Yale
International Center for Finance
Working Paper No. 99-13

Yale
School of Management
Working Paper No. Forthcoming

January 1998

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Acknowledgements:
The authors thank Dave McMillan, Doug Harper, and the National Council of Real Estate Investment Fiduciaries (NCREIF) for data assistance. We thank the Real Estate Research Institute (RERI) for funding of this project.

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Two Decades of Commercial Property Returns:
A NCREIF Index Using Independent Appraisals

Geltner & Goetzmann

Summary

This paper documents twenty years of performance of commercial real estate in the U.S. using a portfolio of properties that comprise the widely followed NCREIF Property Index (NPI). We develop an extension of the repeated-measures regression to examine the magnitude and duration of the of the crash in property values in the early 1990's. We find that total returns based upon income and capital were -15% over a three year period beginning in 1990.

The paper also makes a methodological contribution. We show that the repeated-measures regression (RMR) index, adjusting for intermediate cash flows, is theoretically superior to the simple averaging across all property values used in the official NPI, because most of the NCREIF properties are not reappraised every quarter. As a result, the majority of the valuations on which the NPI is based are "stale" each quarter. In contrast, the RMR is based purely on valuations that are current each quarter. A Granger causality test shows the RMR to be more current, leading the NPI by up to four quarters. The RMR also does not suffer from the seasonality of the NPI, and the RMR exhibits slightly greater quarterly volatility due to the elimination of the partial adjustment in the NPI. The RMR appears to pick up some real movements in the property markets that the NPI missed (e.g., the 1981 recession).

The RMR procedure also allows the direct estimation of the average magnitude of the random component of individual property appraisal error in the NCREIF database. We estimate this individual property appraisal standard error at between 6.5 and 14.5 of the property value, most likely around 10 percent.

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1. Introduction

The decline in returns to commercial real estate in the early 1990's had a profound effect on the methods and magnitude of real estate investment in the United States. Much of the growth in REITS and the restructuring of major property portfolios can be traced to this recent global real estate crisis. In this paper, we examine the crash and subsequent recovery through an analysis of the performance of the individual properties that comprise the most widely used benchmark of property level commercial real estate investment performance in the United States, the appraisal-based NCREIF Property Index (NPI).

The NPI is produced quarterly by the National Council of Real Estate Investment Fiduciaries (NCREIF). It reports quarterly ***total*** returns, including both capital and income components, to enable ***time-weighted*** average returns to be computed for the NCREIF population of real estate assets. For reasons of fiduciary responsibility, information about the individual properties that comprise the index is not made public and hence, up until now, alternate methods of index construction could not be applied to test the accuracy of the index.[1]

Such a test is potentially important. Although widely used and cited, there are certain econometric issues that are known to induce undesirable time-series characteristics in the NPI. The NPI is compiled each quarter, essentially, by totalling up the values and cash flows reported for the current quarter for all properties in the database and comparing this total with the previous quarter total of values reported for the same properties. A value is reported to NCREIF for ***every*** property, every quarter. However, most properties in the database are not in fact re-appraised in most quarters. The typical property is subjected to a serious reappraisal only about once per year, with such reappraisals staggered throughout the year across different properties. Thus, each quarter most of the individual property values reported into the NCREIF database from which the NPI return is calculated are in fact "stale" valuations, appraised as of one or more quarters previously. More properties in the database are reappraised in the fourth calendar quarter than in any other quarter.

These characteristics of the NCREIF database cause various statistical problems, including: (i) Smoothing and lagging due to the partial adjustment in the index caused by the stale valuations, and (ii) Artificial seasonality in the index returns due to the bunching of the reappraisals in the fourth calendar quarter. For this reason the NPI is not a true quarterly index, but rather something more like an annual index ***partially*** updated

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[1] The data used in the present study was provided to the authors on a masked and confidential basis.

each quarter, more up-to-date in the fourth quarter than at other times.

From a statistical perspective, it can be shown that the simple averaging across updated and stale valuations, as done in the NPI, is not the most efficient way to use the available data. The efficient way to estimate the true quarterly appraisal-based return to the underlying population of properties contained in the NCREIF database is to employ what is called a "repeated measures regression" (RMR).

In order to explore the magnitude and duration of the crash, as well as the consequent recovery over the late 1990's, we develop an extension of the RMR to construct an index based upon quarterly performance of individual properties that make up the index, which we label the “RMR index”. Our approach allows the efficient use of all of the ***current*** appraisal information in the database, as well as the incorporation of property-specific intermediate cash flow data from property operations, partial sales, and capital expenditures. These refinements provide a slightly more variable picture of property returns over the last twenty years than what appears in the official NPI. The RMR index of the total return to commercial property investment shows a decline of as much as 15% over the three year period beginning at the end of 1989.

In the section that follows, we describe the methodology we use to create a repeated-measures index of the total return to the NCREIF population of properties. Section 3 describes the features of the database, section 4 reports the results of our analysis. Section 5 presents evidence on the magnitude of individual property appraisal "error" among the NCREIF properties, and section 6 concludes.

2. Methodology

The RMR was first proposed as a procedure for developing real estate return indexes over 30 years ago by Bailey, Muth and Nourse (1963). Important advancements in the technique have been made in the past decade in work by Case-Shiller (1987), Clapp-Giacotto (1992), Gatzlaff-Haurin (1996), and Goetzmann (1992), among others. This methodology has been applied widely in both academic and industry studies of housing in the United States.[2] However, to date no one has developed the RMR procedure for estimating indices of periodic ***total*** returns, as opposed to price change or capital returns, and this methodology has not yet been applied to appraisal-based valuations of commercial properties, such as those in the NCREIF database.

In this section of the paper, a simple numerical example of the RMR methodology and its relevance to the NCREIF Index will be presented as motivation for this study and to demonstrate how the

[2] For example, FNMA and FHLMC regularly publish a repeat-sales based index of US housing prices. See Geltner (1996) for a general discussion of the applicability of the RMR technique to commercial property appraisal-based

RMR methodology works. In this example let us suppose that in a certain population consisting of four commercial properties the "true periodic total returns" during the first three quarters of 1998 are in fact 5.0%, 7.5%, and 1.0% respectively in the first, second, and third calendar quarters. We will explain shortly more specifically what we mean when we say that these are the "true" total returns in this population. For now, however, suppose that these underlying true returns are not directly observable, because not every property in the population is explicitly valued every quarter. In particular, let us suppose that we only have the valuation and income history data presented in Exhibit 1.

Insert Exhibit 1 about here

The meaning of Exhibit 1 can be clarified by briefly considering the four property histories. The value of Property #1 was observable as of the end of the fourth quarter of 1997 to be $220,000 at that time (based either on a transaction price or an appraised value). This property then produced $10,000 in net income at the end of the first quarter of 1998, another $6,000 income in the second quarter, and a further $10,000 in the third quarter. It then either sold or was appraised at a value of $223,891 as of the end of the third quarter of 1998 (ex dividend, that is, net of the $10,000 third quarter income). Property #2 was observed with a value of $50,000 as of the end of 1997, paid

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indexes.

$1,500 operating income at the end of the following quarter, and was valued again at $51,000 (ex dividend) as of the end of that quarter. Property #2 then left the population. Property #3 was valued at $25,000 as of the end of 1997, paid out $5,000 income at the end of the first quarter of 1998, and then was sold for $22,844 at the end of the second quarter (and left the database), before having paid out any operating income that quarter. Finally, Property #4 was not in the population until the end of the first quarter of 1998, when it was observed with a value of $75,000. It sold at the end of the following quarter for $80,625 without yet paying out any operating income that quarter.

It is important to recognize that the type of information in Exhibit 1 is similar to the information in the NCREIF database in that it contains both valuation and intermediate income information for all the properties, but the ***current*** valuations of ***all*** the properties are ***not*** observable ***every*** quarter.

2.1 Definition of periodic total return

Let us now clarify what we mean when we say that the "true" total return in this population is 5%, 7.5% and 1% in quarters 98.1, 98.2 and 98.3 respectively. We mean that these periodic total return rates will discount each subsequent property valuation and any intermediate cash flows back to a "present value" equal to the preceding valuation of that property, as of the time of that preceding valuation. This is seen as follows.

