

Returns, Volatility, and Information Transmission Dynamics in Public and Private Real Estate Markets

Abstract

This paper examines public and private real estate returns and volatility at the aggregate level and by the four major property types over the 1994Q2-2010Q4 sample period. We use both a non-parametric approach as well as VAR and GARCH models to capture conditional dynamic relations in returns and volatility. Our non-parametric results that adjust for differences in financial leverage, property type focus, and management fees suggest that portfolios of U.S. office, industrial, and retail REITs outperformed their private market benchmarks over our sample period; only in the multifamily market do we find some evidence of higher returns in the private market. In the aggregate, unlevered core REITs outperformed their private market benchmark by 46 basis points (annualized) over the 1994Q2 to 2010Q4 sample period. Our baseline VAR results without asset pricing controls suggest that REIT returns predict private market returns, while results including asset pricing controls suggest that REIT returns react to latent asset pricing information more quickly than private market returns given their greater liquidity. REITs therefore serve as a fundamental information transmission channel to private market returns when asset pricing control variables are omitted. Our GARCH estimate results further confirm our VAR results, but they also suggest that REIT returns contain some additional marginal conditional variance information for private market returns.

KEYWORDS: real estate investment trusts, private commercial real estate, return performance, return volatility, information transmission

I. Introduction

Investors can hold ownership positions in commercial real estate both through direct private investment and public real estate securities. Purchasing individual properties directly in the private market gives investors complete control of the asset: who leases it, who manages it, how much debt financing is used, and when it is sold. With publicly-traded real estate securities, in contrast, individuals and institutions invest capital in a real estate company which, in turn, purchases, manages, and holds title to the real estate. In contrast to private real estate markets, exchange-traded real estate securities provide investors with a relatively high degree of liquidity and relatively low transaction costs. Nevertheless, returns in both private and public commercial real estate markets should be driven, at least in the long-run, by the net cash flows derived from leasing space to tenants in local property markets.

Although both the direct private market and the public securities market can provide investors with exposure to the same underlying local property markets, public and private real estate returns as commonly measured have exhibited significantly different risk-return characteristics. According to several recent studies, investments in direct private real estate have produced lower average returns than investments in publicly-traded real estate investment trusts (REITs), even after controlling for differences in financial leverage, property mix, and management fees (Pagliari et al., 2005; Riddiough et al., 2005; and Tsai, 2007). However, these and other studies also document that the measured volatility of returns on private real estate portfolios is lower than the volatility of returns on public real estate portfolios.¹

Public and private real estate returns also display limited correlation over quarterly and annual horizons. For example, the (unconditional) contemporaneous correlation between quarterly returns on equity REITs (as measured by the FTSE NAREIT All Equity REIT Index) and the returns on direct property investments (as measured by the NCREIF NPI) was 0.24 over the 1994-2010 time period. In contrast, the corresponding return correlation between equity REITs and small-cap value stocks (as measured by the Russell

¹ The usual estimate of return volatility, the average of squared deviations over the sample period, provides an unconditional estimate of volatility because it treats the variance as constant over time. In contrast, a conditional statistic allows the variance to change over time based on changes in available information. To the extent that liquidity differences affect volatility, the unconditional volatility estimate will be biased. In our conditional analysis, we control for liquidity effects in examining volatility in public and private real estate markets.

2000 Value Index) was 0.81. Thus, some investors expect REITs to deliver investment returns similar to those of small cap value stocks because of this high correlation, their relatively high dividend yields, and their inclusion in several broader benchmarks of stock market performance.²

In public markets, asset pricing models are commonly used to measure the relative investment performance of exchange-traded assets, portfolios, and managers. However, the use of formal asset pricing models is more difficult in a private market setting where periodic returns are difficult to observe. Comparing public and private real estate returns, both unconditionally and conditionally, therefore requires several adjustments (see, for example, Riddiough et al., 2005, and Pagliari et al., 2005).

In our analysis, we employ a two-stage approach. First, we use a nonparametric approach that consists of adjusting the composition and risk characteristics of publicly-traded REIT portfolios to match as closely as possible the composition and characteristics of our benchmark private market portfolios. In particular, we unlever REIT returns at the firm level before aggregating into portfolios to match the unlevered returns on our benchmark private market portfolios. In addition, when aggregating returns across property types to create representative portfolios, each major property type is assigned the same weight in both the public market and private market portfolios we construct. Our non-parametric results show that portfolios of U.S. office, industrial, and retail REITs outperformed their private market benchmarks over our sample period; only in the multifamily market do we find some evidence of higher returns in the private market. In the aggregate, unlevered core REITs outperformed their private market benchmark by 46 basis points (annualized) over the 1994Q2 to 2010Q4 sample period.

In addition to the extant literature on the relative risk and return performance of public and private commercial real estate investment, there is a growing interest among academics and practitioners in how information is transmitted between the two markets (e.g., Okunev et al., 2000, Li et al., 2009, and Carlson et al., 2010). In our second stage analysis, we use Vector Autoregression (VAR) techniques and various asset pricing control variables to examine the dynamics between public and private real estate returns and

² Recent research suggests that the correlation of equity REIT returns with those of other equities declines as the investment horizon lengthens, whereas the correlation of REIT returns with those of the NCREIF NPI, as well as other private market benchmarks, increases as the investment horizon lengthens.

volatility. This dynamic analysis allows us to answer several important questions, including the extent to which each market is influenced by standard asset pricing risk factors and the degree to which public market returns predict returns in the private market. We also use GARCH procedures to quantify the conditional volatility of public and private market returns, their cross-sectional relation, and the factors that influence them.

Our baseline bivariate VAR results without asset pricing controls suggest REIT returns possess information on future private market returns; in contrast, private market returns have no predictive power in our REIT return regressions. When standard asset pricing control variables are included, we find that the magnitude and significance of REIT returns in private market return regressions are reduced. These results strongly suggest that REIT returns react to latent asset pricing information more quickly than private market returns given their greater liquidity and price revelation. REITs therefore serve as a fundamental information transmission channel to private market returns when asset pricing variables are omitted. Our GARCH model estimates confirm our VAR results, but also suggest that REIT returns contain some marginal conditional variance information for predicting future private market returns, even after controlling for asset pricing variables.

The paper proceeds as follows. In section II, we describe our benchmark private market return indices and present summary statistics on their performance. We then describe the construction of our initial equity REIT sample, the merger of this sample with Compustat data to obtain the accounting information necessary to delever firm-level REIT returns, the methods used to construct indices of levered and unlevered REIT returns, and other nonparametric adjustments we make prior to analyzing the relative performance of public and private real estate market returns. In section III we describe the VAR models and data used to examine the dynamics of public and private market returns as well as the GARCH procedures used to quantify the time-varying volatility of public and private market returns and the factors that explain their cross-sectional relation. Section IV contains a summary and some concluding thoughts.

II. Public versus Private Market Real Estate Returns: A Nonparametric Approach

We first adjust the composition of our public and private market returns to make them more directly comparable; we then examine their return relations and volatility at both the aggregate level and by the four “core” property types: multifamily, office, industrial, and retail. In order to render returns on our equity REIT portfolios comparable

to the corresponding unlevered private market benchmarks, we (1) remove the effects of financial leverage from firm-level REIT returns, (2) exclude from the final analysis those REITs that do not invest in “core” property types, (3) use the same property-type weights as found in the benchmark private market index when creating our aggregate REIT portfolio/index, and (4) adjust downward the returns earned on our benchmark private market portfolios to reflect the fact that these returns are reported gross of asset management fees, whereas REIT returns are reported net of all firm-level management expenses.³

Benchmark Private Market Returns

Our primary source of return data in the private commercial real estate market is the National Council of Real Estate Investment Fiduciaries (NCREIF). Established in 1982, NCREIF is a not-for-profit industry association that collects, processes, validates, and disseminates information on the risk/return characteristics of commercial real estate assets owned by institutional (primarily pension and endowment fund) investors (see www.ncreif.org). NCREIF's flagship index, the NCREIF Property Index (NPI), tracks property-level quarterly returns on a large pool of properties acquired in the private market for investment purposes only. The property composition of the NPI changes quarterly as data contributing NCREIF members buy and sell properties. However, all historical property-level data remain in the database and index.

Unless a constituent property happens to sell during the quarter, the reported quarterly capital gain on an individual property within the NCREIF NPI is based on the change in the property's appraised value. Appraisal-based indices are thought to suffer from two major problems. First, they lag changes in “true” (but unobservable) market values; this smoothing of past returns understates return volatility. Second, formal appraisals of constituent properties in the NCREIF Index by third party appraisers are usually conducted annually; the property's asset manager is responsible for updating the appraisal internally in the intervening quarters. This leads to what is commonly called the “stale” appraisal problem.

