Recovery of Real Estate Returns for Portfolio Allocation

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Abstract

Appraisal-based return indexes may not approximate the true real estate return distributions because of understated return volatility. Recovery of returns from reported, appraisal-based returns may be possible by evoking models to correct for appraisal-based smoothing of the second moment. Because recovery intentionally alters the volatility of the reported return distribution and the correlations among assets in the portfolio, the weights to real estate are likely affected. Our examination of the portfolio implications of altering the return distribution indicates that weights may be quite sensitive to the effects of recovery across a reasonable range of correlation regimes. A comparative analysis of several recovery models reveals that all models achieve the objective of inflating the volatility of reported returns. However, the models also change the mean of the return distribution, which either counteracts or magnifies the effect of the volatility change on allocations. These findings bring into question the applicability of recovery models in their current form.

Keywords: return indexes, appraisal smoothing, portfolio allocation

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Table 1 presents results from a standard portfolio analysis of quarterly real estate returns using the two National Council of Real Estate Investment Fiduciaries (NCREIF) appraisal based series and a National Association of Real Estate Investment Trusts (NAREIT) securitized series combined with returns on stocks, bonds, and U.S. Treasury bills. The results reaffirm some long-standing and troublesome notions about the properties of appraisal-based return series:

- Appraisal-based returns have abnormally low coefficients of variation relative to other risky assets, including real estate securities.
- Appraisal-based real estate returns are uncorrelated with returns on real estate securities.
- Markowitz models produce allocations to unsecuritized real estate that far exceed allocations observed in real-world investment portfolios. Table 1 shows that allocations to unsecuritized real estate are large even in the presence of REITs.

The literature contains two general explanations for the extraordinary risk and return relationships found in appraisal-based real estate. One view is that abnormal returns on investment in unsecuritized real estate provide compensation to investors for illiquidity and informational inefficiency (see, for example, Ibbotson and Siegel, 1984). Lusht (1988) argues that, for these reasons, static equilibrium models annexed from financial economics are a poor fit for real estate. Others cast doubt on the applicability of finance models to real estate because of evidence that indexed and property-level returns, which rely on appraisal information, are not normally distributed and thus violate key model assumptions (Myer and Webb, 1993; Young and Graff, 1995). The second view is that the problems associated with appraisal-based returns occur instead because of systematic behaviors of appraisers.[1] The effects of these behaviors, termed appraisal smoothing, may be modeled and corrective procedures implemented to recover the unsmoothed returns on real estate from reported returns. The logical extension of this line of reasoning is to use these recovered series in pricing and allocation models.

A substantial literature now exists describing appraiser behavior and outlining recovery procedures.[2] Recent studies by DeWit (1993) and Diaz and Wolverton (1996) test specific hypotheses about appraiser behavior. While rich in behavioral explanations for smoothing and recovery technology, the real estate investment literature is impoverished by the absence of empirical study on the economic implications of recovery. This article questions the importance of smoothing for portfolio formation and thus the need to evoke unsmoothing technologies for adjusting reported returns. We accept the premise that improper allocations to real estate and other assets in mixed-asset portfolios represent the greatest potential consequence of using reported, appraisal-based returns. Specifically, our interest involves answering the following questions:

- In a general portfolio framework, how sensitive are asset weights to adjustments in the reported return series that alter volatility and correlations with other assets?
- How do the statistical properties of recovered series, using alternative models, differ from those of the reported series, and each other?
- How do the portfolio allocations to unsecuritized real estate behave when recovered returns are introduced instead of the reported, appraisal-based returns?

We find, as expected, that increasing the volatility of real estate reduces its weight in a mixed-asset portfolio. If changes in the correlation with other assets occur as the result of recovery, then the reduction in weight either will be offset or magnified depending on the direction of the change in the correlation. Recovering a real estate return series from a reported, appraisal-based series using any of several models substantially increases the volatility to real estate and, to a lesser degree, reduces the correlation with other assets. Ordinarily, these changes would lower the weight to real estate by approximately 50 percent. However, recovery also changes the mean return to the extent that the weight to real estate goes to zero with some recovery models and increases with others.

The remainder of the article is organized into five sections. Section 1 reviews the conceptual arguments that explain understated volatility of appraisal-based returns. In the next section, we investigate how changes in the standard deviation of an asset and the correlations among assets influence asset weightings in the portfolio. Section 3 explores the range of possible modeling strategies for empirically recovering unsmoothed returns from reported, appraisal-based returns. Section 4 presents the results of a comparative analysis of recovery models applied to the NCREIF Property Index. In the final section, we provide conclusions regarding the use of reported and recovered real estate series in portfolio models.

1. Understated Volatility of Appraisal-Based Returns

Volatility measures of indexes that rely on market-value appraisals are believed to understate the true volatility of real estate returns. Quan and Quigley (1991) argue that understated volatility originates at the disaggregate level as the result of appraisers following optimal updating strategies when confronted with uncertainties about the reliability of current-period transactions yielding useful information on the true values of real estate. At the aggregate (index) level, appraisal errors may somewhat offset one another (Edelstein and Quan, 1990).

It is generally recognized that aggregate level smoothing is a special case of partial adjustment in time-series data and recovery of unsmoothed returns follows from evoking autoregressive models (for example, Ross and Zisler, 1991; Fisher, Geltner, and Webb, 1994).3 Underlying these models is a market-efficiency assumption. Specifically, once the predictive ability of prior observations is purged from the reported series, the recovered return series follows a random pattern that conforms to the patterns assumed for other financial assets in the portfolio. An alternative model proposed by Geltner (1993) does not rely on the market-efficiency assumption and therefore generates a recovered series without estimating autoregressive parameters. Geltner's model also treats temporal aggregation and seasonality conditions that may infect quarterly appraisal-based indexes.

In one of a few empirical studies of smoothing, DeWit (1993) finds significant differences in volatility of appraisal-based returns generated from in-house versus outside appraisals. Volatility of indexes from outside appraisals does not differ statistically from common stock return volatility, but the volatility of indexes from in-house appraisals is statistically smaller than common stock return volatility. In an experiment involving appraisers, Diaz and Wolverton (1996) discover that the actual value adjustments at the disaggregate level are statistically smaller than appropriate adjustments. They conclude that ``the effect detected seems to be a function of problem solving processes and independent of any business pressures, such as directed valuations, hypothesized by some researchers" (1996, p. 5). Results from the DeWit and the Diaz and Wolverton studies support the hypothesis that appraiser behavior at the disaggregate level causes an understatement of the volatility of appraisal-based real estate return series.