Prop.#1: $$220000 = \frac{10000}{1.05} + \frac{6000}{(1.05)(1.075)} + \frac{223891 + 10000}{(1.05)(1.075)(1.01)} \tag{1a}$$

Prop.#2: $$50000 = \frac{51000 + 1500}{1.05} \tag{1b}$$

Prop.#3: $$25000 = \frac{5000}{1.05} + \frac{22844}{(1.05)(1.075)} \tag{1c}$$

Prop.#4: $$75000 = \frac{80625}{1.075} \tag{1d}$$

In the case of Property #4 the first valuation occurs at the end of 98.1 rather than 97.4 as in the case of the other three properties. So the 5.0% total return rate that applied during 98.1 is irrelevant for discounting Property #4's subsequent cash flow of $80,625 to its prior valuation. Similarly, the 98.3 total return of 1.0% is relevant only for Property #1, as this is the only property with observed cash flow or valuation after the end of the 98.2 quarter.

Alternatively (and equivalently) one may regard the periodic total return rates as the rates which can be used to compound the first valuation up to the value of the subsequent valuation, removing the compounded future value of any intermediate cash flows that were taken out prior to the second valuation. This is seen below for the example of Property #1.[3]

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[3] Note that the third operating cash flow of $10,000 is taken out of the asset at the ***end*** of 98.3, instantaneously prior to the second ex dividend valuation of the property. Thus, no forward compounding of this third income cash flow is required to express this $10,000 amount in dollars valued as of the same

$$223891 = 220000*(1.05*1.075*1.01) - 10000*(1.075*1.01) - 6000*1.01 - 10000 \quad (2)$$

Because we are including intermediate cash flows as well as terminal asset values, the periodic rates of return involved here are ***total*** returns, not just capital returns or not just current cash yields. Furthermore, as these same periodic rates apply individually to all the properties in the population, it seems apparent that the rates of 5%, 7.5% and 1% accurately reflect the periodic total returns in this population.

2.2 NCREIF Index Methodology

Now let us see how the official NCREIF Index computation procedure would construct the NPI returns from the data available in this example population. We will then compare the NPI procedure with how the RMR procedure would build an index from the same data.

In the NCREIF database property values are reported each quarter at their most recent valuation (either appraisal or transaction), even if that most recent valuation was not made during the current quarter. Therefore Property #1 would be recorded in the NCREIF database as having a value of $220,000 in each of the first two quarters of 1998, only moving up to $223,891 at the end of the third quarter of 1998. Similarly, Property #3 would be recorded at the end of the first quarter of 1998 at

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point in time as the second valuation (98.3), for no time elapses between the realization of these two amounts.

$25,000. The index returns are then calculated by summing across ***all*** the properties that are in the database as of ***both*** the beginning and end of the quarter.

Thus, the NPI would compute the total return each quarter as follows.

$$r_{98.1} = \frac{(220000+10000)+(51000+1500)+(25000+5000)}{220000+50000+25000} - 1 = 5.93\% \tag{3a}$$

$$r_{98.2} = \frac{(220000+6000)+(22844+0)+(80625+0)}{220000+25000+75000} - 1 = 2.96\% \tag{3b}$$

$$r_{98.3} = \frac{223891+10000}{220000} - 1 = 6.31\% \tag{3c}$$

The NPI periodic returns of 5.93%, 2.96%, and 6.31% obviously do not equal the true periodic returns of 5.00%, 7.50%, and 1.00%, in that order. The reason for the difference is the use of the stale valuations in the NCREIF procedure.

2.3 RMR Index Methodology

Now consider how the RMR procedure works. We define a regression in which each observation in the regression estimation database is defined as a consecutive pair of repeat valuations of the same property (together with the intermediate cash flows between those two valuations). The valuations need not occur in temporally adjacent calendar quarters, or indeed in any regular frequency at all.[4] We simply require that there be at least one

[4] For example, a property valued in 97.4, 98.3, and 99.4 would correspond to two observations in the database, one spanning 97.4-98.3, and the other

property in the database valued in every quarter (not necessarily the same property), and that there be at least as many observations as there are calendar time periods for which we are trying to estimate the periodic returns.[5] In the above numerical example, the RMR regression would be specified as follows:

$$V_{i,97.4} = \beta_{98.1} D_{i,98.1} + \beta_{98.2} D_{i,98.2} + \beta_{98.3} D_{i,98.3} + \varepsilon_i \qquad (4)$$

The variables in this specification are defined as follows.

$V_{i,97.4}$ is the dependent variable, a dummy variable whose value for each observation "i" is zero unless the first valuation of observation "i" takes place in the base period (in our example the base period is t=97.4), under which case this variable has a value equal to that first valuation.

$D_{i,t}$ (for t=98.1, 98.2, and 98.3 in our example) is a dummy variable corresponding to calendar quarter "t". There is one dummy variable for each calendar quarter after the base period (each period for which a periodic return will be estimated). For each observation "i" this variable has a value of zero if t is either before the first valuation or after the second valuation of that observation. Otherwise this dummy variable takes on a value equal to the net cash flow of the property in period t, defined according to the following convention. The first valuation of the property is a negative amount (like an investment). The second

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spanning 98.3-99.4.

[5] Note that in the NCREIF database there will be many more repeat valuation observations than there are properties, because each property is normally seriously reappraised at least several times during its stay in the database.

valuation is positive (like a "reversion" or resale of the asset). The intermediate cash flows are negative if paid in from the investor to the property and positive if paid out from the property to the investor. Note that this convention of cash flow signing is the same as what is normally used to calculate an internal rate of return (IRR) for the property for the period encompassing the two valuations. Note also that there is no constant or intercept term in the above regression specification.

β_t is the regression parameter or coefficient on D_t, to be estimated by the regression procedure. The parameter β_t equals the inverse of the accumulated level of the total return index for the population as of period "t" (like the inverse of the period t level of a "mountain chart" of compounded total returns for the population of properties in the database). This interpretation of the meaning of the β parameters can be understood by comparing equations (1) and (4). In such comparison note that β_t corresponds to the "discount factor" by which each observation's future cash flows are multiplied to discount them back to "present value" as of the base period (t=97.4 in this case).[6]

ε_i is the regression error term for observation "i". Such error will exist if there is "noise" in the property valuations.

[6] Note that the $75,000 on the LHS of equation (1d) is not at base-period (97.4) value. To get (1d) in base-period values, multiply both sides of the equation by (1/1.05). To get it in the form of equation (4), then subtract the LHS from both sides, to get zero on the LHS and the first valuation with a negative sign on the RHS.

More specifically, the error term will equal the noise in the second valuation minus the noise in the first valuation, measured in dollars discounted back to "present value" as of the base period (e.g., in dollars of 97.4 in the present example). The existence of valuation "noise" may be due either to observational error (such as random appraisal error) or to the presence of idiosyncratic returns which cause individual property returns to differ from the population average return.

In our simple numerical example there are four repeat-valuation observations, one corresponding to each property. The RMR represented in equation (4) would thus be represented by the following system of four linear equations, where "u_i" is defined as the residual in each observation (reflecting the regression "error" term just described).

$$\begin{aligned}
220000 &= \hat{\beta}_{98.1}10000 + \hat{\beta}_{98.2}6000 + \hat{\beta}_{98.3}233891 + u_1 \\
50000 &= \hat{\beta}_{98.1}52500 + u_2 \\
25000 &= \hat{\beta}_{98.1}5000 + \hat{\beta}_{98.2}22844 + u_3 \\
0 &= -\hat{\beta}_{98.1}75000 + \hat{\beta}_{98.2}80625 + u_4
\end{aligned} \quad (5)$$

The regression estimation must solve this system simultaneously. Note that if we ignore the residual terms there are three unknowns in this system, namely the three parameters to be estimated: $\beta_{98.1}$, $\beta_{98.2}$, $\beta_{98.3}$. As there are more than three equations, there may not exist a single solution that solves all four equations (if the equations are not consistent). However, we can always find a solution for the parameter values that minimizes the sum of the squared residuals, that is, which minimizes the sum: $u_1^2+u_2^2+u_3^2+u_4^2$. Such a solution would correspond to OLS estimation of the regression. In this numerical example, it is easy to see what the solution is, because in fact the four equations are consistent. By comparison to equations (1a-d) we can see that the following solution will cause the sum of squared errors to equal exactly zero, which is certainly the minimum possible sum of squares.

$$\begin{aligned}\hat{\beta}_{98.1} &= 1/(1.05)\\ \hat{\beta}_{98.2} &= 1/(1.05*1.075)\\ \hat{\beta}_{98.3} &= 1/(1.05*1.075*1.01)\end{aligned} \tag{6}$$

As an example, substitute this solution into the fourth equation in the regression estimation system (the equation corresponding to observation i=4 and property #4 in the population). A little algebraic manipulation then produces the present value equation for Property #4 in equation (1d), as follows. From (5) and (6) we have:

$$0 = -\frac{75000}{1.05} + \frac{80625}{(1.05)(1.075)} + u_4$$

With u_4=0, this is the same as:

$$75000 = \frac{80625}{1.075}$$

which is the same as equation (1d).

