclosures in loan portfolios), savings and loans (foreclosed property), insurance companies, real estate investment trusts, and university endowments. In addition, the dollar value of claims contingent on equity, real estate investment (mortgages and mortgage bonds) is comparable to the total market values of outstanding corporate securities. Wendt and Haney [1979] estimate that equity investments held by intermediaries topped $40 billion in 1976. Thus, it appears that the time is ripe for the creation of a national real estate market index.

2 Casual observation (Leader [1978]) suggests that property has been changing hands more frequently in recent years. The introduction of more institutional investors into the real estate arena has apparently increased the volume of trading.

Furthermore, evidence suggests that a national market has developed in investment real estate (Wendt and Haney [1979]). If the geographical diversity of the sample (categorized by investor) is any indication, markets for industrial properties are definitely not localized. Confirming this hypothesis is the growth of large national investment real estate brokers, nationwide information services (for instance for industrial properties, the Site Selection Handbook and Western Real Estate News), the prototype of a national market, the American Real Estate Exchange, and the increasing growth of pooled real estate funds, syndications and equity real estate investment trusts which attract a nationwide clientele. Although the income of real estate agents, brokers, and managers went down during the 1974 real estate decline, income (due primarily to transactions) has recovered and continues to grow faster than the rate of price appreciation.

3 For a discussion of valuation with infrequently traded stock assets using similar techniques to those proposed in Section 4, see

Perhaps the most obvious use of this technique is in residential housing. Consider two identical tract houses situated in the middle of a neighborhood. Both have been maintained in approximately the same condition. If one of these houses transacts, the value of the house next door should be very near to that transaction price.

One interesting question concerns the efficiency of the real estate market in processing fundamental information. Most real estate writers assert that the market is inefficient. The bulk of evidence for the stock market suggests that public information is processed rapidly and efficiently. Of course, no evidence exists for the real estate market because no measures of return are available. Thus tests of market efficiency await completion of an index of market returns such as the one under construction herein. Until proven otherwise, a null hypothesis of efficiently established prices would seem prudent.

The bulk of evidence in the stock market suggests that rewards for information processing are not consistently evident in returns to investment vehicles such as mutual funds. Thus, the null hypothesis is that if the model is adequately specified with fundamental characteristics, appraisals will not improve the valuation function.

When the estimation of the valuation function is complete, an assessment of the value of appraisal information will be forthcoming. Given the breadth of the market data assembled for industrial properties plus the objective nature of the estimation procedure, it would seem unlikely that appraisers could have appraisals with consistently positive value.

Under certain assumptions, detailed in Lintner [1975], this market return is a value weighted index of the compound rates of returns for individual properties.

The relationship of common stock risk and return to fundamental characteristics has been demonstrated in the stock market (see, for instance, Beaver, Kettler, and Scholes [1970], and Rosenberg and McKibben [1973]).

For example, it is possible to purchase a property (for $P_{t-1}$), maintain the property (such that $CF_t << 0$), allow the insurance to lapse,
and have the property burn to the ground. Assuming free disposal
\( P_\tau \geq 0 \), \( r_\tau < -1 \) requires \( P_\tau + CF_\tau < 0 \) or \( CF_\tau < 0 \) and \( P_\tau < -CF_\tau \). The circumstances above are one possible set where \( r_\tau < -1 \).

11 If \( \bar{r}_m \equiv \ln \left( \sum I \bar{r}_I \right) \) then for \( \bar{r}_I \) small and \( 2 \geq \sum I \bar{r}_I (1+\bar{r}_I) > 0 \),

\[
\bar{r}_m \equiv \ln \left( \sum I \bar{r}_I (1+\bar{r}_I) \right) = \sum I \bar{r}_I (1+\bar{r}_I) - 1 \geq \sum I \bar{r}_I \bar{r}_I.
\]

If \( \bar{r}_I \) is normally distributed, then \( \bar{r}_m \) should be approximately normally distributed.

12 The homogeneity of regression across time can be tested by noticing that estimating equation (12) is equivalent to estimating equation (10) subject to the \( K(1-l) \) linear restrictions implied by the alternative hypothesis which states that:

\[
f^*_1 k = f^*_1 k, f^*_2 k = f^*_2 k, ..., f^*_n k = f^*_n k.
\]

Then the \( F \)-test can be used to ascertain the validity of the pooling process (for details, see Maddala [1977]).

13 Note that the microeconomic valuation characteristics should include property type. This paper (Sections 5-8) examines only one relatively homogeneous subsample of properties—industrial (warehouses)—and ignores the remainder. This is comparable to creating an index for one broad category of industry (such as banks or manufacturing). Future research is planned to examine other property types. For the remainder of these sections, the examples and characteristics will be oriented toward industrial (warehouse) real estate. In future work, the estimation procedure of Section 4 can be applied to a multiplicity of property types and the industrial real estate subindex can be combined with other subindexes to form one investment real estate index.

14 Later, it should be possible to value packages of properties or buildings with mixtures of property types in the same way that it is possible to value a conglomerate merger using value additivity.

15 For excellent analyses of this effect in the stock market, see Litzenberger and Ramaswamy [1978] and Rosenberg and Marathe [1979]. An analysis of the overall effect of taxation on relative asset prices appears in Hoag and Rosenberg [1979].
Interpretation of individual coefficient standard errors should be made with great care due to the multicollinearity of the independent variables. In Hoag [1980], as in Rosenberg [1974], factor analytic techniques are used to produce independent predictors of value. Alas, intuitive explanations of these factors are not possible and, hence, these estimates are not presented herein.

Another use of the techniques of this paper which is related to the index issue is obtaining estimates of return for any large stock index which includes assets (such as real estate or OTC stocks) which trade infrequently (or nonsynchronously). This problem was first pointed out by Fisher [1966]. Our method calls for the introduction of fundamental factors into the valuation process coupled with smoothed time varying generalized least squares estimates (for a review of these techniques, see Rosenberg [1973]) of the logarithmic returns. Contrast this technique with those of Dimson [1978], Schwert [1977], and Scholes and Williams [1977] who use limited descriptor sets consisting of historical B and OLS estimates for nonsynchronous assets. Efficient, unbiased estimates can be obtained from the technique proposed in Hoag [1980].
REFERENCES