Others argue that understated volatility is rooted in institutionalized valuation procedures and not so much the result of appraiser updating behavior at the disaggregate level. Shulman (1986) and Graaskamp (1987) in separate Salomon Brothers research reports, discuss how the long-run assumptions necessary to implement the income approach induce smoothing. From an analysis of the relationship of NCREIF income and capital-return components, Wheaton and Torto (1989) find a constant relationship between the two components during the period 1978 through 1988. This result contrasts with predictions from valuation theory. The alternative explanations they provide for this empirical relationship trace directly to systematic applications of the income approach.

1.1. Economic Rationale for Understated Volatility

Alternative explanations for understated volatility that rely on financial and economic fundamentals either diminish or entirely dismiss appraiser behavior as a contributing factor. Gyourko and Linneman (1990) attribute much of the understated volatility of real estate returns to the low amounts of leverage (relative to common stock) on properties in appraisal-based indexes. Although they recognize that valuations contribute to smoothing, they also argue that fundamental factors (long-term leases) create stability in cash flows and valuations. The most serious challenge to the appraisal-smoothing explanation for understated volatility appears in an article by Lai and Wang (1998). Lai and Wang question the four premises (lack of confidence, moving-average appraisals, reliance on past information, and temporal aggregation) on which the smoothing explanation is based. If superior returns to real estate exist, then they claim that fundamental reasons illiquidity and costly information-- are the root causes.

2. Portfolio Implications of Recovery

In this section, we examine the implications of altering the return distribution of a single asset, as would occur in recovery, on the weight of that asset in a mixed-asset portfolio. Conventional wisdom holds that the standard deviation of appraisal-based real estate return distribution is understated, which results in excessive weight to real estate. The change in the optimal weight given a change in the standard deviation across various correlation regimes therefore represents an important set of relationships for understanding the consequences of unsmoothing. If the weight is sensitive to changes in the standard deviation, then the conceptual issues noted above and technical issues discussed later in this article regarding of understated volatility of real estate returns require careful attention. Otherwise, unsmoothing the observed return series is less consequential than currently believed.

Assume a portfolio comprised of N risky assets. The expected return and variance of the portfolio are as follows:

$$E(r_p) = \sum_{i=1}^{N} w_i \, E(r_i) \tag{1}$$

$$\sigma_p^2 = \sum_{i=1}^{N} w_i^2 \, \sigma_i^2 + \sum_{i=2}^{N} \sum_{j=1}^{N} 2 w_i \, w_j \rho_{ij} (\sigma_i)(\sigma_j) \tag{2}$$

where $E(r_p)$ is the expected return on the portfolio, w_i is the weight to asset i, r_1 is the expected return to asset i, σ_p^2 , is the variance of the portfolio, σ_i is the standard deviation of return on asset *i*, and p_{ij} is the correlation coefficient for asset *i* and asset *j*.

Now assume that the portfolio objective is to maximize the Sharpe ratio (S_p):

$$S_p = \frac{r_p - r_f}{\sqrt{\sigma_p^2}} \tag{3}$$

where r_f is is the risk-free rate. A solution then may be found for the optimal weights in a portfolio consisting of two risky assets.[4] The optimal weight to asset one (real estate) is

$$w_1 = \frac{\sigma_2\left(-r_f\sigma_2 + r_f\rho\sigma_1 - r_2\rho\sigma_1 + r_1\sigma_2\right)}{r_1\rho\sigma_1\sigma_1 - r_1\sigma_2^2 - 2r_f\rho\sigma_1\sigma_2 + r_2\rho\sigma_1\sigma_2 + r_f\sigma_1^2 + r_f\sigma_2^2 - r_f\sigma_1^2} \tag{4}$$

with the weights constrained to add to 1.0, the optimal weight to asset two is simply $(1 - w_1)$.

Figure 1 shows the value for w1, the weight to real estate, in a two-risky-asset portfolio that includes the NCREIF Property Index and the S&P 500. The return and volatility measures come from table 1. In figure 1, two key parameters are allowed to vary —σ_1, the volatility of real estate, and ρ_{12}, the correlation between real estate and the S&P 500. The actual values for the standard deviation and correlation, 2.12% and 8.0%, respectively, produce an optimal weight of approximately 40%. A close examination of the figure 1 reveals that the optimal weight always decreases when volatility increases. The optimal weight also decreases as the correlation increases and is extremely sensitive to changes in correlation.

The magnitude of the reduction in weight given a change in volatility can be estimated by taking the partial derivative of the optimal weight with respect to its standard deviation. Figure 2 shows the value of the partial derivative, $(\partial w_1/\partial\sigma_1)$ over a range of correlations. Given the observed correlation of –8.0%, a 1% change in volatility results in a 25% reduction in the weight. If the correlation becomes more negative, a smaller reduction occurs, while increasing the correlation results in a larger weight reduction. It appears that the optimal weight will drop if the recovered real estate series are more volatile then reported series; however, the magnitude of the drop is an empirical question that depends on the resulting correlations.

Care must be taken to incorporate both the recovered volatilities and correlations in portfolio allocations. A simple increase in the standard deviation is not sufficient to capture the effects of smoothing in a portfolio context.

3. Recovery Model Choices

The recovery models that have appeared in the literature during recent years transform reported, appraisal-based return series into new return series that have been adjusted for appraiser behavior and understated volatility. The initial step in the process of recovering returns from appraisal-based return indexes generally involves modeling the effects of prior observations on current returns. The model has the following general form:

$$r_t^* = \sum_{i=1}^{N} \phi_i r_{t-i}^* + e_t \tag{5}$$

where r_t^* is the observed return for period *t*, r_{t-i}^* are prior observations from the return series, ϕ_i is a vector of lag coefficients, and e_t is a residual. The term $\sum_{i=1}^{N} \phi_i r_{t-i}^*$ captures the mean effect of prior returns on the current return. The residual term contains r_t, the recovered return, and the effect of appraisal-induced smoothing. Thus, $e_t = r_t \alpha$ where α represents the smoothing factor. Finally, recovery of r_t occurs by substitution and rearranging terms so that

$$r_t = \frac{1}{\alpha}\left[r_t^* - \sum_{i=1}^{N} \phi_i r_{t-i}^*\right]. \tag{6}$$

Standard autoregressive procedures are applied to estimate the ϕ_i vector using lagged values of the series. The exogenous smoothing factor may enter the recovery model either as a volatility condition or mean constraint to identify the model.[5] The output of this model is a return series that approximates the true return on real estate.