Thus, we see how the RMR procedure yields an estimate of the total returns. Starting from the observable data consisting of infrequent and irregular repeat valuations of the properties and complete information on their intermediate cash flows (cash flows occurring between the two valuations), the RMR estimation recovers estimates of the periodic total returns. Note that the estimated parameters on the time dummy variables on the right-hand-side of the regression are estimates of the ***inverse*** of the accumulated value ***levels*** of the total return index. Therefore, the general formula for deriving from the RMR an estimate of the total return in each period "t" is:

$$\hat{r}_t = \frac{\hat{\beta}_{t-1}}{\hat{\beta}_t} - 1 \tag{7}$$

where $\hat{r}_t$ is the estimated periodic total return for period "t". The level of the index in the base period, β_0 (in the case of our example, $\beta_{97.4}$) is always unity, by construction. Thus, the specific return estimates in the case of our three-quarter, four-observation numerical example are:

$$\hat{r}_{98.1} = \frac{1}{1/1.05} - 1 = 1.05 - 1 = 5.00\%$$
$$\hat{r}_{98.2} = \frac{1/1.05}{1/(1.05*1.075)} - 1 = 1.075 - 1 = 7.50\%$$
$$\hat{r}_{98.1} = \frac{1/(1.05*1.075)}{1/(1.05*1.075*1.01)} - 1 = 1.01 - 1 = 1.00\% \tag{8}$$

These, of course, are the exact true periodic total returns for our example population of properties. Using the same data as that available to the NCREIF Index procedure, the RMR gives the exact true returns in this example whereas the NPI procedure gave seriously faulty returns, as we saw previously.

The reason why the RMR obtained ***exact*** true returns in this example is that there was ***no noise*** in this case. That is, all the observed valuations of every property were exactly consistent with the true underlying population returns. This is why the four equations in the estimation system were consistent and the regression residuals were all zero. Of course, this will not generally be the case in the real world. (As noted, noise will derive both from idiosyncratic, but true, return components in individual properties, as well as from random "errors" in the appraisals or observed transaction values.) However, in the real world there will typically be many more degrees of freedom in the regression estimation than were present in this example. Here there was only one more observation than the number of periods of time for which we wished to estimate returns (four repeat-valuation observations and three quarterly returns to estimate). In the NCREIF Index there will be thousands more repeat valuation observations than there are quarters of calendar time in the index. As a result, it should be possible for the appraisal-based periodic total returns to the NCREIF population of properties to be estimated quite accurately, even if there are substantial amounts of noise present at the level of the individual property valuations.[7]

In any case, the usual theorems of statistics tell us that the RMR procedure will indeed be the "best" way to estimate the return index when not all properties are revalued every period, at least according to the classical statistical criteria for judging "best" estimation procedures. For example, if the error terms in the RMR regression (the ε_i in equation (4)) are identically and independently distributed, and if there is no random error in the observed appraisal valuations, then the classical OLS estimation procedure produces estimates which are both "efficient" and "unbiased" in a statistical sense. This means the RMR would give, in principle, the most precise estimates one could possibly get for the index returns, where the index is defined based on the appraised values of the NCREIF population of properties.

[7] The regression specification described above estimates an index that is, like the official NPI, defined by the ***value-weighted, arithmetic*** average returns across the properties within the database each period. Note that, by definition (as far as the construction of the NCREIF Index is concerned), the relevant statistical "population" of properties consists of all (and only) the properties in the NCREIF database.

An important problem to recognize, however, is that the appraised values that appear in the time dummy variables on the right-hand-side of (4) in reality will contain random appraisal error (not just idiosyncratic return noise). This is known as an "errors in variables" problem, and it will cause simple OLS estimation to be biased (the $\hat{\beta}$ estimates would be biased below the true β values, causing estimated index returns to be biased upward). The solution to this problem is to use an "instrumental variables" (IV) estimation procedure, as described by Shiller (1991). With such an IV estimation procedure applied to the above regression specification, the RMR Index should be more accurate than the official NPI as a measure of the true periodic total returns to the population of properties represented by the NCREIF database.[8]

3. The NCREIF Property Database

The database used for the present study is the entire NCREIF database from inception through the second quarter of 1997.[9] Although NCREIF was founded in 1982, the property database and

[8] Other caveats have to do with possible sample selection bias and heteroskedasticity because some properties are reappraised more frequently than others, as well as possible autocorrelation in the residuals due to multiple repeat appraisals of the same property. However, in practice these problems are likely to be minor in the NCREIF Index, because there is not a great deviation in reappraisal frequency among the vast majority of properties in the NCREIF database, and statistical techniques can be used to identify and mitigate these problems.

[9] Like the official NPI, our database combines both the levered and unlevered property holdings of all NCREIF members. In keeping with the NPI being a property-level index, levered properties are included without the effect of

index goes back to the end of 1977, with quarterly index returns being reported from the first quarter of 1978 onward. In 1977 there were only 233 properties in the NCREIF database (worth a total of $576 million at that time). The database grew rapidly at first, reaching 1000 properties around 1984 (worth approximately $10 billion), and reaching a plateau at over 2000 properties ($40 billion) by the early 1990s, before resuming growth in the mid-1990s. By mid-1997 there were 2697 properties, worth a total of $64 billion.

In addition to valuation information, the database includes current income and cash flow information for each property during each quarter. This intermediate cash flow information includes the net operating income (NOI) and capital improvement expenditures, as well as receipts from any partial sales that have occurred during the quarter.[10]

During the history of the NCREIF database there have been approximately 3500 different individual properties in the database at one time or another.[11] This has resulted in approximately 95,000 quarterly property value reports, where each report is

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leverage, that is, with property level income and valuation data.

[10] Partial sales occur when a portion of a property is sold, such as if the property consists of multiple buildings or more than one land parcel. Major redevelopment of properties is rare in the NCREIF database, but if they occur the cash investment would be recorded in the capital improvement expenditures reported for the property. Most capital improvement expenditures reported among NCREIF properties are routine items associated with leasing, including tenant improvement expenditures and leasing commissions.

[11] Properties enter the database either when a new member joins NCREIF or when an existing member purchases a new property. Properties leave the database when they are sold or the member quits NCREIF (or, in some cases, when the form of ownership of the property changes, as for example if the fund holding the property becomes a REIT). When a property leaves the database, its historical

defined as one property for one quarter. (In other words, the average property resides in the NCREIF database about 27 quarters, 95000/3500, or just under seven years.) It is from these 95,000 value reports (and the corresponding income reports) that the NPI is computed, as described in section 2.2. As noted, most of these 95,000 value reports are "stale" in the sense that they do not reflect serious re-examinations of the property value as of the current quarter.

3.1 The RMR Database Filter

The RMR index is based on a filtered subset of these 95,000 value reports, namely those that reflect either "serious" current reappraisals or actual transaction prices. Our method of filtering out the stale valuations and keeping only the serious current valuations consists of a two-stage filter, summarized schematically in Exhibit 2. First, there is a field in the NCREIF report for each property which indicates if the appraisal was conducted by an "external" fee appraiser (as opposed to an internal valuation made by the investment advisor's own staff). If this field was explicitly filled in with a "yes", then the valuation report was kept (whether or not it indicated any change in value from the previous report for that property).