Any analysis of the relative return performance, volatility, and the lead-lag relations between public and private real estate returns must overcome the smoothing and stale

³ Many retail and institutional investors participate in the REIT market through actively managed funds, which do include some management costs. This issue is discussed in more detail below.

appraisal problems. Our solution is to employ the NCREIF Transaction Based Index (TBI) as our primary measure of private real estate returns. The capital gain component of the TBI in each quarter is based only on the constituent properties in the NCREIF database that were sold that quarter.⁴ The TBI indices are available from NCREIF at the national level back to 1994:Q2 for multifamily, office, industrial, and retail properties; this availability dictates the beginning of our sample period. NCREIF's All-Properties TBI Index includes hotel properties. We therefore construct a Core-Properties TBI Index that excludes hospitality properties, which we use in some of our analyses. For comparison, we also report the risk-return characteristics of the widely used NCREIF NPI.

Comparisons of public and private market return performance will be sensitive to the time period selected for the analysis. In this case, the constraint imposed on our analysis by the lack of TBI indices prior to 1994Q2 requires us to exclude the early 1990s, a period which more accurately captures the beginning of the most recent complete real estate cycle and during which public REIT markets generally outperformed private markets. This sample selection issue is addressed in more detail below.

We first calculate quarterly property type weights using the total market value of all properties in each of the four core property type categories contained in the NCREIF NPI database. More specifically, the portfolio weight assigned to property type f in quarter t is:

$$w_{f,t}^{NPI} = \frac{mval_{f,t-1}}{\sum_{f=1}^4 mval_{f,t-1}} \quad (1)$$

where $f = 1 \dots 4$ for apartment, office, industrial, and retail properties, respectively, and $mval_{f,t-1}$ is the total market value of property type f at the end of quarter $t-1$ as reported by the NCREIF NPI. The return in quarter t on our Core-Properties NPI index is defined as

$$R_t^{NPI} = \sum_{f=1}^4 w_{f,t}^{NPI} r_{f,t}^{NPI} \quad (2)$$

where $w_{f,t}^{NPI}$ is the percentage of the total market value of the four core property types in the NCREIF database represented by property type f and $r_{f,t}^{NPI}$ is the NPI total return for

⁴ Detailed information on the construction of the NCREIF TBI is available at www.ncreif.org. Prior to the second quarter of 2011, the TBI was produced by the MIT Center for Real Estate on behalf of NCREIF. Beginning in the second quarter of 2011, NCREIF took the production of the TBI in house, revised the index construction methodology, and provided a restated set of quarterly indices for the 1994Q2-2011Q1 time period. We use the original family of TBI indices produced by the MIT Center for Real Estate in this paper. The restated indices yield very similar results to the MIT produced TBI, except for in the early 1990s where there were fewer transactions.

property type f in quarter t . This weighting and aggregation process is repeated each quarter to generate a time series of Core-Properties NPI returns.

Similarly, the return in quarter t on our Core-Properties TBI index is defined as

$$R_t^{TBI} = \sum_{f=1}^4 w_{f,t}^{NPI} r_{f,t}^{TBI} \quad (3)$$

where $r_{f,t}^{TBI}$ is the TBI return for property type f in quarter t . Note the required use of NPI property type weights, $w_{f,t}^{NPI}$, in the construction of our Core-Properties TBI index.⁵ This weighting and aggregation process is repeated each quarter to produce a time series of aggregate Core-Properties TBI returns.

Finally, we adjust downward the quarterly returns on our NPI and TBI total return indices to reflect the fact that these returns are reported gross of management fees, whereas reported firm-level REIT returns are net of all firm-level management fees. According to industry sources, investment management fees as a proportion of assets under management range between 50 and 120 basis points per year in the direct private market (see, for example, Riddiough et al., 2005). We conservatively estimate total advisor/management fees to be 80 basis points per year (20 BPS per quarter) in our formal analysis.⁶

Figure 1 displays cumulative total returns, net of estimated asset management fees, on our Core-Properties NPI index over the 1994Q2-2010Q4 sample period, along with the constituent multifamily, office, industrial, and retail NPI indices obtained directly from NCREIF. The starting point of 1994Q2 is dictated by the availability of TBI returns by property type. Summary statistics for these five return indices are reported in panel A of

⁵ Quarterly NPI property type weights must be used because the aggregate TBI series reported by NCREIF is estimated by including all properties in the database in that quarter; thus, it is not possible to determine the property type weights associated with NCREIF's estimation of their aggregate TBI return series.

⁶ Investors, including institutional investors, can invest in REITs using low-cost index funds or exchange-traded funds. Nevertheless, much investment appears to take place through actively managed funds, which does involve some additional cost. However, a Cohen & Steers analysis reports that active REIT portfolio managers outperformed the FTSE NAREIT All Equity REITs Index by 160 basis points gross of fees over the same period. According to the Cohen & Steers report, "In our view, active REIT management for a diversified strategy should add 200 basis points of alpha; REITs' stock-exchange liquidity enables portfolio managers to capitalize on valuation anomalies and performance variances across property types and markets as economic and real estate cycles change." If the alpha provided by active REIT portfolio management compensates for some, if not all, of the cost of active management, a smaller downward adjustment to NPI and TBI returns is not warranted.

Table 1. Figure 2 displays the corresponding cumulative returns for our TBI indices; TBI summary statistics are reported in panel B of Table 1.

The smoothed nature of NPI returns relative to TBI returns is clearly visible in Figures 1 and 2. These figures also reveal the prolonged bull market experienced by the private commercial real estate market that began in early 1993. From 1994Q2 through 2007Q3, our Core-Properties TBI return index produced a geometric mean quarterly return of 3.11 percent, or 13.03 percent annually.⁷ After peaking in late 2007, our Core-Properties TBI index produced a mean quarterly return of -3.93 percent (-14.81 percent annually) from 2007Q4 through 2009Q4. This sharp drop in return performance reduced the average annual TBI return over the full 1994Q2-2010Q4 sample period to 8.88 percent with a standard deviation of 7.10 percent; the autocorrelation of the Core-Properties TBI index is 0.55. The annualized mean return on our Core-Properties NPI index over the full sample period (panel A) is 8.12 percent, substantially lower than the 8.88 percent mean TBI return. The annualized standard deviation of our NPI series is 4.99 percent, which is also lower than the volatility of our TBI return series due to appraisal smoothing. The smoothed nature of the NPI returns is also evident in the 0.85 autocorrelation of quarterly returns.

According to the TBI, multifamily properties produced a mean annualized return of 10.16 percent over the full sample; the corresponding mean returns for office, industrial, and retail properties are 8.52 percent, 9.09 percent, and 8.72 percent, respectively. Thus, direct private investments in multifamily properties produced significantly higher mean returns than the other core property types over the 1994Q2 to 2010Q4 sample period. Multifamily properties also outperformed office, industrial, and retail properties on a simple return-per-unit-of-risk (standard deviation) basis. The mean NPI returns for the four core property types reported in panel A are significantly lower than the corresponding TBI returns.

REIT Data and Levered Returns

Our initial sample of publicly-traded U.S. equity REITs is obtained from the CRSP-Ziman database. We collect the following data for each REIT at the beginning of each

⁷ All reported mean returns are geometric means.

quarter: REIT identification number, property type and sub-property type focus, and equity market capitalization.⁸

Column A of Table 2 displays the total number of independent equity REITs used by CRSP-Ziman to construct their equity return index in the fourth quarter of each year over the 1994Q2 to 2010Q4 sample period. Column B contains the number of REITs from the CRSP-Ziman database used to construct our initial return index in the fourth quarter of each year; column C displays the difference between columns A and B. A positive difference indicates our initial index contains fewer REITs at the beginning of that quarter than are used to calculate the CRSP-Ziman Index return in the quarter. Over the 67 quarters in our sample period, the difference in the number of REITs in the two samples ranges from -9 to 9. These quarterly variations reflect the use of different methodologies. The quarterly returns reported by CRSP-Ziman are "built up" from compounding daily returns. This means that the CRSP-Ziman equity REIT portfolio is "rebalanced" every day; that is, firms can enter and exit the index daily and the firm-level equity market capitalizations used to value-weight returns also vary daily.

In contrast, we take the equity REITs in the CRSP-Ziman index at the beginning of each quarter and hold those REITs constant for the entire quarter. In essence, our index is built on the assumption that investors are rebalancing their portfolios quarterly; that is, our index assumes a quarterly "buy-and-hold" strategy. In addition, the weights we use to construct the value-weighted return in each quarter are based on the market capitalization of each REIT at the beginning of the quarter.⁹ Given the expense investors would face with daily portfolio rebalancing, our quarterly buy-and-hold assumption is more consistent with the trading behavior of most investors. Moreover, our assumption is consistent with the construction of the NCREIF NPI and TBI indices; that is, NCREIF does not include in their indices in a particular quarter properties added to the database during that quarter. Thus, the NCREIF indices also implicitly assume a quarterly "buy-and-hold" strategy.