Actual recovery of r_t using equation (6) requires several choices. First, the recovered series may be the total return on real estate or only the capital return. Some apply the unsmoothing technology to recover total returns (Ross and Zisler, 1991), while others recognize that the smoothing problem is largely confined to the capital return component (Fisher, Geltner, and Webb, 1994). Second, the lag structure either may be limited to one period (Quan and Quigley, 1991), determined by knowledge about appraisal frequency (Fisher, Geltner, and Webb, 1994) or defined by the data (Newell and Brown, 1994). The lag coefficients are not constrained to a distributed lag structure, and the estimated intercept does not enter the deserialization step of recovery.

The value of α presents another set of choices. Fisher, Geltner, and Webb (1994) introduce a volatility condition driven by the assumption that the true volatility of commercial real estate equals one-half of the volatility of the S&P 500 index of stock market values. Thus,

$$\sigma_{rt} = \frac{\sigma_{SP}}{2}, \tag{7}$$

where σ_{rt} is the standard deviation of the true value of commercial real estate and σ_{SP} is the standard deviation of the S&P 500 index. The equation for the smoothing parameters becomes

$$\alpha = \frac{2\sigma_{et}}{\sigma_{SP}}, \tag{8}$$

where σ_{et} is the standard deviation of the residuals from the autoregressive model—a proxy for σ_{rt}.

Another question involves how recovery with a volatility condition effects the mean of the recovered series. The mean of the reported series at the aggregate level and over a complete cycle is an unbiased estimate of the true mean (Geltner, 1989; Gau and Wang, 1990). As pointed out by Fisher, Geltner, and Webb (1994) in a footnote, an alternative specification to the volatility condition is to set α so that the mean of the recovered series equals the mean of the reported series (mean constraint).[6]

3.1. Recovery without Assuming Efficient Markets

In the recovery model discussed above, the reported real estate series is randomized to rid current returns of the effects of previous estimates of value. The assumption of efficient markets underlies this step in recovery. Thus, it may be argued that the recovered series conforms more closely than the reported series to the underlying market structure of the financial assets to which real estate is comparatively evaluated in portfolio analysis. If real estate returns do not follow a random walk, the randomization step may be inappropriate regardless of the comparison argument.[7]

Geltner (1993) presents a model that recovers returns without assuming an efficient market. The model does not rely on an empirical deserialization of the reported series to adjust for the effects of previous estimates of value. The model uses annual data to recover a return series. The recovery model has the following general form:

$$r_t^* = ar_t + (1 - a)r_{t-1}^*, \tag{9}$$

where a is a parameter that captures for the combined effects of appraisal smoothing, seasonality, and temporal aggregation in the capital-return component. This single parameter model closely mimics an infinite-order moving-average process that explicitly accounts for appraisal smoothing and seasonality. Geltner presents evidence to support a value of $a = 0.4$, with a reasonable range from 0.33 to 0.50. Recovery of the true returns proceeds by

$$r_t = \frac{1}{a}[r_t^* - (1 - a)r_{t-1}^*]. \tag{10}$$

4. Comparisons of Alternative Unsmoothing Models

We perform a comparative analysis of several variations of the two dominant recovery models described in the previous section—efficient-markets models and the Geltner (1993) model. Initially, the first and second moments for each recovered series are compared to those of the reported series. Second, we examine how recovery alters the correlations between the returns on real estate and other assets. Finally, each recovered real estate series is introduced into a standard portfolio model together with stock, bond, REIT, and Treasury bill returns to generate allocations to real estate.

The data are for quarters 1978-I through 1997-I, which covers nearly an entire real estate cycle. Six quarters of data at the beginning of the period are lost during recovery due to the estimation of lag relationships. Recovered returns on real estate come from application of various models to the reported NCREIF Property Index (NPI). Other returns come from the following sources: the S&P 500 Index for stocks, the Lehman Government/ Corporate bond Index for bonds, the National Association of Real Estate Investment Trusts Index of equity REIT share prices for securitized real estate, and the three-month Treasury bill series produced by Salomon Brothers for risk-free assets.

4.1. Distributional Characteristics

The following recovery-model variations produce the recovered series:

R1 Ross and Zisler (1991) regress a one-quarter lag of the NCREIF nominal return and a seasonal dummy (1, 2, 3, and 4 representing each quarter) on the current, nominal NCREIF index return to deserialize the index. They recover an unsmoothed standard deviation by predicting with this model (without an intercept) and then scaling the result by a multiplier equal to $1/(1-\beta_1)$, where β_1 is the lag coefficient. We replicate this procedure to generate a quarterly recovered series.

R2 Equation (5) (efficient market model) is applied to the reported NCREIF capital return expressed in real terms using an AR 1,4 lag structure and the volatility condition in equation (6) following Fisher, Geltner, and Webb (1994). The nominal, recovered capital return is then added to reported income return, the denominator of which is adjusted to the unsmoothed value, to form the recovered total return. Volatility of real estate is specified as one half of the volatility of the S&P 500 following Fisher, Geltner, and Webb (1994).[8]

R3 Same procedure as R2 except, following Newell and Brown (1994), an optimal lag structure is estimated from a stepwise regression of the previous eight quarters of data. The optimal lag structure is an AR 1, 2, 4, 5, and 6 over the entire period.

R4 The Geltner (1993) model is used to recover the annual, NCREIF capital return. The recovered capital return then is added to the reported income return, the denominator of which is adjusted to the unsmoothed value. We assume the parameter α=0.4, which is similar to assuming that real estate has one-half of the volatility of stocks.