For most of the valuation reports, this "external appraisal" field is not filled in at all, either "yes" or "no", so we cannot

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record remains in the database.

tell from this field whether the value report was based on a serious reappraisal of the property. We therefore apply a second-stage filter. In those cases where the external appraisal box is not checked "yes", we test whether the value reported for the current quarter differs from that reported for the previous quarter for the same property. If it differs, then we keep the value report as a (presumably) "serious reappraisal", no matter whether this reappraisal was done by an internal or external appraiser.[12]

Insert Exhibit 2 about here

In summary, NCREIF database value reports are ***rejected*** from the RMR database only if ***both*** the "external appraisal" box is not checked "yes" ***and*** the current quarter value does not differ from the previous quarter value. In this way the RMR database should consist nearly purely of all (and only) those value reports that reflect current quarter "serious" reappraisals (or actual

[12] The filter is in fact slightly more complicated than this. We defined a value report as "different" from the previous report only if it differed by at least 0.1 percent from the previous value report. This is to allow for typographical errors, round-off, and minor accounting adjustments that would not really reflect a serious reappraisal. Furthermore, the test for difference was applied to the current quarter value defined in two ways: with and without current quarter capital improvement expenditures included. In some cases NCREIF members automatically add the value of the current quarter's capital expenditures to the previous property value to arrive at the current quarter's reported value. In this case, if the current quarter value differed from the previous quarter's value only and exactly by the amount of the capital expenditures, then this would in fact indicate no change in the actual value report, and this would indicate (presumably) that no serious reappraisal had taken place that quarter. Only if the current value report differs from the previous according to ***both*** of these definitions of current quarter value is the report kept as a "serious reappraisal". Otherwise it is rejected from the RMR estimation database.

transaction prices, in a few cases). This results in an elimination of approximately three-quarters of all the valuation reports in the NCREIF database. The RMR database contains 22,166 "serious" valuation reports, which correspond to 18,703 repeat-valuation pairs on the same properties. These 18,703 repeat valuations, spanning the period 1977.4-1997.2, make up the observations from which the RMR index returns are estimated, using the regression procedure described in section 2.3.

3.2 The RMR Database: NCREIF Property "Serious" Reappraisals

The RMR database consists of essentially the same properties as those in the NCREIF database.[13] The difference is that instead of containing a (usually stale) value report for ***each*** quarter for each of those properties, the RMR database contains valuation reports for each property only in those quarters in which a serious reappraisal of the property was made. As noted, this results in 18,703 repeat-valuation pair observations on 3,463 different properties, spanning the 79 calendar quarters from 1977.4 through 1997.2.

Exhibit 3 shows a histogram of the length of time between reappraisals. It is most typical for reappraisals to occur annually, with over 45 percent of all reappraisals occurring at the four-quarter interval. A substantial number of appraisals

[13] The only case in which a property would appear in the NCREIF database and not in the RMR database would be if the property was ***never*** seriously reappraised or

occur more frequently than that, however, with some 20 percent of reappraisals occurring in consecutive calendar quarters and another 15 percent occurring at the two-quarter interval. Such greater reappraisal frequency generally occurs for larger properties, or when the investment manager suspects a major change in value may have occurred, or (in the case of properties held in separate accounts) when the client specially requests a reappraisal. Some 88.7 percent of all reappraisals occur within one year, and 97.5 percent within two years. Across the 18703 repeat-valuation observations the mean interval between serious reappraisals is 3.49 quarters, and the median reappraisal frequency is four quarters.

Insert Exhibit 3 about here

Exhibit 4 shows a histogram of the frequency of serious reappraisal by calendar quarter in the NCREIF database. About 37 percent of all reappraisals occur in the fourth calendar quarter, with about 20 percent occurring in each of the other quarters. As noted, this is why the NPI displays seasonality, or "spiking" in its returns in the fourth calendar quarters.

Insert Exhibit 4 about here

Exhibit 5 shows a cross-sectional histogram of the internal rate of return (IRR) per quarter taken across the 18703 repeat-

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transacted during its entire stay in the NCREIF database.

valuation observations in the RMR database. The mean quarterly IRR was 1.09 percent, with a median of 1.88 percent and a cross-sectional standard deviation of 5.16 percent. It is important to note that the IRR is a multi-period, dollar-weighted return measure that is sensitive to the timing of capital flow into or out of the investment. Such returns differ conceptually from the period-by-period total returns (or "periodic returns") the NCREIF Index is designed to measure. The NCREIF Index is designed to allow the computation of time-weighted returns, which are neutral as to the timing of capital flow into or out of the investment. [14]

Insert Exhibit 5 about here

Exhibit 6 shows the frequency of valuation observations per quarter over the 1977.4-1997.2 period covered by this study. The exhibit shows the "first appraisals" and "second appraisals" separately, stacked to indicate the total number of valuations in each quarter. The spiked nature of the chart reflects the seasonal bunching of serious reappraisals in the fourth quarters. There are relatively few observations at first, when the number of properties was small. The quarters with the least number of valuations were the first three quarters of 1978, which had 22, 21, and 31 serious reappraisals respectively. To derive the

[14] The returns the NCREIF Index is designed to measure are sometimes referred to in the finance literature as "holding period returns" (HPR). For an in-depth discussion of the difference between "dollar-weighted" returns such as the IRR and "time-weighted" returns such as the NCREIF Index, see the Bank Administration Institute (1968).

estimate of the return in any one quarter the RMR procedure utilizes valuations from many other quarters besides just that particular quarter, and it does not require that any one quarter contain ***both*** a first ***and*** second valuation (only that every quarter have at least one valuation).[15] However, the more valuation observations available per quarter, the greater will be the precision at which the population return can generally be estimated for that quarter. The relative sparseness of observations in the early years of the NCREIF index suggests that the RMR index may have difficulty filtering out noise during those years.

Insert Exhibit 6 about here
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4. Results of the study: The RMR version of the NCREIF Index

The RMR procedure described in section 2.3 was applied to the database described in section 3, including both the "serious reappraisal" information and the intermediate cash flow information. The result is the RMR version of the NCREIF quarterly total return index (the "RMR index" for short), for the period from the end of 1977 through the second quarter of 1997. Exhibit 7 presents the RMR index level along side that of the official NPI, both indexed to equal 1.00 at the beginning of 1984,

[15] Note that as the procedure uses only ***repeat***-valuation observations, this forces all the valuations in the last quarter to be only ***second*** valuations.

for comparison. The RMR is presented as the solid line, and the official NPI as the dashed line.

Insert Exhibit 7 about here

Exhibit 7 reveals that at the broad brush level the two indexes are very similar. This is not surprising, as the shortcomings in the official NPI which are corrected in the RMR are not problems that should much affect the long run overall performance of the index. However, some differences are apparent. In particular, the RMR appears to be a bit more volatile than the NPI, as would be expected due to the inertia of the stale valuations in the NPI. Interestingly, the RMR appears to detect an effect in the property markets of the economic recession of 1981, while the NPI registered no such impact. The RMR also shows a slightly sharper and more definitive drop during the 1989-91 period than did the NPI (another recession period). On the other hand, the RMR shows a sharper and quicker recovery in the property markets after the 1981 recession, and again in the mid-1990s (especially during 1994).

In this regard, the RMR shows a peak-to-trough total return drop during 1990-93 of 15 percent (cumulative), while the comparable drop in the official NPI was only 11 percent. On the other hand, the cumulative recovery from the trough through mid-1997 was over 45 percent in the RMR as compared to only 34 percent in the NPI. The inertia of the stale valuations in the NPI dampens the apparent magnitude of the true property cycle swings.[16]

Exhibit 8 traces out the periodic total returns in each quarter for both indices. The greater quarterly volatility in the RMR is more clearly apparent in this chart. While the RMR is slightly more volatile throughout the historical period covered, the greater volatility is most pronounced during the early years of the index, until about 1984. The high volatility in the RMR during the 1978-83 period probably reflects noise in the index, at least to some extent. The relatively smaller number of repeat-appraisal observations available during those years makes it more difficult for the regression estimation procedure to filter out such noise. However, at least some of the extra volatility apparent in the RMR as compared to the NPI during the early years probably reflects real economic and property market phenomena, as for example in the case of the response to the 1981 recession noted above.[17]

Insert Exhibit 8 about here
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[16] To go back further in time, the previous rise to peak from 1977 to 1990 was a cumulative 356 percent in the RMR but only 333 percent in the NPI.
[17] The late 1970s and early 1980s were a turbulent period with great changes and uncertainty surrounding inflation, monetary policy, tax policy, and oil prices, as well as separate back-to-back recessions in both 1980 and 1981. Even though commercial property markets were clearly on a general upswing during that time, it seems unlikely they were as smooth and stable then as the NPI suggests. The smoothing in the NPI caused by the presence of numerous stale appraisals no doubt eliminates some noise which shows up in the RMR, but this smoothing also certainly obscures some true information that is revealed in the RMR.