⁸ Most prior studies that use firm-level data to compare the risk-return characteristics of public and private real estate use a combination of NAREIT constituent lists for each property type and SIC classification codes to identify REITs and their property type specialization. Return data for the REITs are then obtained from CRSP data. We obtain both our property type constituent lists and return data from CRSP-Ziman. It is important to note that relying on the SIC classification code for REITs (6798), as almost all prior studies have done to select REITs from the CRSP database, results in a number of REITs being misclassified and left out of the analysis.

⁹ If a REIT is delisted during a quarter, its total return is included in that quarter and weighted by its beginning-of-quarter market capitalization.

The number of equity REITs in our initial sample ranges from 111 (2009Q3) to 198 (1996Q1). The latter number reflects the culmination of the 1993-1994 REIT IPO boom. The reduction in publicly-traded REITs to 111 in 2009Q3 reflects the wave of REIT mergers and acquisitions that occurred in 2005-2007 and the sharp downturn in REIT share prices that occurred in 2008 and the first quarter of 2009.¹⁰ The average number of REITs across our 67 quarter sample is 157.

To obtain the balance sheet and income statement information necessary to unlever quarterly returns at the firm level (see below), our initial REIT sample is merged with data collected from the quarterly CRSP/Compustat database. In particular, we require the following firm-level data at the beginning of each quarter: debt in current liabilities (DLCQ), long term debt (DLTTQ), preferred dividends (DVPQ), interest and related expenses (XINTQ), and total assets (ATQ).¹¹ Preferred stock-liquidation values (PSTKL) are obtained from Compustat on an annual basis.

Column D of Table 2 displays the number of equity REITs in our merged sample at the beginning of the fourth quarter of each calendar year. The number of REITs lost each quarter is reported in column E. On average, 3.7 REITs are lost due to a lack of required accounting information in Compustat.

Levered monthly total returns for each REIT in our All-Properties sample are downloaded from CRSP-Ziman and then compounded (chain-linked) to produce the levered total return on equity for REIT i in quarter t , or $r_{i,t}^e$.¹² We create an index of equity REIT returns for each quarter by weighting the total return of each constituent REIT in quarter t by its equity market capitalization at the end of quarter $t-1$. The index weight for REIT i in quarter t is therefore

$$w_{i,t}^e = \frac{(mcap_{i,t-1}^e)}{\sum_{i=1}^{N_t} (mcap_{i,t-1}^e)} \quad (4)$$

where $mcap_{i,t-1}^e$ is the equity market capitalization of firm i at the end of quarter $t-1$. The total number of equity REITs in the index in quarter t is denoted as N_t .

¹⁰ The wave of REIT mergers and acquisitions that occurred in 2005-2007 is discussed in detail in Ling and Petrova (2011).

¹¹ Note that, unlike Riddiough et al. (2005), we do not require REITs to have a full calendar year of data to be included in the sample.

¹² CRSP calculates monthly returns for each REIT by compounding daily returns. Thus, although we assume quarterly buy-and-hold investment strategies, firm-level returns assume daily compounding.

Finally, the total levered return on our All-Properties REIT index return in quarter t is defined as

$$R_t^E = \sum_{i=1}^{N_t} w_{i,t}^e r_{i,t}^e. \quad (5)$$

This weighting and aggregation process is repeated each quarter to generate a time series of levered REIT returns.

The mean levered total return on our All-Properties REIT index is 10.12 percent (panel C of Table 1); the corresponding returns on the CRSP-Ziman and FTSE NAREIT All Equity REIT indices are 10.22 percent and 10.31 percent, respectively. The correlation of our levered quarterly REIT returns with the CRSP-Ziman and FTSE NAREIT indices are 0.9999 and 0.9984, respectively. Thus, our All-Properties return index closely mirrors the returns on two widely-reported equity REIT indices, despite the use of a quarterly buy-and-hold methodology and the loss of several firms most quarters due to a lack of accounting information in Compustat.

Figure 3 displays cumulative returns on our levered All-Properties REIT index over the 1994Q2-2010Q4 sample period. For comparison, we also plot the cumulative returns on our (unlevered) Core-Properties TBI index. Equity REITs entered a 16-year bull market in late 1990, approximately three years before the private market began its recovery. From 1994Q2 through 2006, equity REITs produced somewhat higher returns than private markets, albeit with more measured volatility. However, the REIT bear market that began in the second quarter of 2007 was even more severe than the downturn captured by the TBI for the private market. For example, our levered All-Properties REIT index produced an average quarterly return of -12.39 percent, or -41.08 percent annually, from 2007Q2 through 2009Q1. The recovery in the REIT market, however, began at least three quarters earlier than the recovery in the private market.

Over the full sample period, the 10.12 percent mean return on our levered All-Properties REIT index exceeds the corresponding Core-properties TBI return of 8.88 percent (panel B) by 124 basis points. The outperformance of our levered All-Properties REIT index relative to the Core-Properties NPI index (panel A) is 200 basis points. However, the additional return provided by REITs is associated with relatively more measured volatility and less measured auto-correlation than private market returns. Nevertheless, as we discuss below, the relative illiquidity and lack of price revelation of

properties traded in the private market likely understates true volatility, and overstates the autocorrelation, of private market returns as measured by both the NCREIF NPI and TBI.

We also use the methodology described above to create levered REIT return indices for each of the four core property types. The property type focus of each REIT at the beginning of each quarter is obtained from CRSP-Ziman.¹³ Over the 67 quarter sample period, the apartment, office, industrial, and retail indices contain an average of 22, 19, 9, and 41 REITs, respectively.

Our levered return indices for multifamily, office, industrial, and retail REITs are displayed in Figure 4. For comparison purposes, our levered All-Properties REIT index is also included. Summary statistics for these four levered property type indices are reported in panel C of Table 1. Over the 1994Q2-2010Q4 period, multifamily REITs produced an average annualized levered return of 12.11 percent. The corresponding levered returns on office, industrial, and retail REITs were 10.92 percent, 9.39 percent, and 11.13 percent, respectively. Interestingly, the (annualized) standard deviation of levered apartment returns is somewhat lower than the standard deviation of returns on office, industrial, and retail REITs. Thus, multifamily REITs significantly outperformed the other core property types on a simple return-per-unit-of-risk basis over the 1994Q2-2010Q4 sample period.

Delevering REIT Returns

The first step in delevering REIT returns at the firm level is to calculate the firm's unlevered return on assets (weighted average cost of capital) in each quarter. We estimate the unlevered return on total assets for REIT i in quarter t , $r_{i,t}^{TA}$, as

$$r_{i,t}^{TA} = (r_{i,t}^e \theta_{i,t}^e) + (r_{i,t}^d \theta_{i,t}^d) + (r_{i,t}^p \theta_{i,t}^p), \quad (6)$$

where $r_{i,t}^e$ is the levered total return on equity, $r_{i,t}^d$ is the total return earned by the firm's long-term and short-term debt holders in quarter t , and $r_{i,t}^p$ is the return earned by preferred shareholders. The time-varying quarterly weights corresponding to equity, debt,

¹³ More specifically, a REIT is included in our retail index if it is classified by CRSP-Ziman as having a property type focus of 9 (retail) and a sub-property type focus of 5 (freestanding), 14 (outlet), 15 (regional), 17 (shopping center), or 18 (strip center). Our industrial index includes REITs classified by CRSP-Ziman as having a property type focus of 4 (industrial/office) and a sub-property type focus of 8 (industrial). Our quarterly office sample includes REITs with a property type focus of 4 (industrial/office) and a sub-property type focus of 13 (office). Finally, a REIT is included in our apartment index in a given quarter if it is assigned by CRSP-Ziman a property type focus of 8 (residential) and a sub-property type focus of 2 (apartments).

and preferred shares in the firm's capital structure are denoted as $\theta_{i,t}^e$, $\theta_{i,t}^d$, and $\theta_{i,t}^p$, respectively.

Let $bval_{i,t}^d$ represent the total book value of short- and long-term debt and $lval_{i,t}^p$ the estimated liquidation value of outstanding preferred shares for REIT i at the end of quarter t .¹⁴ The returns on debt obligations and preferred shares, respectively, are calculated as

$$r_{i,t}^d = \frac{int_{i,t}^d}{bval_{i,t-1}^d} \quad (7)$$

$$r_{i,t}^p = \frac{pdiv_{i,t}^p}{lval_{i,t-1}^p} \quad (8)$$

where $int_{i,t}^d$ is total interest paid to debt holders in quarter t and $pdiv_{i,t}^p$ is total preferred dividends.¹⁵ $r_{i,t}^e$ is constructed by chain-linking monthly returns obtained from CRSP-Ziman.