The reported NPI is designated by RO. Note that R1, R2, and R3 are reported and recovered as quarterly series, while R4 is recovered as an annual series, in accordance with the original papers. Plots of the reported and recovered series in figures 3 and 4 show that changes in the recovered series lag and magnify movements of the reported series.

The means, standard deviations, and other relevant test statistics for the five return series appear in tables 2 and 3. While the means of the recovered series are noticeably different from the means of RO, the differences are not statistically significant at the usual levels. This result holds for the quarterly models in table 2 and the annual model in table 3.

Each of the quarterly recovery methods achieves the objective of initiating the return volatility above the reported level. In every case, the F-test indicates that the recovered variance is significantly different from the reported variance. Model R1 yields a standard deviation of approximately twice the magnitude of the reported standard deviation and one-half the size of the S&P 500 standard deviation. The standard deviations from models R2 and R3 are about 300 percent greater than the reported standard deviation and nearly as large as the S&P 500 standard deviation. These results are not intuitively appealing given the volatility assumptions underlying models R2 and R3 (that is, true real estate return volatility is one-half the volatility of stocks).

As expected, model R3 is the most efficient of the models in purging the reported series of autocorrelation. The Durbin-Watson statistic indicates that some autocorrelation remains in the recovered series produced with models R1 and R2.

Recovery using annual data and model R4 produces a variance that is not statistically different from the reported annual variance. The standard deviation from model R4, however, is 200 basis points above the reported standard deviation and is about two-thirds as large as the S&P 500 standard deviation.

4.2. Correlations

Correlation coefficients reported in tables 4 and 5 indicate that all of the recovered real estate series are closely correlated with the NPI. Also, with the exception of the correlation between the recovered series from model R1 and the S&P 500, recovery makes real estate more negatively correlated with stocks and bonds and in every case much less positively correlated with Treasury bill. Finally, unsecuritized and securitized real estate remain uncorrelated following recovery.

4.3. Mixed-Asset Portfolio Results

A reexamination of figure 1 indicates that the increases in the volatility of real estate from recovery reported in table 2 should be associated with a significant reduction of the weight to real estate in a simple two-asset portfolio. This decline is offset somewhat by more negative correlations with other assets. Nevertheless, we expect that recovery will cause real estate allocations to fall well below the levels shown in table 1. This expectation, however, is based on a constant mean assumption. Because the mean of the return distribution is affected by the recovery process, the effects of recovery on the weight to real estate cannot be predicted with accuracy.

Recovery with model R1 lowers the mean and raises the standard deviation of real estate. As shown in tables 6 and 7, the combined effect of these changes to the return distribution makes real estate relatively unattractive such that it does not enter the portfolio. Quarterly models R2 and R3 increase the mean return from the reported levels and noticeably elevate the standard deviations above the reported standard deviations. These results reduce allocations along the lower return segment of the efficient frontier and generally produce larger allocation to real estate along the higher return segment.

The annual reported real estate series (NPI) yields allocations to real estate in the range of approximately 1% to 7% within a fairly narrow band of higher portfolio return and standard deviation combinations. These allocations differ markedly from the allocations to real estate generated with reported quarterly data. Recovery using model R4 increases the mean and standard deviation of reported returns. Because allocations to real estate following recovery occur in a range of seven to 13.5% along the entire efficient frontier, the effect of the upward mean shift dominates the effect of the higher standard deviation of real estate returns on the allocations.

Tables 8 and 9 show allocations using quarterly (table 8) and annual (table 9) data using the reported mean instead of the recovered mean. Introducing the reported mean is identical to adding or subtracting the difference between the reported mean and recovered mean from each recovered data point within each series. This technique maintains the recovered volatiles and correlations. The results are intuitively appealing and generally conform to predictions from the literature and the allocations observed in many institutional portfolios. Real estate has a positive weight across a broad range of portfolio variances, with the weight never exceeding 20%.

Conclusion

Despite advancements in the technology of recovery modeling, the expected and actual outcomes from recovery have not been thoroughly examined. We perform such an examination and conclude that increasing the volatility of real estate, the primary objective of recovery, will reduce the weight to real estate in a mixed-asset portfolio. If, however, the correlations among assets changes as the result of recovery, then the reduction in weight either will be offset or magnified depending on the directions of the changes in the correlations.

Recovering a real estate return series from the NPI using any of several models substantially increases the volatility to real estate and, to a lesser extent, reduces the correlation with other assets. Lower allocations to real estate should occur from these changes, but recovery also shifts the mean of the reported return distribution. As a result of a downward shift in the mean in one case, real estate drops out of the portfolio. In other cases, the mean drifts upward, and the allocations to real estate either fall or rise depending on the position along the efficient frontier.

Practical application of recovery for investment decision making will require adjustment to the models currently available so that volatility inflation occurs without shifting the mean of the distribution. We show that if the reported mean is introduced along with the volatility and correlation relationship following recovery allocations generally fall close to levels found in institutional portfolios and suggested elsewhere (e.g., Folger, 1984).

Notes

1. See Gatzlaff and Tirtirouglu (1995) for a review of the evidence on commercial real estate market efficiency.

2. Blundell and Ward (1987); Wheaton and Torto (1989); Geltner (1989b); Gyourko and Linneman (1990); Ross and Zisler (1991); Geltner (1991); Quan and Quigley (1991); Giaccotto and Clapp (1992); Geltner (1993); DeWit (1993); Fisher, Geltner, and Webb (1994); and Barkham and Geltner (1994).

3. Ross and Zisler (1991) refer to the phenomena as inertia in the return series.

4. Maple V is used to generate the solution to equation (4) following methods described in Huang and Litzenberger (1988).

5. See Fisher, Geltner, and Webb (1994) for a discussion of the relationship between the volatility condition and mean constraint.

6. Choosing the correct stock market index and specifying the exact nature volatility relationship between real estate and stocks certainly has the potential for further debates about recovery procedure.

7. In a recent literature review, Gatzlaft and Tirtiroglu (1995) ®nd the evidence unconvincing that unsecuritized, income-producing property markets operate as ef®ciently as security markets.

8. Attempts to implement a recovery model with a mean constraint proved unsuccessful given the historical pattern of the return data. The unsmoothing parameter, a, could not be set at a positive number to equalize the mean returns of the reported and recovered series.