The overall differences and similarities between the RMR and NPI total returns are summarized by the statistics presented in Exhibit 9. The statistics are presented for three different overlapping sub-periods, all ending in 1997: (i) The complete 78-quarter return history from 1978.1 through 1997.2; (ii) The 1984.1-97.2 period after any possible excess noise has apparently settled out of the RMR; and (iii) The 1990.1-97.2 more recent period reflecting the crash and subsequent recovery in the commercial property markets. Exhibit 9 shows the time-weighted average quarterly total return measured both as the geometric mean and the arithmetic mean, as well as the quarterly standard deviation (also known as "volatility"), and the contemporaneous cross-correlation coefficient between the two versions of the index.

In all three periods the overall investment performance is very similar between the two indexes, as measured by the mean return.[18] The RMR slightly beats the NPI over the entire 1977-97 sample period, with a geometric mean total return of 2.24 percent per quarter versus 2.13 percent for the NPI. As these time-weighted returns exceed the pooled average IRR (dollar-weighted returns) across the repeat-valuation observations, there is some implication in these results that the effect of property

[18] The greatest difference is the 24 basis points by which the RMR beats the NPI in the arithmetic mean return over the entire history. However, this difference partly reflects the greater volatility during the early years, as the geometric means over the same period differ by only 11 basis points between the two indexes. (The geometric mean is not sensitive to volatility.)

management capital flow timing has been generally negative for NCREIF members over the 1977-97 period.[19]

In all three periods noted in Exhibit 9 we see that the volatility is greater in the RMR. However, the volatility is only modestly greater in the RMR since the end of 1983. As noted, it is possible that at least some of the early excess volatility in the RMR is noise due to estimation error in the regression. Noise may also explain why the contemporaneous cross-correlation between the two versions of the index is only 32 percent overall, but 75 percent in each of the more recent sub-intervals.

Insert Exhibit 9 about here

An important difference between the RMR and the NPI is that the RMR largely eliminates the seasonality in the NPI. As noted, the NPI tends to have fourth quarter return "spikes", due to the larger number of up-to-date appraisals at the end of the calendar year. In principle, the RMR procedure is free of this effect, so that any remaining seasonality in the RMR would reflect true seasonality in the underlying property market as reflected in the

[19] Recall that the mean IRR is 1.09% per quarter, and the median is 1.88%. These IRRs reflect only the effect of the timing of capital expenditures and partial sales, property management level management decisions dictated to a considerable extent by the timing of lease expirations. Overall portfolio asset management and fund level capital flow timing is not reflected in the property level returns of the NCREIF database. Furthermore, the RMR index developed here is value-weighted, giving greater weight to larger properties, whereas the cross-sectional average IRR statistics reported in Section 3 are equally-weighted across all the pooled observations, thus giving relatively greater weight to smaller properties than is reflected in the RMR and NPI. Because of this, the IRR and time-weighted average return figures are not directly comparable.

appraisal process. In fact, at least for the post-1983 period during which the RMR is well behaved, there is no evidence of seasonality in the RMR. This is seen in the return autocorrelation statistics shown in the chart in Exhibit 10. Seasonality would be revealed by a spike in the fourth-order (lag 4) autocorrelation coefficient, as seen in the NPI. The RMR has no such spike.

Insert Exhibit 10 about here

In general, Exhibit 10 reveals that the RMR has less autocorrelation in its returns than does the NPI. This reflects the fact that the RMR has less "inertia" than the NPI. However, there is still substantial positive autocorrelation in the RMR returns, which suggests that there is still some "sluggishness" in the RMR. In this regard it is important to keep in mind that the RMR is an appraisal-based index. Appraisers, at the level of individual property appraisal, may tend to be more "backward-looking" than property market participants are.[20] If so, there would still be some "smoothing" and inertia in the RMR index as compared to true property market returns. Nevertheless, it is also quite possible that there truly is considerable inertia in the commercial property market, much more, for example, than in

[20] For example, appraisers may place more reliance on past sales "comps", or they may have a greater tendency toward adaptive expectations and partial adjustment in their perceptions of property value changes. Diaz & Wolverton (1998) find some experimental evidence for "anchoring" behavior among commercial appraisers, that is, a tendency to be influenced by prior

the stock or bond market over comparable periods of time.[21]

A final important indication of the difference between the RMR and the NPI is that the RMR appears to "lead" the NPI by about four quarters, at least during the 1984-97 period during which the RMR is free of excessive noise. In other words, over the 1984-97 period the RMR has, to a statistically significant extent, been a ***predictor*** of the NPI over the subsequent four quarters, while the reverse is not true. This is measured by a test of "Granger Causality", summarized in Exhibit 11.

In this test the F-statistic for the significance of lagged RMR returns predicting NPI returns (beyond the predictive power of the NPI's own lagged returns by themselves) is compared to the same F-statistic for the significance of the reverse causality (NPI predicting RMR). The test uses the 54 quarterly returns from 1984-97, with four quarters of lags. The F-statistic for the NPI predicting the RMR is not significant. (With an "F" value of 1.31, what this means technically is that we cannot reject the null hypothesis that past NPI returns do ***not*** improve the prediction of the RMR return.) The F-statistic for the RMR predicting the NPI is significant. (The "F" value of 4.30 allows rejection, with better than 99 percent confidence, the null

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appraisals.

[21] This would be consistent with the findings of the prior literature which developed transactions-based (as opposed to appraisal-based) repeat-sales indexes of housing price changes (as opposed to commercial property). For example, Case & Shiller (1990), like all subsequent repeat-sales housing articles, found high levels of inertia in housing market returns in four US cities.

hypothesis that the past RMR returns do ***not*** improve the prediction of the NPI return.)

In other words, some of the information contained in the current RMR return is not fully reflected in the NPI until up to four quarters later. This type of leading behavior on the part of the RMR is exactly what we would expect given the difference in the way the two indexes are constructed.

Insert Exhibit 11 about here
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5. The RMR and appraisal error in the NCREIF population

A side benefit of the RMR procedure is that it allows a direct estimation of the average magnitude of the random component of appraisal error for individual property appraisals within the NCREIF population of properties. This is useful, as the knowledge of the likely magnitude of appraisal error is important in a variety of policy applications, ranging from setting reservation prices in property sales negotiations to conducting property tax and eminent domain adjudication.

Previous literature focusing on the magnitude of disaggregate level random error in commercial property appraisal is relatively sparse. Geltner, Graff and Young (1994) used an indirect approach to attempt to estimate the magnitude of individual property appraisal error in the NCREIF database, and came up with an estimated standard error of about 11 percent of property value, assuming independent errors. Diaz and Wolverton (1998) have conducted controlled experiments in which professional appraisers have simultaneously and independently appraised the same commercial property as of the same point in time, using the same information supplied by the experimenter. The standard deviation in the resulting appraisals was in the range of 5 to 7 percent of the property value.[22]

To see how the RMR procedure can be used to estimate the magnitude of appraisal error recall the RMR equation (4) from section 2.3. Assuming that the intermediate cash flows in each repeat-valuation observation are observed without error, the error term in the RMR for observation "i", ε_i, consists of the dollar value of the noise in the second valuation minus the noise in the first valuation, with all dollars reduced to base period present value by using the total return index to discount dollars across time. Thus, we can model the residuals from an OLS estimation of equation (4) as follows.

$$u_i = \hat{\beta}_s e_{i,s} - \hat{\beta}_f e_{i,f}$$
$$e_{i,t} \equiv V^*_{i,t} - V_{i,t} \tag{9}$$

where t=f and t=s refer to the quarters of the first and second valuations, respectively, in observation i, and $V^*_{i,t}$ is the observed dollar value of the property in observation i as of

[22] The evidence on the magnitude of appraisal error in commercial appraisals is

quarter t, and $V_{i,t}$ is the (unobservable) "true" value of that property at that time.[23] In other words, $e_{i,t}$ is the dollar value of the "noise" in the valuation of the property in observation i in quarter t.

The first step in analyzing appraisal error is to multiply the raw residual of each observation by the estimated index value level at the time of the first appraisal in that observation. This puts the residuals in terms of dollars as of the time of the first appraisal in each observation. The second step is to divide these adjusted residuals by the dollar value of the first appraisals, to yield "normalized" residuals, which are the residuals expressed as a percentage of the property value. Label these normalized percentage residuals, "n_i":

$$n_i = \frac{u_i}{\hat{\beta}_f V^*_{i,f}} = \frac{e_{i,s}}{\left(\hat{\beta}_f / \hat{\beta}_s\right) V^*_{i,f}} - \frac{e_{i,f}}{V^*_{i,f}} \qquad (10)$$

(Recall that $\hat{\beta}_t$ is the ***inverse*** of the index level at time t.)