Total asset value for REIT i at the end of quarter t , $TA_{i,t}$, is set equal to

$$TA_{i,t} = mcap_{i,t}^e + bval_{i,t}^d + lval_{i,t}^p, \quad (9)$$

where $mcap_{i,t}^e$ is the market capitalization of common equity at the end of quarter t . The capital structure weights in the return on total assets equation for each REIT in each

¹⁴ Using quarterly Compustat data, the book value of debt is set equal to Debt in Current Liabilities (DLCQ) plus Long Term Debt (DLTTQ); the estimated liquidation value of preferred shares is set equal to Preferred Stock - Liquidating Value (PSTKL). In the quarterly Compustat file, Debt in Current Liabilities, i.e., the book value of short-term debt is often missing for one or more quarters. In these cases, we obtain the book value of short-term debt at the end of each year from the annual Compustat file. We then assume that the change in the book value of short-term debt from the end of one year to the next occurs in equal amounts over the four quarters. This assumption obviously smooths quarterly changes in short-term debt but is preferable to dropping the firm in that quarter or assuming the book value of short term debt is zero. It is also important to note that the quarterly book value of preferred shares reported in Compustat is not usable because the field (PSTKQ) is not well populated; moreover, when a figure is reported it generally appears to be implausible. Thus, we use the estimated liquidation value of preferred shares. As discussed by Riddiough et al. (2005), preferred shares are often convertible to common shares and/or are callable by the REIT. This optionality makes the estimation of liquidation value difficult because it is set equal to the capitalized dividend stream of the preferred shares or the converted value to common shares, whichever is greater. As a result of this complexity, reported liquidation values are likely noisy estimates of true market value.

¹⁵ Using Compustat data, total interest paid is set equal to Interest Expense on Short-Term Borrowing plus interest Expense on Long Term Debt (XINTQ); total preferred dividends paid is set equal to Dividends Preferred (DVPQ). In the quarterly Compustat file, Interest Expense on Short-Term Borrowing plus interest Expense on Long Term Debt (XINTQ) and Dividends Preferred (DVPQ) are sometimes missing. In these cases, we obtain the total amount of dividends paid and Interest Expense on Short-Term Borrowing and Long Term Debt (XINTQ) in the year from the annual Compustat file and then assume the annual total was paid in equal amounts over the four quarters. Although preferred dividends on REITs are often constant for long periods of time, this assumption may smooth quarterly dividends on preferred shares but is again preferable to dropping the firm in that quarter or assuming no preferred dividends were paid.

quarter are based on the claims of equity, debt, and preferred shares outstanding at the end of quarter $t-1$, relative to total assets outstanding, or

$$\theta_{i,t}^e = \frac{(mcap_{i,t-1}^e)}{TA_{i,t-1}} \quad (10)$$

$$\theta_{i,t}^d = \frac{(bval_{i,t-1}^d)}{TA_{i,t-1}} \quad (11)$$

$$\theta_{i,t}^p = \frac{(lval_{i,t-1}^p)}{TA_{i,t-1}} \quad (12)$$

Figure 5 displays how the weights of equity, debt, and preferred share obligations in the typical REIT's capital structure vary by quarter over the sample period. These aggregate weights (shares) are constructed by equally-weighting REIT-level shares each quarter. On average, equity market capitalizations approached 70 percent of estimated total asset value in 1994. Use of preferred stock was negligible until 1997 and has since averaged about two percent of the typical equity REITs capital structure. The significant stock price declines experienced by equity REITs in 1998 and 1999 pushed the average equity weight down to nearly 40 percent by the beginning of 2000, with a corresponding increase in the importance of debt (at book value) in REIT capital structures. During the early 2000s, the role of equity in REIT capital structures gradually increased, maintaining an average weight in the 55-to-56 percent range from 2004-2007Q2. Beginning in late 2007, equity weights again decreased sharply as REIT stock prices plummeted, reaching an average of just 32 percent in 2009Q2. The average debt share increased to 60 percent over this period, forcing many REITs to pay down debt obligations and to pursue other strategies to improve their balance sheets. This delevering strategy, coupled with sharply rising stock prices, pushed the average debt share down to 43 percent by 2010Q4. The average quarterly weights of equity, debt, and preferred shares over the full sample period are 53.1 percent, 44.4 percent, and 2.5 percent, respectively.

Finally, an index of unlevered returns on total assets in quarter t , R_t^{TA} , is constructed by summing over the weighted unlevered returns earned by each constituent REIT; that is,

$$R_t^{TA} = \sum_{i=1}^{N_t} w_{i,t}^{TA} r_{i,t}^{TA}, \quad (13)$$

where $r_{i,t}^{TA}$ is REIT i 's unlevered (total) return on assets [equation (6)] and

$$w_{i,t}^{TA} = \frac{(TA_{i,t-1})}{\sum_{i=1}^{N_t} TA_{i,t-1}}. \quad (14)$$

When constructing the aggregate All-Properties index, N_t equals the total number of REITs in the sample at the beginning of quarter t . When constructing an index of returns on office REITs, for example, N_t equals the number of office REITs in the sample. Unlevered quarterly returns are compounded to obtain an index of cumulative returns for both our All-Properties REIT index and our four core property type indices.¹⁶

Figure 6 displays cumulative returns on our unlevered All-Properties REIT index. For comparison, cumulative returns on our levered All-Properties REIT index are also displayed. The annualized mean quarterly return on the unlevered All-Properties return index is 8.76 percent; the annualized quarterly standard deviation is 9.92 percent (panel D of Table 1). As previously reported, the corresponding mean return and standard deviation for the levered return series are 10.12 percent, and 21.41 percent, respectively. Thus, the levered index (unconditionally) outperforms the unlevered index by 136 basis points annually over the full sample. However, the standard deviation of levered REIT returns is 2.16 times as large as the volatility of unlevered returns.

The impact of leverage on returns and volatility is most pronounced after 2002. During 2003-2006, levered REIT returns were significantly higher than their unlevered counterparts. However, the downturn in the REIT market that began in 2007 and ended in 2009Q1 was much more pronounced on a levered basis than on an unlevered basis.

¹⁶ Riddiough et al. (2005) derive their annual capital structure weights by averaging, for example, the equity market capitalization of a firm at the beginning and end of each year. However, using the market capitalization of each REIT at the end of the year along with the beginning-of-year market capitalization to construct average yearly stock market capitalizations can create a significant “look-ahead” bias. More specifically, REITs that perform well during the year will have higher average market capitalizations for the year. This, in turn, will cause the weight applied to their equity return, $\theta_{i,t}^e$, in equation (6) to be overstated. This artificially high weight biases upwards the estimated return on total assets for this REIT. In contrast, REITs that perform poorly during the year will have lower average market capitalizations. This, in turn, will cause the weight applied to this REIT’s equity return, relative to the weights applied to debt and preferred stock, to be understated in that year. In short, using (unknown) end-of-period data when unlevering returns creates an upward bias in the calculation of the return on assets of “winners” and a downward bias in the calculation of the return on assets of “losers.” In addition, when an index of unlevered returns in a given time period is constructed by summing over the weighted unlevered returns earned by each constituent REIT during that period, this look-ahead bias places too large a weight on the unlevered returns earned by winners and too low a weight on the unlevered returns earned by losers. This look-ahead bias accounts for at least a portion of the REIT outperformance, relative to private markets, reported by Riddiough et al. (2005). We avoid this look-ahead bias by weighting only by beginning-of-period equity market capitalizations.

Similarly, the upturn in the REIT market that began in 2009Q2 and persisted through the end of the sample period boosted levered returns more than unlevered returns.

Unlevered mean returns, standard deviations, and autocorrelations for our four core property type REIT indices are also reported in panel D of Table 1. Consistent with our All-Properties Index, our unlevered property focused indices display lower mean returns than their levered counterparts, but also significantly less volatility. The effect of leverage on mean returns, however, varies noticeably across property types. On a simple return-per-unit-of-risk basis, levered REITs appear to have significantly underperformed their (hypothetical) unlevered benchmark.

Adjusting REIT Returns for Differences in Property Focus

Similar to the institutional investors who are the data-contributing members of NCREIF, publicly-traded REITs typically focus their investments in institutional quality properties. However, the NCREIF TBI index is more heavily weighted toward office and industrial properties than the CRSP-Ziman and FTSE NAREIT indices, which have higher concentrations of retail properties. In addition, health care, self-storage, and other specialty REITs typically account for approximately a fourth of the FTSE NAREIT equity market capitalization, but have no presence in the core-orientated TBI index. Failure to account for these differences in property type focus when aggregating return data across REITs could lead to erroneous conclusions about differences in the risk-return characteristics of public and private commercial real estate markets.