References

Barkham, R., and D. M. Geltner. (1994). ``Understanding British Valuation-Based Returns Without Assuming an Efficient Market," *Journal of Property Research* 11(2), 81-95.

Blundell, G. F., and C. W. R. Ward. (1987). ``Property Portfolio Allocations: A Multi-Factor Model," Land Development Studies 4(2), 145-156.

DeWit, D. P. M. (1993). ``Smoothing Bias in In-House Appraisal-Based Returns of Open-End Real Estate Funds," *Journal of Real Estate Research* (8)2, 157-170.

Diaz, J., III, and M. L. Wolverton. (1996). ``A Longitudinal Examination of the Appraisal Smoothing Hypothesis." Paper presented at the RICS ``Cutting Edge" Property Research Conference, Bristol, England, September.

Edelstein, R. H., and D. C. Quan. (1990). ``Micro and Aggregate Errors in Appraisal-Based Return Indices," Working paper presented at the AREUEA meetings in Washington, DC, December.

Fisher, J. D., D. M. Geltner, and R. B.Webb. (1994). ``Value Indices of Commercial Real Estate: A Comparison of Index Construction Methods," *Journal of Real Estate Finance and Economics* 9(2), 137-164.

Folger, H. R. (1984). ``Twenty Percent in Real Estate: Can Theory Justify It?" *Journal of Portfolio* Management 10(2), 6-13.

Gatzlaff, D. H., and D. Tirtirouglu. (1995). ``Real Estate Market Ef®ciency: Issues and Evidence," *Journal of Real Estate Literature* 3(2), 157-189.

Gau, G. W., and K. O. Wang. (1990). ``A Further Examination of Appraisal Data and the Potential Bias in Real Estate Return Indexes," *Journal of the American Real Estate and Urban Economics Association* 18(1), 40-48.

Geltner, D. M. (1989a). ``Bias in Appraisal-Based Returns," Journal of the American Real Estate and Urban Economics Association 17(3), 338-352.

Geltner, D. M. (1989b). ``Estimating Real Estate's Systematic Risk from Aggregate-Level Appraisal-Based Returns," *Journal of the American Real Estate and Urban Economics Association* 17(4), 463-481.

Geltner, David M. (1991). ``Smoothing in Appraisal-Based Returns," *Journal of Real Estate Finance and Economics* 4(3), 327-345.

Geltner, D. M. (1993). ``Estimating Market Values from Appraised Values Without Assuming an Efficient Market," *Journal of Real Estate Research* 8(3), 325-345.

Giaccotto, C., and J. Clapp. (1992). ``Appraisal-Based Real Estate Returns Under Alternative Market Regimes," *Journal of the American Real Estate and Urban Economics Association* 20(1), 1-24.

Graaskamp, J. A. (1987). ``Appraisal Reform and Commercial Real Estate for Pension Funds,'' *Salomon Brothers Real Estate Research Report* (January).

Gyourko, J., and P. Linneman. (1990). ``Analyzing the Risk of Income Producing Real Estate,'' Urban Studies 27(4), 497-508.

Huang, C., and R. H. Litzenberger. (1988). *Foundations for Financial Economics*, ch. 3. New York: North- Holland.

Ibbotson, R. G., and L. B. Siegel. (1984). ``Real Estate Returns: A Comparison with Other Investments,'' *AREUEA Journal* 12(3), 219-242.

Lai, T. Y., and K. Wang. (1996). ``Appraisal Smoothing: The Other Side of the Story.'' *Real Estate Economics* 26(3), 511-535.

Lusht, K. M. (1988). ``The Real Estate Pricing Puzzle,'' *AREUEA Journal* 16(2), 95-104.

Meyer, F. C. N., and J. R. Webb. (1993). ``Return Properties of Equity REITs, Common Stocks, and Commercial Real Estate: A Comparison,'' *Journal of Real Estate Research* 8(1), 87-106.

Newell, G., and G. Brown. (1994). ``Correcting for Appraisal-Smoothing in Real Estate Returns.'' Working paper, University of Western Sydney.

Quan, D. C., and J. M. Quigley. (1991). ``Price Formation and the Appraisal Function in Real Estate Markets,'' *Journal of Real Estate Finance and Economics* 4(2), 127-146.

Ross, S. A., and R. C. Zisler. (1991). ``Risk and Return in Real Estate,'' *Journal of Real Estate Finance and Economics* 4(2), 175-190.

Shulman, D. (1986). ``The Relative Risk of Equity Real Estate and Common Stock: A New View,'' *Salomon Brothers Real Estate Research Report* (June).

Wheaton, W. C., and R. G. Torto. (1989). ``Income and Appraised Values: A Reexamination of the FRC Returns Index,'' *Journal of the American Real Estate and Urban Economics Association* 17(4), 439-449.

Young, M. S., and R. A. Graff. (1995). ``Real Estate Is Not Normal: A Fresh Look at Real Estate Return Distributions,'' *Journal of Real Estate Finance and Economics* 10(3), 225-259.

Table 1. Real estate and other asset return characteristics and allocations, quarterly data, 1979-II to 1997-I.

Panel A: First and Second Moments

	Mean Return for Quarter	Standard Deviation	Coefficient of Variation	Sharp Ratio
NPI	1.99%	1.84%	92.84%	0.08
NCPI	1.86	1.85	99.69	0.01
NAREIT	3.78	6.96	183.93	0.28
S&P 500	4.06	7.17	176.85	0.31
Lehman Bond	2.48	4.21	169.71	0.15
Treasury bill	1.84	0.76	41.12	0

Panel B: Correlations

	NPI	NCPI	NAREIT	S&P 500	Lehman Bond	Treasury Bill
NPI	1					
NCPI	0.98	1				
NAREIT	0.01	0.04	1			
S&P 500	−0.05	−0.04	0.66	1		
Lehman Bond	−0.14	−0.16	0.39	0.37	1	
Treasury bill	0.60	0.61	−0.05	−0.06	0.11	1