The normalized percentage residuals are approximately the difference between the percentage error in the second appraisal minus the percentage error in the first appraisal. The approximation is because the first term on the RHS above has as denominator $\left(\hat{\beta}_f / \hat{\beta}_s\right) V^*_{i,f}$ instead of $V^*_{i,s}$. As the index is a ***total*** return index rather than just a capital value index, this will

analyzed and summarized, including the Diaz-Wolverton experiment, in a recent article by Geltner (1998).

[23] "True" value here refers to the true value the property would have if its

result in the normalized percentage residuals being a little bit less (on average) than the actual differences in the two consecutive appraisal error percentages. But this bias should be small, as there is generally not much time between the first and second appraisals in the NCREIF population.

Now recall that "error" in the RMR results from two sources: (1) From true "idiosyncratic" variance in the individual property returns; and (2) From the random appraisal error component. The former component is not really "error". The latter component is the appraisal error we are interested in quantifying. We can distinguish statistically between these two components of "error", because the former component (idiosyncratic risk) is a temporal phenomenon that is a positive function of the interval of time between the first and second appraisals.[24] Indeed, if the idiosyncratic risk in the return is independent across time, then the variance in the idiosyncratic risk component of the RMR residuals is ***directly*** proportional to the length of time between the two appraisals in the observation. In contrast, the random appraisal error is a ***non-temporal***, cross-sectional realization in the observed value ***level*** per se, which occurs whenever an appraisal is made.

Therefore, we can perform a "second stage" regression,

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returns always exactly equaled the population average return.

[24] Idiosyncratic risk materializes only over ***time***, as it occurs in the property's ***return***, that is, in the ***change*** in the property's value over time, and does not exist inherently in the property's value ***level*** per se.

regressing the squares of the normalized percentage residuals onto a constant and the time between the two appraisals:[25]

$$(n_i)^2 = \alpha + \gamma(s-f)_i + \eta_i \tag{11}$$

where: ***(s-f)i*** is the number of quarters between the first and second appraisals in observation i; and η_i is the second-stage regression error in observation i. In this second stage regression the coefficient on the time-between-appraisals term, γ, will pick up the idiosyncratic risk component (the variance across time) per quarter, while the constant, α, will pick up the non-temporal component of noise, which is the component reflecting the appraisal error.

To be more precise, the estimated constant, $\hat{\alpha}$, has the following relationship to the appraisal error:

$$\hat{\alpha} = 2(1-\rho)VAR[e_j/V_j] \tag{12}$$

where ρ is the correlation coefficient between the appraisal errors in successive appraisals of the same property; and e_j/V_j is the percentage error in individual appraisal j. Equation (12) follows because, as seen in (10), the residuals that are being regressed in the second stage are ***differences*** between two percentage error terms (those in the first and second appraisals).

[25] For purposes of estimating the average appraisal error, this second stage regression is performed on the residuals from a simple OLS first stage regression of (4), that is, without the instrumental variables correction. This is because for the purpose of estimating appraisal error we do not care about bias in the first stage regression coefficients, but we do care about minimizing the squared residuals, which the unconstrained OLS will better

The variance of a difference between two random variables is the sum of their variances minus twice their covariance, which is what is reflected in equation (12). Thus, an empirical estimate of the standard error of individual property appraisal is obtained from the second stage regression as:

$$STD[e_j/V_j] = \sqrt{\hat{\alpha}/(2(1-\rho))} \tag{13}$$

The results of the second stage regression on the RMR database is: $\hat{\alpha}$=0.008474 (Tstat=12.43), and $\hat{\beta}$=0.005966 (Tstat=38.51). Applying (13), we have the following empirical estimates for the cross-sectional standard deviation of random appraisal error as a percentage of property value in the NCREIF population:

$$\begin{aligned} STD[e_j/V_j]&=6.51\%, \text{ if } \rho=0; \\ STD[e_j/V_j]&=10.29\%, \text{ if } \rho=+60\%; \\ STD[e_j/V_j]&=14.56\%, \text{ if } \rho=+80\%. \end{aligned} \tag{14}$$

These estimates are a function of the longitudinal correlation in appraisal error, ρ. We have no way to directly estimate this correlation empirically in the NCREIF population. One would expect that random error in the first and second valuations of the same property would tend to be positively correlated, at least if both valuations are made by the same appraiser within a year or so. This would typically be the case in most of the observations in the RMR database from which our "n_i" residuals are obtained. How great this positive correlation

accomplish.

is can only be estimated.

Relevant to this question, the results of the controlled appraisal experiment reported in Diaz & Wolverton (1998) shed some light. Their experimental data reveal a correlation of +80% between the errors in the first and second appraisals of the same property by the same appraiser. However, in the Diaz-Wolverton experiment there were only 6 months between the two experiment sessions, whereas in the RMR database there are on average about 10.5 months (3.5 quarters) between the two serious reappraisals. Also, in the RMR database the consecutive appraisals are not always conducted by the same appraiser (even when it is the same appraisal firm it would not always be the same individual person). For both of these reasons one would expect the longitudinal error correlation to be less than +80% in the RMR database. Perhaps 60 percent would be a reasonable estimate for ρ, which would imply random appraisal error of around 10 percent in the NCREIF population.[26]

6. Conclusion

The present paper reports the results of the development of an RMR

[26] There is evidence that the appraisal standard percentage error has been getting smaller over time, and that it is smaller for larger properties. An expanded second stage regression including calendar time and property size as independent variables gives the following results: $\hat{\alpha}$=0.057903 (Tstat=44.42); $\hat{\gamma}$=0.004847 (32.41); coefficient on calendar time (in quarters elapsed since 1977.3) = -0.000912 (-41.48); and coefficient on property size (in $ millions based on the first valuation) = -0.000093 (-8.58).

version of the NCREIF index. The RMR index appears broadly similar to the official NPI, but different and (we argue) ***"a little better"*** in some respects. By avoiding stale valuations, the RMR is by nature more "up-to-date" than the NPI, and eliminates the artificial seasonality. Statistically, the RMR is a leading indicator of the NPI four quarters later, and displays greater volatility than the NPI. During the early years, when there were few properties in the NCREIF database, the RMR displays some evidence of excessive noise, which the NPI does not suffer. Even then, however, the RMR reflects real events that should have affected real estate, such as the 1981 recession, while the NPI is completely smooth throughout the early period. From a statistical perspective, the RMR is a "true quarterly index", while the NPI is more like an "annual index, partially updated each quarter". For these reasons, and because the RMR requires no more information than NCREIF already collects to produce the NPI, it would seem interesting for NCREIF to consider regularly publishing the RMR index each quarter, in addition to the traditional NPI.

Because of its greater accuracy, the RMR is perhaps the best indicator of the true magnitude of the 1990s crash and recovery in the commercial property markets in the US. The RMR indicates a slightly deeper total loss than the NPI during the 1990-93 period (15% versus 11%), but also a stronger recovery since then (45% versus 34%). Finally, a side-benefit of the RMR procedure is the estimation of the magnitude of property-level random appraisal error. We estimate a standard error of 10 percent among appraisals of the NCREIF properties.

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Exhibit 1: Example valuation & income data for four properties				
Property\YY.Q	97.4	98.1	98.2	98.3
Property #1:				
Valuation	$220,000	NA	NA	$223,891
Income	0	$10,000	$6,000	$10,000
Property #2:				
Valuation	$50,000	$51,000	NA	NA
Income	0	$1,500	NA	NA
Property #3:				
Valuation	$25,000	NA	$22,844	NA
Income	0	$5,000	0	NA
Property #4:				
Valuation	NA	$75,000	$80,625	NA
Income	NA	0	0	NA
"NA"=Data not available				