To adjust for differences in property type focus, we use information from the CRSP-Ziman database to identify core-focused REITs. As discussed above, this classification is performed quarterly, and CRSP-Ziman re-categorizes a REIT's property type focus if its focus changes. This information allows us to construct quarterly REIT returns for the four core property types. We then aggregate these four series using the same property type weights we employ to construct our aggregate Core-Properties TBI return index [see equations (1) and (3)]. This weighting procedure therefore holds constant the weights of apartment, office, industrial, and retail properties in our Core-Properties public and private market return series.¹⁷

¹⁷ This weighting procedure holds constant the weights of the four major property types in both our public and private market return series. However, the sub-property type mix within each of the four major property type categories likely varies in public versus private markets. For example, if retail

The number of core-focused REITs at the beginning of the fourth quarter of each calendar year is shown in Table 2, column F. Column G contains the difference between our final sample of equity REITs that meet our data requirements for calculating unlevered returns (column D) and the number of core-focused REITs. Figure 7 plots the number of equity REITs by quarter in our All-Properties REIT index (top curve) as well as the number of core-focused REITs.¹⁸ Over the 1994Q2-2010Q4 sample period, the quarterly difference in the two samples averages 66 and ranges from 53 (2009Q2 to 2010Q1) to 81 (1995Q2).

Figure 8 reveals that the percentage of equity REITs classified as core investors hovered near 60 percent during the mid-to-late 1990s. Beginning in the early-to-mid 2000s, this percentage drifted downward; by 2008Q2, 52 percent of equity REITs were focused on one of the four core property types. This underscores the importance of controlling for the mix of property types when comparing the performance of REIT and private market return indices.

Panel E of Table 1 displays summary statistics for our Core-Properties REIT index. It is interesting to note that mean unlevered returns on core-oriented REITs exceed the unlevered returns on our all-property-types REIT index over the 1994Q2-2010Q4 sample period (panel D of Table 1). The cumulative total returns on both indices are plotted in Figure 9. The mean unlevered return on our Core-Properties REIT index averaged 9.34 percent over the sample period with an annualized standard deviation of 9.79 percent. The corresponding mean and standard deviation for the unlevered All-Properties REIT index are 8.76 percent and 9.92 percent, respectively. Thus, on a simple return-per-unit-of-risk basis, REITs invested in core properties appear to have outperformed non-core REITs.

Unconditional Results: Public versus Private Market Returns

Now that adjustments have been made for financial leverage, property type focus, and portfolio/asset management fees, we turn next to a detailed analysis of the relative performance of our carefully adjusted public and private return indices. Cumulative unlevered returns on our Core-Properties REIT and TBI indices are plotted in Figure 10. From 1994Q2 through 2004Q4, we observe little difference in the return performance of

REITs hold, in the aggregate, a different percentage of their assets in regional malls in a given quarter than do NCREIF investors, this could account for a portion of any difference in the performance of retail REITs relative to the NCREIF retail benchmark.

¹⁸ From 1994Q2 to 1994Q4 the total number of REITs in our All-Properties Index increased dramatically from 152 to 185; REITs in our Core-Properties Index increased from 77 to 105. Both increases reflect the record number of REIT IPOs that occurred in 1994.

core public and private real estate at the aggregate level. However, beginning in 2005 private real estate began to produce higher mean returns than public real estate. In 2007, quarterly returns on both indices declined and began to turn negative; both series experienced large negative returns during the late 2007 to 2009 commercial real estate recession. However, the Core-properties REIT index turned negative in 2007Q2; in contrast, private market returns did not turn negative until 2007Q4. Moreover, REIT returns rebounded strongly in the second quarter of 2009. In fact, unlevered returns on core-focused REITs averaged 6.16 percent per quarter (27.04 percent annually) from 2009Q2 to 2010Q4. In contrast, private market returns remained negative through 2009Q4 and did not turn as sharply positive as their public market counterparts until 2010. Although not plotted in Figure 10, the relative performance of core-focused REITs is enhanced when the NCREIF NPI is used as our private market benchmark in place of the TBI.

Similar to the aggregate indices, the return performance of publicly-traded office, industrial and retail REITs varied little from the return performance of their private market benchmarks over the 1994Q2-2004Q4 subsample (see Figures 12, 13, and 14). However, distinguishable differences in the performance of multifamily REITs and privately-held multifamily portfolios began to appear as early as the late 1990s (Figure 11). In fact, privately-held multifamily properties produced higher mean returns than multifamily REITs until early 2009. During 2009Q2-2009Q4, multifamily REITs outperformed their private market benchmark and produced very similar returns in 2010. Over the full 1994Q2-2010Q4 period, privately-held multifamily properties produced an annualized mean return of 10.16 percent; the corresponding unlevered return on multifamily REITs was 9.29 percent, a difference of 87 basis points. Moreover, the measured standard deviation of returns on privately-held multifamily properties was 9.15 percent, somewhat lower than the 9.66 percent standard deviation of multifamily REIT returns. Thus, on both a “raw” return basis and a return-per-unit-of-risk basis, privately held multifamily properties appear to have outperformed multifamily REITs over the sample period.

Raw performance results differ, however, for the remaining three property types. Over the full sample period, industrial REITs produced an annualized unlevered mean return of 9.05 percent; the corresponding return on privately-held industrial properties was 9.09 percent, a difference of just three basis points. Cumulative returns on both public and private market industrial properties are displayed in Figure 12.

As can be seen in Figures 13 and 14, office and retail REITs produced significantly higher average returns than their private market benchmarks over the full sample, with most of the (unconditional) outperformance coming in 2009 and 2010. Over the full sample period, office REITs produced a mean unlevered return of 9.73 percent; the corresponding return on privately held office properties was 8.52 percent, a difference of 121 basis points. Retail REITs outperformed their private market benchmark on a raw return basis by 72 basis points. Again, the outperformance of office and retail REITs is amplified by the use of the NPI as the benchmark in place of the TBI. Clearly, the observed outperformance of our unlevered Core-Properties REIT index, relative to the Core-Properties TBI index, is driven by office and retail REITs, tempered by the relative underperformance of apartment REITs.

The constraint imposed on our analysis by the lack of TBI indices prior to 1994Q2 requires us to exclude the early 1990s, a period during which public REIT markets outperformed private markets. More specifically, from 1990Q1 through 1994Q1 the annualized mean return on the CRSP-Ziman REIT index was 11.53 percent (Table 3). The corresponding mean return on the NCREIF NPI was -1.21 percent, an annualized difference of 12.74 percent. Over the 1994Q2-2010Q4 study period, the CRSP-Ziman Index outperformed the NCREIF NPI by 127 basis points (annually). However, over the 1990Q1-2010Q4, this outperformance increases to 368 basis points before any adjustments for leverage, property type focus, or management fees. In short, excluding 1990Q1-1994Q1 from the analysis substantially decreases the outperformance of equity REITs.

Finally, although TBI indices are preferred to the use of appraisal-based indices, as robustness checks we also make use of NCREIF's Open-End Diversified Core Equity (ODCE) fund and NCREIF's Townsend Fund Returns. The ODCE is an index of investment returns earned by 28 open-end commingled funds pursuing a core real estate investment strategy. NCREIF's Townsend Fund Core Index tracks the performance of real estate private equity funds pursuing a core investment strategy. The NFI-ODCE Index NCREIF's Townsend Fund Core Index are time- and capitalization-weighted and, similar to the NCREIF TBI and NPI indices, are reported gross of fees. We therefore downward adjust quarterly returns on these two indices by 20 basis points per quarter.

Figure 15 plots cumulative unlevered returns on our Core-Properties REIT index along with NCREIF ODCE and NCREIF's Townsend Core Property cumulative returns. Over the 1994Q2-2010Q4 sample period, the NCREIF ODCE fund and the NCREIF Townsend Core Property fund produced mean annualized returns of 7.11 percent and 6.94

percent, respectively. These annualized fund returns are, respectively, 223 and 240 basis points lower than the 9.34 percent mean return on our unlevered Core-Properties REIT index. Thus, the outperformance of equity REITs is further magnified when the NCREIF ODCE fund and Townsend Core Property fund are used as private market benchmarks.

III. The Dynamic Relation between Public and Private Market Real Estate Returns

Empirical methodology: Vector Autoregressive Models (VAR)

We employ vector autoregression (VAR) models to measure the dynamics between public and private market real estate returns and the influence of asset pricing factors. In its simplest form, a VAR model is composed of a system of regressions where two or more dependent variables are expressed as linear functions of their own and each other's lagged values as well as some potential exogenous control variables. In more technical terms, a VAR model is the unconstrained reduced form of a dynamic simultaneous equations model. An unrestricted p^{th} -order Gaussian VAR model can be represented as:

$$Y_t = \mu + \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} + \dots + \Phi_p Y_{t-p} + e_t, \quad (15)$$

where Y_t is a vector of variables, μ is a $p \times 1$ vector of intercepts, $\Phi_1, \Phi_2, \dots, \Phi_k$ are $p \times p$ matrices of parameters with all eigenvalues of Φ having moduli less than one so that the VAR is stationary. e_t is a vector of uncorrelated structural shocks [$\sim NID(0, \Omega)$]. We obtain maximum likelihood estimates of Φ and Ω using iterated least squares. In our empirical implementation, we augment our VAR models with a vector of exogenous asset pricing control variables to capture other potential sources of variation in both sets of returns. We choose the number of quarterly lags in the VAR system based on examination of the Akaike Information Criteria (AIC), Schwarz Bayesian Information Criteria (SBIC), and the likelihood ratio selection criteria for various choices of p .