Panel C: Allocations

Portfolio return (percent per quarter)	2.00	2.30	2.60	2.90	3.20	3.50	3.80
Standard deviation (percent)	0.83	1.48	2.29	3.15	4.08	5.05	6.05
NPI	0%	19.05%	40.67%	47.45%	34.92%	22.38%	8.14%
NAREIT	2.91	6.51	9.93	14.50	20.56	26.63	32.35
S&P 500	4.61	12.66	20.61	29.50	39.59	49.68	59.51
Lehman Bond	0.52	4.10	7.95	8.55	4.93	1.32	0
Treasury bill	91.96	57.69	9.93	0	0	0	0
Portfolio return (percent per quarter)	2.00	2.30	2.60	2.90	3.20	3.50	3.80
Standard deviation (percent)	0.83	1.51	2.38	3.29	4.21	5.13	6.07
NCPI	0%	0%	0%	4.33%	9.67%	14.57%	1.49%
NAREIT	2.91	7.82	12.72	17.38	21.98	25.04	32.39
S&P 500	4.61	13.36	22.12	30.89	39.66	45.51	57.52
Lehman Bond	0.52	2.12	3.71	5.88	8.18	9.72	8.59
Treasury bill	91.96	76.70	61.44	41.52	20.51	6.51	0

Data source: NCREIF.

Notes: NPI–National Council of Real Estate Investment Fiduciaries Property Index, NCPI– National Council of Real Estate Investment Fiduciaries Classic Property Index, NAREIT – National Association of

Real Estate Investment Trusts Index of Equity REIT share prices, S&P 500 – Standard and Poors index of 500 common stocks returns, Lehman Bond – Lehman Brothers index of corporate and government bond returns, and Treasury bills,– index of three month United States Treasury bill returns produced by Salomon Brothers.

Table 2. Distributional characteristics of quarterly reported and recovered real estate return series.[a]

Return Series	Mean Return (Percent)	Difference from Base Case RO (Level of Significance in Percent)[b]	Standard Deviation (Percent)	Difference from Base Case (Level of Significance in Percent)[c]	Durbin-Watson D
S&P 500	4.057	—	7.175	—	
Lehman Bond	2.479	—	4.208	—	
Treasury bill	1.838	—	0.756	—	
NAREIT	3.783	—	6.958	—	
RO (NPI)	1.987		1.845	—	
R1	1.211	−0.775 (14.18)	4.007	2.163 (0.001)	2.578
R2	2.867	0.880 (25.61)	6.220	4.375 (0.001)	1.813
R3	2.390	0.403 (58.46)	5.903	4.059 (0.001)	1.965

Notes: [a] Series covers quarterly returns from 1979-II through 1997-I. Six quarters of data are lost in recovery.

[b] Level of significance for t-test on Ho: Mean of base case and mean of recovered series are equal, under an assumption of unequal variances.

[c] Level of significance for F-test on Ho: Variance of base case and variance of recovered series are equal.

Table 3. Distributional characteristics of annual reported and recovered real estate return series.[a]

Return Series	Mean Return (Percent)	Difference from Base Case RO (Level of Significance in Percent)[b]	Standard Deviation (Percent)	Difference from Base Case (Level of Significance in Percent)[c]
S&P 500	17.004	—	13.023	—
Lehman Bond	9.572	—	13.273	—
Treasury bill	7.684	—	3.184	—
NAREIT	16.909	—	13.716	—
RO (NPI)	8.543		6.957	
R4	9.522	0.979 (71.98)	9.122	2.165 (0.001)

Notes: [a] Series covers annual returns from 1979 through 1996.

[b] Level of significance for t-test on Ho: Mean of base case and mean of recovered series are equal, under an assumption of unequal variances.

[c] Level of significance for F-test on Ho: Variance of base case and variance of recovered series are equal.

Table 4. Correlation matrix – reported and recovered quarterly real estate returns with stock and bond returns.[a]

Return Series	S&P 500	Lehman Bond	Treasury Bill	NAREIT	NPI
S&P 500	1.000				
Lehman Bond	0.371	1.000			
Treasury bill	−0.062	−0.110	1.000		
NAREIT	0.691	0.390	−0.053	1.000	
RO (NPI)	−0.053	−0.136	0.604	0.011	1.000
R1	−0.044	−0.200	0.192	0.117	0.748
R2	−0.167	−0.357	0.165	0.000	0.497
R3	−0.143	−0.358	−0.027	0.006	0.512

Note: [a] Series covers quarterly returns from 1979-II through 1997-I.

Table 5. Correlation matrix—reported and recovered yearly real estate returns with stock and bond returns.[a]

Return Series	S&P 500	Lehman Bond	Treasury Bill	NAREIT	NPI
S&P 500	1.000				
Lehman Bond	0.091	1.000			
Treasury bill	−0.040	−0.116	1.000		
NAREIT	0.592	0.154	0.036	1.000	
NPI	−0.077	−0.284	0.711	0.196	1.000
R4	−0.061	−0.447	0.260	0.212	0.802

Note: [a] Series covers yearly returns from 1980 through 1996.

Table 6. Comparisons of portfolio allocations to real estate, quarterly data.[a]

	Portfolio Return (Percent Per Quarter)										
Model	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0
R0	0	11.84	26.25	40.67	51.63	43.27	34.92	26.56	18.20	8.14	0
R1	0	0	0	0	0	0	0	0	0	0	0
R2	5.74	15.48	15.48	20.36	25.23	30.11	34.98	35.65	35.38	18.53	1.69
R3	4.54	12.74	12.74	16.85	20.95	25.05	28.89	26.25	23.61	11.34	0

Note: [a] Series covers quarterly returns from 1979-II through 1997-I.

Table 7. Comparisons of portfolio allocations to real estate, annual data.[a]

	Portfolio Return (Percent Per Year)										
Model	8.8	9.6	10.4	11.2	12.0	12.8	13.6	14.4	15.2	16.0	16.8
R0	0.0	0	0	0	0	0	0	1.68	4.83	6.66	0
R4	9.88	13.65	16.67	19.69	22.71	25.73	28.74	24.37	17.87	11.37	2.20

Note: [a] Series covers annual returns from 1979 to 1996

Table 8. Comparisons of portfolio allocations to real estate, using reported mean, quarterly data.[a]

	Portfolio Return (Percent Per Quarter)										
Model	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0
R0	0	11.84	26.25	40.67	51.63	43.27	34.92	26.56	18.20	8.14	0
R1	0.92	2.91	4.9	6.9	8.89	10.88	12.87	14.86	11.57	5.44	0
R2	4.99	6.85	8.72	10.58	12.44	14.31	16.17	17.08	13.29	8.45	0
R3	3.61	5.68	7.76	9.83	11.91	13.99	16.06	16.92	12.85	8.37	0

Note: [a] Series covers quarterly returns from 1979-II through 1997-I.