Exhibit 2: Schematic Diagram of RMR Database Filter

Exhibit3: Histogram of NCREIF Properties Reappraisal Interval

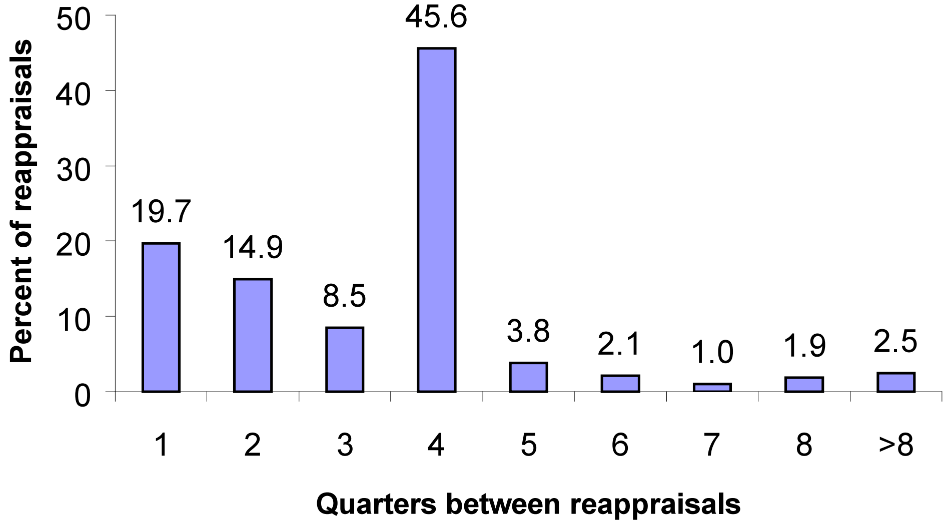


Exhibit 4: Frequency of NCREIF Reappraisal by Calendar Quarter

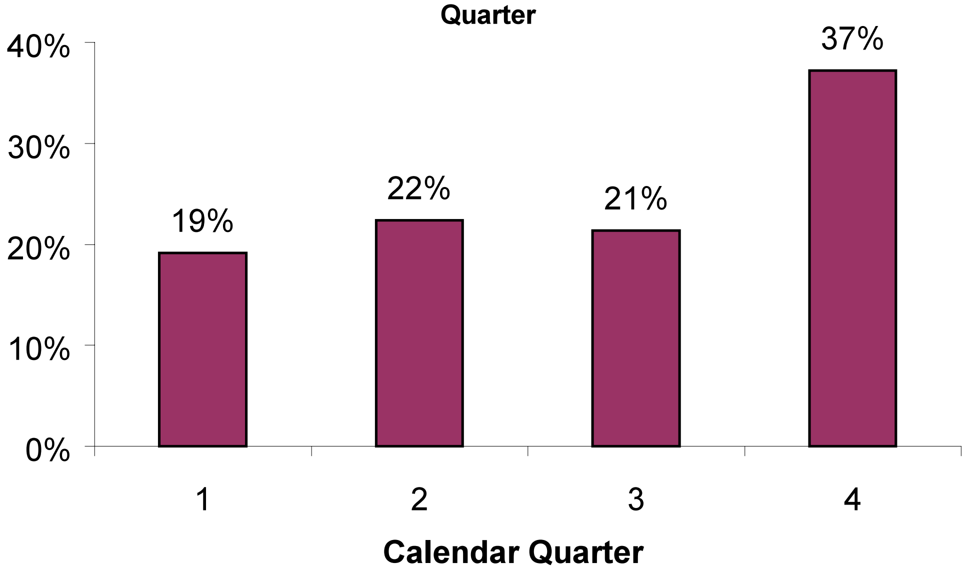


Exhibit 5: Histogram of IRR/qtr Across Repeat-Valuation Observations

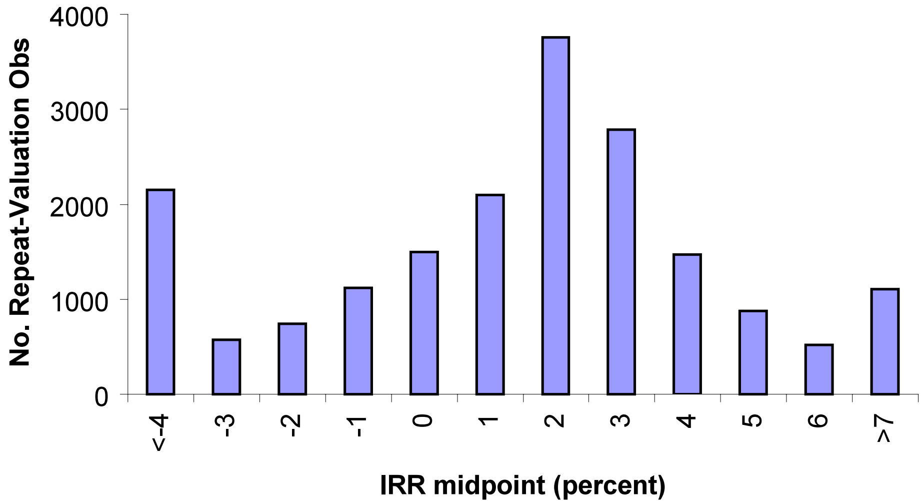
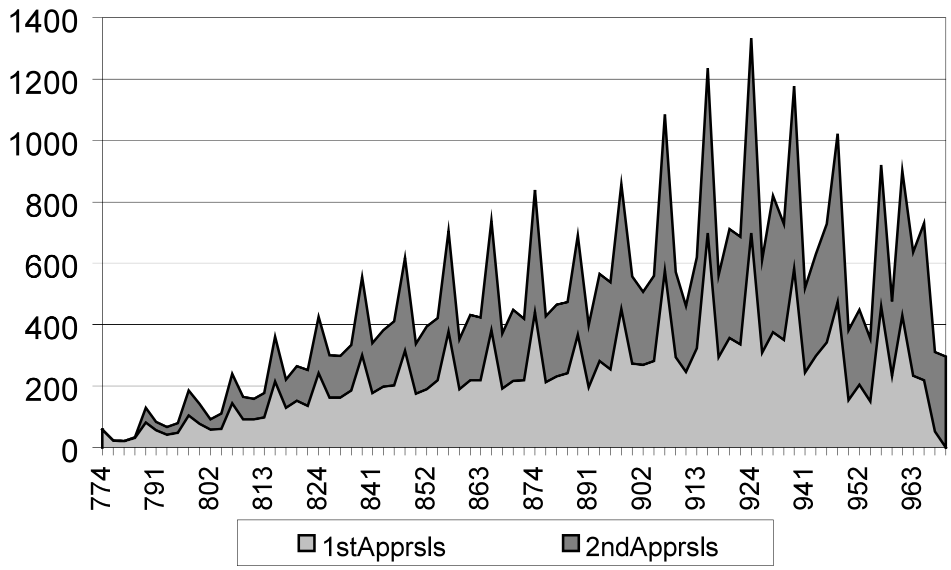


Exhibit 6: Number of Reappraisal Observations Per Quarter



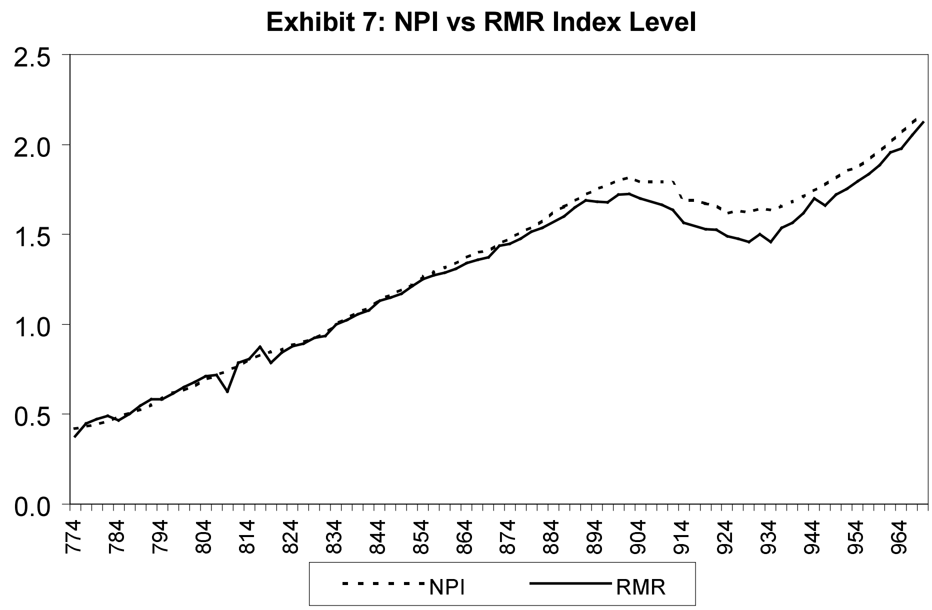


Exhibit 7: NPI vs RMR Index Level
2.5
2.0
1.5
1.0
0.5
0.0
774
784
794
804
814
824
834
844
854
864
874
884
894
904
914
924
934
944
954
964
NPI
RMR