In a bivariate framework consisting of only REIT and TBI returns as endogenous variables, the diagonal coefficients of Φ represent conditional momentum in REIT and TBI returns, while the off-diagonal coefficients of Φ represent conditional positive feedback and anticipation effects (changes in TBI returns following changes in REIT returns and vice versa). In addition to quantifying the dynamic relation between REIT and TBI returns and controlling for important factors such as a potential smoothing bias in TBI, the VAR model allows us to estimate impulse response functions for the variables of interest. Impulse

response functions provide the time path of the short-run dynamic relations that result from a shock to the variables in the system.

Return Data

As discussed earlier, two key differences between REIT and TBI returns are that REIT returns are levered and the property mixes/weights differ across the two sets of returns. To address these differences, we carefully unlever REIT returns at the firm level and construct REIT portfolios with property type weights similar to the TBI portfolios we use as benchmarks in our analysis. The well-known smoothing bias of NCREIF returns is not likely an issue with TBI returns, but we also account for this potential effect with the inclusion of lagged TBI returns in our VAR analysis. However, there are likely other variables that differentially influence REIT and TBI returns, such as liquidity effects and standard asset pricing factors.

Previous studies either compare adjusted returns as we do in section II (e.g., Pagliari et al., 2005, and Riddiough et al., 2005) or perform conditional analyses using unadjusted returns and/or few or no asset pricing controls (Li et al., 2009, and Oikarinen et al., 2011). We next examine the conditional dynamic relation between private and public real estate returns using our All-Properties and Core-Properties return indices; we also control for a host of known asset pricing variables.

Asset Pricing Control Variables

To control for other potential sources of variation in public and private real estate returns, we include the following standard quarterly asset pricing control variables in all of our bivariate VAR specifications: the yield on three-month U.S. Treasury securities (*TBILL3M*), the slope of the Treasury term structure of interest rates (*TERMSPREAD*), the spread between yields on BAA rated and AAA rated corporate bonds (*DEFSPREAD*), the rate of inflation (*INFL*), and the excess return on the market portfolio (*MKT*) (e.g., Chen, Roll, and Ross, 1986; Ferson and Harvey, 1991; Fama and French, 1993; Fama and Schwert, 1977; Sharpe, 2002). In addition, we include the remaining Fama-French risk factors, *SMB* and *HML*, augmented by a return momentum factor, *MOM* (e.g., Fama and French 1996; Liew and Vassalou, 2000; Lettau and Ludvigson, 2001; Jegadeesh and Titman, 1993; and Carhart, 1997). To capture liquidity effects, we include Pastor and Stambaugh's (2003) liquidity innovation factor, *LIQ_PS*.

Prior research has shown that dividend (current) yields are also a significant predictor of subsequent asset price changes (Ghysels, Plazzi and Valkanov, 2007; Fama and French, 1988). Therefore, as additional control variables, we include the dividend yield on equity REITs (*DIVYLD*) and the aggregate capitalization rate (*CAPRATE*) for commercial properties (i.e., the ratio between a property's annual net rent and its price) as proxies for current yields. *CAPRATE* is each quarter's weighted average capitalization rate across apartment, industrial, office, and retail properties. Dividend yields and capitalization rates are obtained from NAREIT and the American Council of Life Insurers (ACLI), respectively.¹⁹ Table 4 reports descriptive statistics for the asset pricing control variables over our 1994:Q2-2010:4 sample period. The mean dividend yield (*DIVYLD*) for equity REITs is 6.1 percent and ranges from 3.6 percent to 9.4 percent. The average cap rate (*CAPRATE*) for commercial properties over our sample period is 8.2 percent, ranging from a low of 6.1 percent to a high of 9.4 percent. Both *DIVYLD* and *CAPRATE* also display significant first-order autocorrelations.

Unit Root Tests

A potential problem arises with the VAR framework if the variables in the system are non-stationary. In general, a series is non-stationary if its mean, autocovariances, or other higher moments are time dependent. If a series is non-stationary, simple time-series techniques can result in misleading (or spurious) values of inferential statistics (i.e., t-statistics, R^2 and DW) that may cause one to erroneously conclude that a meaningful relation exists among the regression variables.²⁰

Table 5 reports Augmented Dickey-Fuller (DF), DF-GLS and Phillips-Perron unit root test results for the various unlevered equity REIT and TBI return series used in our VAR analysis. The null hypothesis is that the return series contains a unit root. We also report the first and second autocorrelations to further document each return series' time dependency. The sample period for the tests spans 1994:Q2-2010:Q4.

¹⁹ In contrast to our asset pricing control variables, Li et al. (2009) use only a limited number of economic controls in their VAR framework (i.e., GDP, credit spread, term spread, and Fed funds rate), while Oikarinen et al. (2011) do not use any asset pricing control in their cointegration and VEC analysis.

²⁰ Simply stated, the test for a unit root (non-stationarity) in a time series is the test that a regression of a series on itself lagged one period yields a coefficient of one, although this test is complicated by several features arising from the non-stationarity of the series under the null hypothesis.

Overwhelmingly, the unit root tests indicate that non-stationarity is not a problem with our return series. In all but four test cases, the null of a unit root is rejected at the 1 percent significance level. In these four cases, the null is rejected at the 1 percent significance level with two of the three unit root tests. Similarly, the autocorrelations are relatively small and mostly insignificant for each of the unlevered REIT return series. Only the TBI Core-Properties index and the TBI office index display some significant persistence in their returns, but the autocorrelations are not above 0.55. Furthermore, untabulated lag autocorrelations drop off quickly, and the unit root tests reject the null of a unit root at the 5 percent significance level for each test for both Core-Properties and office TBI returns. In sum, the results from the unit-root tests suggest that each of the return series we use in our unconstrained bivariate VAR specifications are stationary, so a vector error correction (VEC) model is not the appropriate model for our analysis.

Although not tabulated, we also conducted a battery of cointegration tests. The results varied somewhat conditional on the inclusion of exogenous asset pricing control variables and the assumptions of the cointegration test (deterministic trend test assumptions). When asset pricing control variables are included, the number of cointegrating relations among the bivariate returns is zero for virtually every test specification assumption. In cointegration tests that exclude the exogenous asset pricing control variables, the number of cointegrating relations varies by the model specification assumptions employed. Tests that exclude asset pricing controls and include an intercept and trend suggest zero cointegrating relations across tests (trace and maximum eigenvalue), while test specifications that exclude exogenous asset pricing controls and assume no intercept or trend suggest that the number of cointegrating relations is one. Overall, the unit root and cointegration tests suggest that a VAR model is appropriate for our analysis.²¹

Baseline Dynamic Relations between TBI Returns and Unlevered REIT Returns

Table 6 contains our baseline VAR results using TBI returns and unlevered REIT returns as endogenous variables; exogenous asset pricing control variables are excluded from the specifications. The first set of results in Panel A contains the individual coefficient

²¹ Li et al. (2009) also use a VAR framework. Oikarinen et al. (2011) use a cointegration and VEC framework, although they do not use leverage and property-type adjusted returns or asset pricing controls in their analysis.

estimates from using the All-Properties REIT and All-Properties TBI indices; the second set of results contains the individual coefficient estimates obtained from estimating the models using our Core-Properties indices. The quarterly lag-length of the VARs is chosen by using AIC, SBIC, and the likelihood ratio criterion. In Panel B of Table 6, we report the sum of the lagged coefficients of the endogenous variables and test for their joint significance. P-values associated with these joint tests are reported in parentheses. ***, **, and * represent 1 percent, 5 percent, and 10 percent significance levels, respectively.

Quarterly REIT returns (*REITRET*) predict TBI returns (*TBIRET*) in subsequent quarters using both the All-Properties and Core-Properties indices. However, lagged TBI returns have no predictive power in the *REITRET* equations. In fact, the adjusted R²'s for the *REITRET* equations are negative; in contrast, they range from approximately 26 percent in the All-Properties *TBIRET* return equation to 46 percent in the Core-Properties *TBIRET* return equation. That is, the Core-Properties REIT index is able to explain significantly more variation in TBI returns than the All-Properties REIT index. This highlights the importance of adjusting for differences in the mix of property types when constructing aggregate indices.

The sum of the four lagged estimated coefficients on *REITRET* in the *TBIRET* equation is positive and highly significant (Panel B). The sum of the four lagged coefficients on *TBIRET* is marginally significant in both *TBIRET* equations. However, the magnitude of this TBI return effect is small in comparison to the impact of REIT returns. Overall, the results reported in Table 6 suggest that lagged REIT returns are predictive of returns in the private market.