Table 9. Comparisons of portfolio allocations to real estate, using reported mean, annual data.[a]

	Portfolio Return (Percent Per Year)										
Model	8.8	9.6	10.4	11.2	12.0	12.8	13.6	14.4	15.2	16.0	16.8
R0	0.0	0	0	0	0	0	0	1.68	4.83	6.66	0
R4	9.35	10.10	10.65	11.21	11.77	12.33	12.89	13.44	13.55	7.08	0.62

Note: [a] Series covers annual returns from 1979 to 1996.

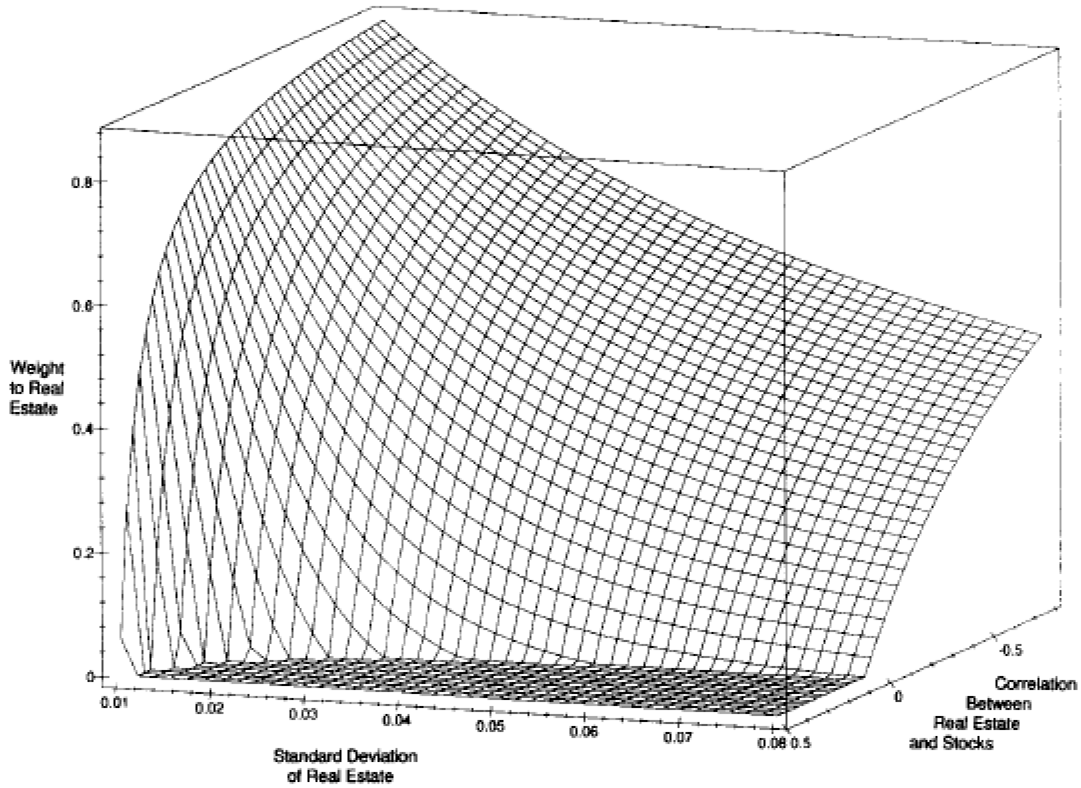

Figure 1. Optimal weight to real estate.

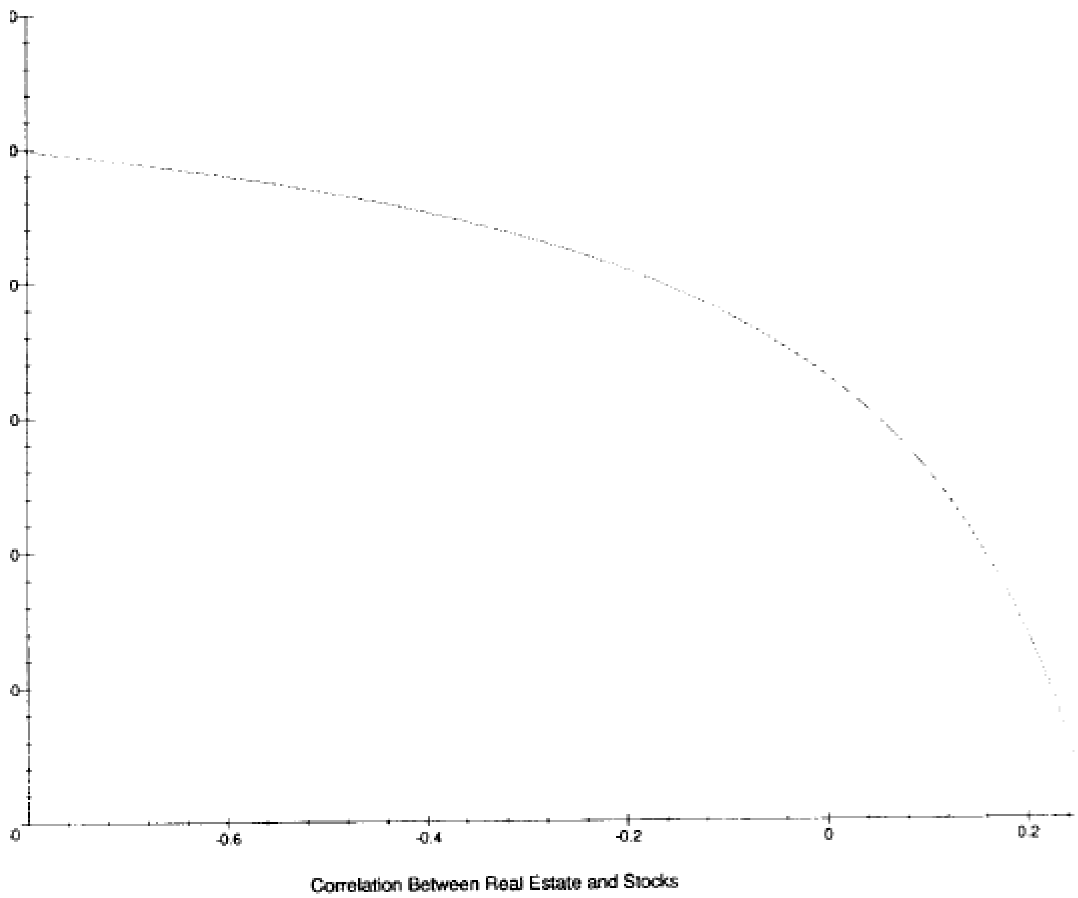

Figure 2. Partial derivative of optimal weight with respect to volatility.