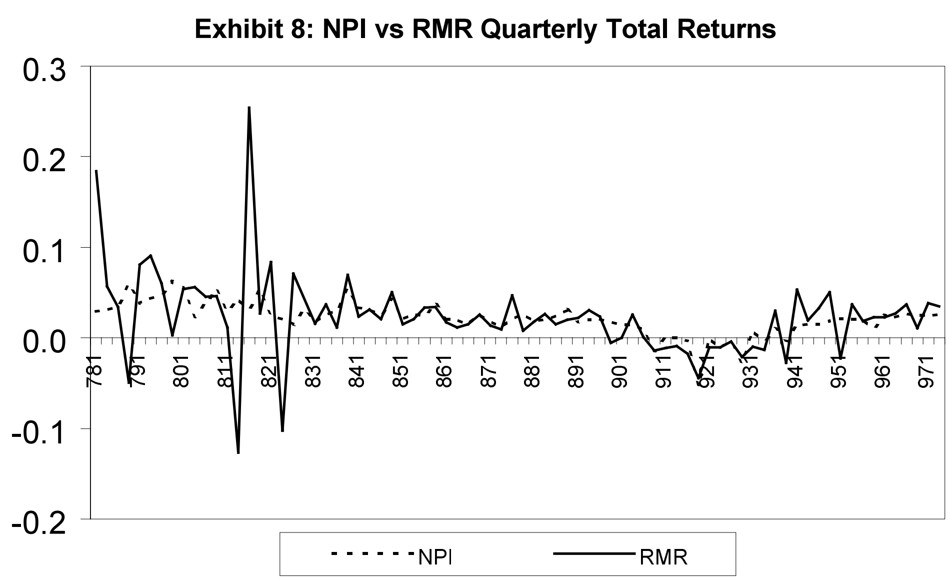
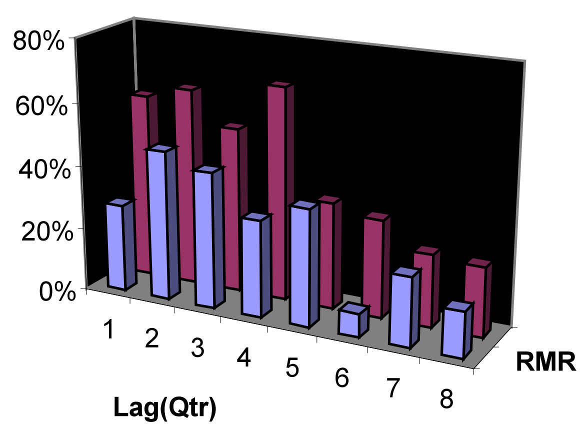


Exhibit 8: NPI vs RMR Quarterly Total Returns
0.3
0.2
0.1
0.0
-0.1
-0.2
781
791
801
811
821
831
841
851
861
871
881
891
901
911
921
931
941
951
961
971
NPI
RMR

Exhibit 9: NPI & RMR Quarterly Total Return Statistics:			
1978-97:	**NPI**		**RMR**
Geometric mean	2.13%		2.24%
Arithmetic mean	2.15%		2.34%
Std Deviation	1.84%		4.73%
Cross-correlation		32.41%	
1984-97:	**NPI**		**RMR**
Geometric mean	1.45%		1.40%
Arithmetic mean	1.46%		1.43%
Std Deviation	1.60%		2.15%
Cross-correlation		75.42%	
1990-97:	**NPI**		**RMR**
Geometric mean	0.72%		0.78%
Arithmetic mean	0.74%		0.81%
Std Deviation	1.75%		2.51%
Cross-correlation		75.11%	

Exhibit 11: Granger Causality Test (1984-97, 4 lags, 54 obs)		
Null Hypothesis:	**F to reject:**	**Prob:**
RMR not cause NPI:	4.30	0.5%
NPI not cause RMR:	1.31	28.1%

Exhibit 10: Autocorrelation



Appendix A: NPI & RMR Total Returns

(Level indexed to 1983.4=1.00)

YrQ	NPI Level	RMR Level	NPI Return	RMR Return	YrQ	NPI Level	RMR Level	NPI Return	RMR Return
774	0.4194	0.3784			881	1.5084	1.4745	0.0184	0.0179
781	0.4315	0.4481	0.0290	0.1842	882	1.5385	1.5136	0.0200	0.0265
782	0.4448	0.4734	0.0307	0.0566	883	1.5754	1.5360	0.0240	0.0148
783	0.4599	0.4897	0.0339	0.0344	884	1.6238	1.5669	0.0307	0.0201
784	0.4869	0.4655	0.0588	-0.0495	891	1.6522	1.6015	0.0175	0.0221
791	0.5055	0.5032	0.0382	0.0811	892	1.6852	1.6506	0.0200	0.0307
792	0.5273	0.5487	0.0432	0.0904	893	1.7198	1.6896	0.0205	0.0236
793	0.5524	0.5817	0.0475	0.0601	894	1.7499	1.6805	0.0175	-0.0054
794	0.5866	0.5835	0.0619	0.0032	901	1.7740	1.6803	0.0138	-0.0001
801	0.6190	0.6148	0.0553	0.0536	902	1.8009	1.7228	0.0152	0.0253
802	0.6336	0.6492	0.0236	0.0560	903	1.8161	1.7239	0.0084	0.0007
803	0.6576	0.6789	0.0379	0.0456	904	1.7901	1.6993	-0.0143	-0.0143
804	0.6926	0.7101	0.0532	0.0460	911	1.7909	1.6808	0.0005	-0.0109
811	0.7130	0.7181	0.0295	0.0113	912	1.7911	1.6651	0.0001	-0.0093
812	0.7432	0.6272	0.0423	-0.1266	913	1.7849	1.6357	-0.0035	-0.0177
813	0.7671	0.7865	0.0322	0.2540	914	1.6896	1.5630	-0.0534	-0.0444
814	0.8077	0.8079	0.0529	0.0272	921	1.6892	1.5465	-0.0002	-0.0106
821	0.8279	0.8757	0.0249	0.0839	922	1.6718	1.5300	-0.0103	-0.0107
822	0.8450	0.7858	0.0207	-0.1027	923	1.6645	1.5242	-0.0044	-0.0038
823	0.8578	0.8415	0.0152	0.0709	924	1.6178	1.4916	-0.0281	-0.0214
824	0.8840	0.8776	0.0305	0.0429	931	1.6303	1.4772	0.0077	-0.0096
831	0.8994	0.8913	0.0175	0.0156	932	1.6264	1.4574	-0.0024	-0.0134
832	0.9223	0.9245	0.0254	0.0372	933	1.6413	1.5007	0.0092	0.0297
833	0.9496	0.9349	0.0296	0.0112	934	1.6372	1.4590	-0.0025	-0.0278
834	1.0000	1.0000	0.0531	0.0696	941	1.6586	1.5362	0.0131	0.0529
841	1.0335	1.0234	0.0335	0.0234	942	1.6838	1.5655	0.0152	0.0191
842	1.0661	1.0553	0.0316	0.0311	943	1.7092	1.6165	0.0151	0.0326
843	1.0924	1.0772	0.0246	0.0208	944	1.7413	1.6984	0.0188	0.0507
844	1.1384	1.1315	0.0421	0.0504	951	1.7780	1.6601	0.0210	-0.0225
851	1.1621	1.1482	0.0209	0.0148	952	1.8151	1.7216	0.0209	0.0370
852	1.1923	1.1717	0.0260	0.0205	953	1.8525	1.7539	0.0206	0.0187
853	1.2207	1.2111	0.0238	0.0336	954	1.8727	1.7944	0.0109	0.0231
854	1.2663	1.2519	0.0373	0.0337	961	1.9177	1.8354	0.0240	0.0228
861	1.2920	1.2729	0.0203	0.0168	962	1.9619	1.8845	0.0230	0.0268
862	1.3174	1.2879	0.0196	0.0118	963	2.0140	1.9547	0.0266	0.0373
863	1.3371	1.3077	0.0149	0.0153	964	2.0659	1.9762	0.0258	0.0110
864	1.3714	1.3413	0.0257	0.0257	971	2.1159	2.0512	0.0242	0.0380
871	1.3965	1.3597	0.0183	0.0137	972	2.1721	2.1223	0.0266	0.0346
872	1.4130	1.3724	0.0119	0.0093					
873	1.4426	1.4370	0.0210	0.0471					
874	1.4811	1.4486	0.0267	0.0081					