In Table 7 we report the results obtained from separately estimating our VAR model for each of the four core property types. Standard asset pricing controls are again excluded. To examine the cumulative effects of the lagged endogenous variables, we report the sum of the estimated coefficients on the four lags of *REITRET* and *TBIRET* and associated tests of joint significance. Similar to the All-Properties and Core-Properties results reported in Table 6, lagged REIT returns are highly predictive of TBI returns across each of the four property type specifications. However, TBI returns have no predictive power in the *REITRET* equations. For industrial and office properties, lagged TBI returns have some predictive power in the *TBIRET* equations. However, the magnitude and significance of the lagged coefficients on *REITRET* in the *TBIRET* equations are much larger and more significant. We also find that each of the four *REITRET* equations has a negative adjusted

R^2 , further indicating that neither lagged REIT returns nor lagged TBI returns are able to predict current REIT returns.

Although not tabulated, Granger causality tests confirm the influence of REIT returns on TBI returns using our baseline bivariate VAR model. In each bivariate VAR specification, we can reject the null hypothesis that REIT returns do not cause TBI returns at the 5 percent level. In contrast, we cannot reject the null hypothesis that TBI returns do not cause REIT returns for any of the four property types. These findings are consistent with Li et al. (2009) and Oikarinen et al. (2011).

Adding Asset Pricing Control Variables

Our baseline VAR results do not control for asset pricing variables. However, REIT share prices are quicker than private market values to embed information given their greater liquidity. Therefore, adding exogenous asset pricing control variables could serve as a direct channel, thereby resulting in a reduction in the predictive ability of REIT returns in our *TBIRET* equations. This alternative channel, however, does not take away from our earlier results on the predictive power of REITs, but rather provides evidence on the sources of that predictability. We therefore include in an enhanced specification a quarterly lag of the following set of standard exogenous asset pricing control variables in both the REIT and TBI return equations: the yield on the three-month Treasury bill, the slope of the Treasury term structure of interest rates, the spread between yields on BAA rated and AAA rated corporate bonds, inflation, the three Fama-French risk factors (*MKT*, *SMB*, and *HML*) augmented by momentum, Pastor and Stambaugh's innovation liquidity factor, the dividend yield on equity REITs, and the average capitalization rate for commercial properties.

Looking first at the estimated effects of lagged endogenous variables in Panel A of Table 8, we see that lagged REIT and TBI returns have no significant influence on contemporaneous REIT returns across both the All-Properties and Core-Properties specifications. These results are consistent with our baseline specification results without exogenous controls. However, in contrast to our baseline results, we find in Panel A that only the three quarter lag of *REITRET* is positive and significant in the *TBIRET* equation. Moreover, in our All-Properties specification the sum of the four lagged coefficients on *REITRET* is no longer significant in the *TBIRET* equation. It is important to note, however, that the sum of the four lagged coefficients on *REITRET* remains significant in the Core-

Properties specification (p-value = 0.011). This again highlights the importance of using only “core” REITs when comparing the risk-return characteristics of REITs to private market returns as measured by the NCREIF NPI or TBI indices. The Core-Properties result also suggests that there is some additional predictive power in REITs beyond standard asset pricing controls in explaining private market returns.

Overall, our results strongly suggest that asset pricing control variables are an important fundamental channel through which REIT returns influence TBI returns. Lagged inflation (*INFL*), for example, has a significant effect on both REIT and TBI returns. This finding is consistent with Hoesli, et al. (2008) who document that real estate returns are linked to inflation. Similarly, REIT returns are influenced by several asset pricing variables including *SMB*, *MOM*, and *LIQ_PS*, while TBI returns are associated with lagged values of *CAPRATE*.²² The adjusted R²s for the REIT return specifications are now positive, suggesting again that the models are better specified when exogenous control variables are included.

Although not separately tabulated, we also performed numerous robustness checks. These checks include adding control variables such as real non-durable consumption expenditures, the percentage of properties sold from the NCREIF NPI index as a measure of private market liquidity, REIT turnover measures, and the use of levered REIT returns. In each case, the results are similar to those reported above, with no inferential or economic significance changes.

The results reported in Table 9, based on separate estimates for each property type, further demonstrate the importance of including asset pricing controls. For apartment and office properties, lagged REIT returns continue to predict TBI returns, although the impact is again muted relative to specifications that do not include the exogenous controls. However, for industrial and retail properties, the sum of the lagged coefficients on *REITRET* in the *TBIRET* equation cannot be distinguished from zero. The adjusted R²s for each of the four REIT return equations are positive and range from 4 percent to 16.6 percent, providing additional evidence that exogenous asset pricing controls are important determinates of REIT returns. Although not reported, *INFL_{t-1}* has a significant effect on

²² While *MKT* is not statistically significant in any of our complete model specification results, it is significant if we exclude all of the other exogenous controls. This result suggests that the *MKT* effect is being absorbed by the inclusion of the other asset pricing control variables.

both REIT and TBI returns across property types. Similarly, REIT returns by property type are significantly influenced by *SMB*, *MOM*, and *LIQ_PS*.

Impulse Response Functions: REIT and TBI Return Dynamics

We employ generalized impulse response functions to further quantify the economic significance of relations between the REIT and TBI returns. Impulse response functions trace the effect of a one standard deviation residual shock to current and future values of the endogenous variables within the dynamic structure of the VAR. We express responses in standard deviation units similar to Griffin, Nardari, and Stulz (2007). In particular, we standardize each variable in our VAR prior to estimation and then generate the associated impulse response functions. Similar to Statman, Thorley, and Vorkink (2006), we also aggregate responses across periods to illustrate the cumulative effect of REIT returns on TBI returns over time.

The VAR generalized impulse response functions displayed in Figure 16 provide additional evidence regarding the impact of REIT returns on TBI returns. In Panel A, we provide the impulse response functions for our All-Properties and Core-Properties indices using the baseline VAR specifications that exclude exogenous control variables. Panel B presents the corresponding impulse response functions from the VAR specifications that include exogenous control variables. The vertical axis in each panel measures the standard deviation change in TBI returns in response to a one standard deviation shock in REIT returns. The solid line in each figure represents the estimated diffusion of quarterly TBI returns to a shock in REIT returns, whereas the remaining two curves depict the 95 percent confidence interval of these estimates.

Panel A of Figure 16 reveals an economically significant increase in TBI returns in response to a shock to REIT returns for both the All-Properties and Core-Properties REIT indices. In particular, a one SD shock to the All-Properties REIT return index results in a 1.037 SD change in All-Properties TBI returns over the subsequent four quarters. In percentage terms, this is a 5.08 percent change in TBI returns. Similarly, a one standard deviation shock to the Core-Properties REIT returns results in a 1.168 SD change in Core-Properties TBI returns over the subsequent four quarters; this is a 4.15 percent change in TBI returns. In sharp contrast, Panel B shows that when the exogenous asset pricing control variables are included in the VAR specifications, the TBI return response to a shock

in REIT returns is substantially muted and statistically not different from zero as displayed by the 95 percent confidence bounds.

IV. Public and Private Market Real Estate Return Volatility Dynamics

Until recently, the focus of most financial time series modeling centered on measuring and understanding mean effects (i.e., conditional first moments). However, as risk and uncertainty considerations increased in importance, new econometric techniques have been developed that allow for the modeling of time-varying variances (i.e., conditional second moments). Particularly noteworthy is the autoregressive conditional heteroskedastic (ARCH) model introduced by Engle (1982) and a more generalized version (GARCH) developed by Bollerslev (1986). Numerous studies have found GARCH models useful in describing a wide array of financial time series such as interest rates, exchange rates, and stock prices because they enable conditional variances to change through time, thus allowing time-varying volatility to be explicitly modeled. Theoretical research by Ross (1989) suggests that volatility is related to the rate of information flow.

In our volatility analysis, we examine time-varying conditional return variances using GARCH models. This analysis allows us to assess the extent to which conditional volatility influences REIT and TBI returns and the extent to which these returns have an influence on their cross-market conditional return variances.

Consider the following generalized GARCH model of public and private market returns:

$$R_t = \sum_{i=1}^N \gamma_i X_{it} + \theta f(h_t) + \varepsilon_t \quad (16)$$

$$\varepsilon_t \sim N(0, h_t)$$

$$h_t = \alpha_0 + \sum_{i=1}^{NAR} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{NMA} \beta_j h_{t-j} + \sum_{k=1}^{NGT} \phi_k g_{kt}$$

where:

X_{it} = is a set of explanatory variables,

h_t = is the conditional variance (GARCH),

g_{kt} = is a set of explanatory variables.

The explanatory variables, X_{it} , are economic and other variables (including lagged returns) that impact returns over time, while g_{kt} are variables that impact the variance of returns.

In general, the conditional variance, h_t , captures the relation between the volatility of returns and explanatory variables, including lagged return volatility. The estimated ϕ coefficients provide direct information on the relation between the conditional variance and the explanatory variables, including past returns. The γ coefficients and θ provide information on the mean effect (i.e., return effects through the explanatory variables and through a variance effect – the mean effect (M) GARCH-M). If $NMA=0$, the model becomes a pure ARCH model. ARCH models allow the residuals to have a variable variance and still have a zero conditional mean.