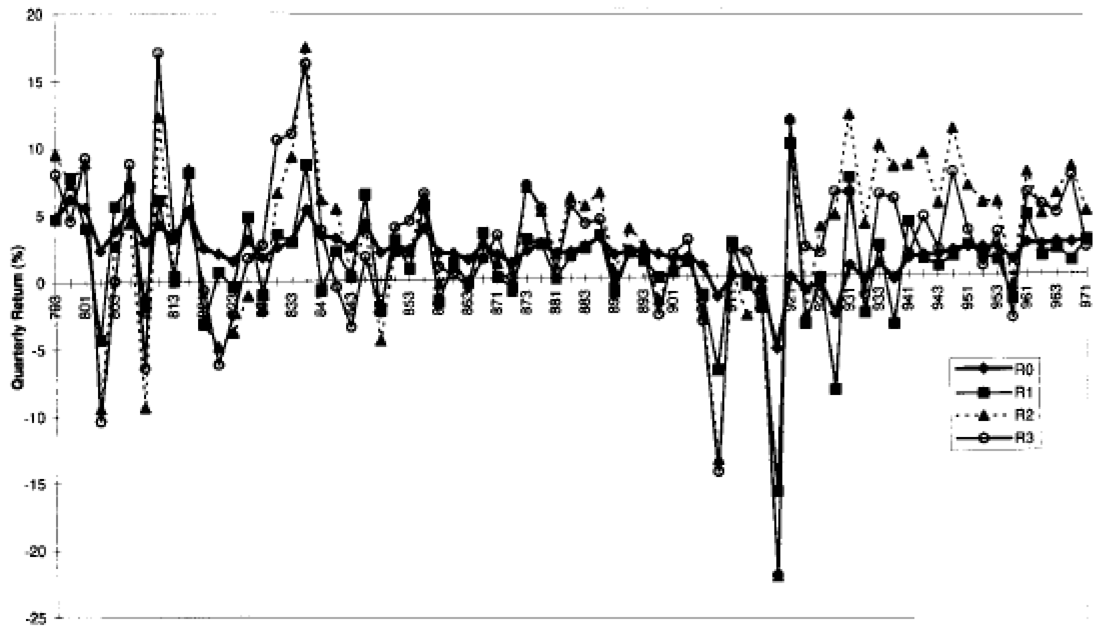

Figure 3. Plots of reported and recovered real estate return series (quarterly data).

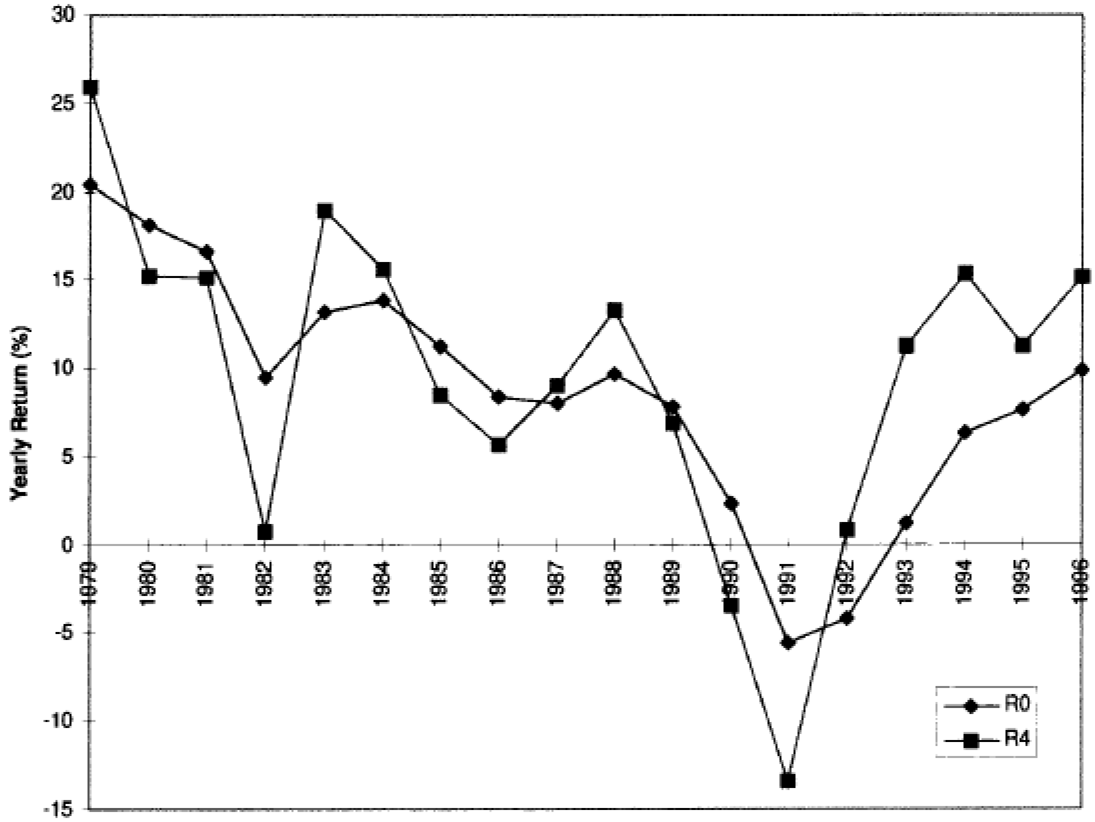

Figure 4. Plots of reported and recovered real estate return series (yearly data).