In Table 10 we report GARCH estimates for TBI and REIT returns using both our All-Properties (Panel A) and Core-Properties (Panel B) return indices. The first specification (model 1) includes two lags of within-market returns, two lags for the cross market returns, and no asset pricing control variables in the returns (mean) equation. For the variance equation, we include a constant, one-period lags of squared residuals (NAR (1)), and lagged conditional variance, GARCH(-1), (NMA (1)). Unlike the first specification, model (2) includes asset pricing controls in the returns equation. Finally, model (3) includes lagged, squared cross-market returns in the variance equation to capture the extent to which they influence the other market's return variance (e.g., $REITRET^2$ on $TBIRET$ variance).²³

We find that lagged REIT returns have a significant influence on TBI returns within a GARCH framework. In the conditional variance equation, the lagged conditional variance also has a significant impact. However, lagged REIT returns no longer have a significant predictive effect on TBI returns once asset pricing controls are included [model (2)]. This result is consistent with our earlier VAR findings. Similar to our baseline GARCH specification, we also find a lagged conditional variance effect in the conditional variance equation. In the third $TBIRET$ specification, we find that the inclusion of lagged squared REIT returns in the conditional variance equation has a marginally significant effect (p-value = 0.095) and subsumes the lagged GARCH effect. Overall, these results suggest that REIT returns continue to contain some marginal variance information for future TBI returns, even after controlling for asset pricing variables in the returns equation.

²³ The specifications are relatively parsimonious and focused primarily on cross-market return tests because including additional variables in the mean or variance equation results in convergence problems. We also include the asset pricing controls in the return equation given our earlier findings that these variables significantly affect the influence of REIT returns on TBI returns. If we include the conditional variance in the mean equation, the return models often fail to converge.

The second half of Panel A in Table 10 contains results for the REIT return GARCH models. For model (1) we find that lagged REIT returns have a marginally significant predictive effect. In the conditional variance equation, both lagged squared residuals and the lagged conditional variance have a significant effect on the conditional variance of REIT returns. In the model specification that includes asset pricing controls, we find that the lagged predictive marginal effect is no longer significant. However, we continue to find that both lagged squared residuals and the lagged conditional variance have a significant effect on the conditional variance of REIT returns. Finally, the results for model (3) suggest that lagged TBI returns do not have a significant information transmission to the conditional variance of REIT returns.

Turning to our GARCH estimates using our Core-Properties indices (Panel B of Table 10), we find some lagged return effects when the asset pricing controls are excluded, but no significant lagged return effects when the asset pricing controls are included. Similar to Panel A, we continue to find a lagged conditional variance (GARCH(-1)) effect in the conditional variance equation. One notable difference with the Core-Properties results is that lagged squared REIT returns do not influence the conditional variance of TBI returns. However, it is important to note that this specification would only converge with one lag of squared REIT returns in the conditional variance equation.²⁴

V. Conclusion

Both the direct private market and the public securities market can provide investors with exposure to local property markets. However, public and private commercial real estate returns, as commonly measured, have exhibited significantly different risk-return characteristics. According to several recent studies, investments in direct private real estate have produced lower average returns than investments in publicly-traded real estate investment trusts (REITs), even after controlling for differences in financial leverage and property mix. However, these and other studies also document that the measured volatility of returns on private real estate portfolios is lower than the volatility of returns on public real estate portfolios. Moreover, public and private real estate returns, as commonly measured, display limited correlation over quarterly and annual horizons.

²⁴ Though not tabulated, the GARCH return results by property type provide similar results to the Core property results.

Comparing public and private real estate returns, both unconditionally and conditionally, requires several adjustments. We employ a two-stage approach. First, we use a nonparametric approach that consists of adjusting the composition and risk characteristics of publicly-traded REIT portfolios to match as closely as possible the composition and characteristics of our benchmark private market portfolios. In particular, we unlever equity REIT returns at the firm level before aggregating into portfolios. In addition, when aggregating returns across property types to create representative portfolios, each major property type is assigned the same weight in both the public market and private market portfolios.

Our sample period runs from 1994Q2-2010Q4, thereby capturing the recent boom and bust in commercial real estate markets. However, in addition to extending the time period under analysis, our procedure for unlevering REIT returns at the firm level, our careful classification of each REIT's property type focus and our construction of an aggregate index that includes only those REITs that invest primarily in core property types collectively provide a contribution to the existing literature on the relative return performance of private and public market commercial real estate. We find evidence in our first-stage analysis that portfolios of U.S. office, industrial, and retail REITs have produced higher returns than their private market benchmarks; only in the multifamily market do we find evidence of higher return performance in the private market. In the aggregate, unlevered core REITs outperformed their private market benchmark by 46 basis points (annualized) over the 1994Q2 to 2010Q4 sample period.

Although we carefully unlever REIT returns and construct REIT portfolios with similar property types and weights as our private market benchmark portfolios, there are likely other factors that differentially influence the relative risk and return characteristics of public and private real estate investments. These other factors include liquidity, inflation, dividend yields, the term structure of interest rates, defaults spreads, as well as standard CAPM and Fama-French risk factors. Therefore, in our second stage analysis, we use vector autoregressive (VAR) models and various asset pricing controls to examine the dynamics between public and private real estate returns and volatility. This dynamic analysis allows us to answer several important questions, including the extent to which each market is influenced by risk factors and the degree to which public market returns predict private market returns. We also examine the time-varying volatility of public and private market returns using GARCH procedures, which allow us to quantify the

conditional volatility of public and private market returns, their cross-sectional relation, and the factors that influence them.

Our baseline bivariate VAR results that exclude asset pricing controls suggest lagged REIT returns are highly predictive of private market returns; in contrast, lagged private market returns have no predictive power in our REIT return regressions. Results including asset pricing controls suggest that common asset pricing control variables, which are correlated with REIT returns, are an important channel through which public market returns appear to be predictive of private market returns. We also find that lagged returns on a portfolio of REITs that invest in core properties (apartments, office, industrial, and retail) better predict private market returns than broader REIT market return indices that include non-core properties. This result highlights the importance of using “core” REITs when comparing the risk return characteristics of REITs and private market investment vehicles. GARCH model estimates confirm our VAR results, but also suggest that REIT returns contain some marginal conditional variance information for TBI returns, even after controlling for asset pricing variables in the returns equation.

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Figure 1: NPI Cumulative Returns

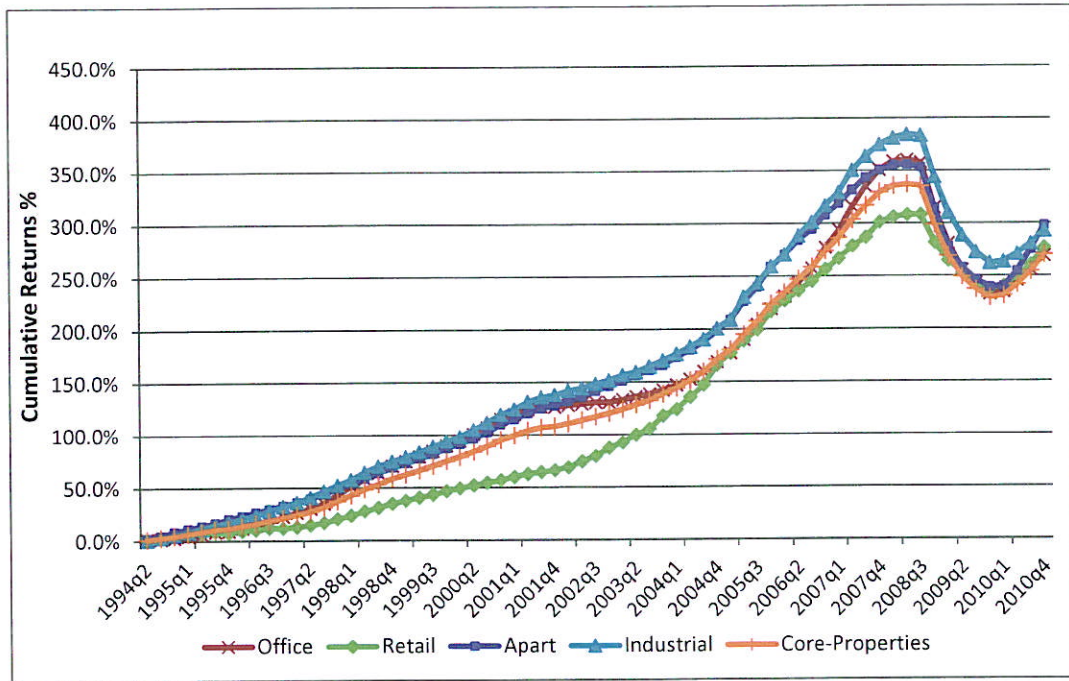


Figure 2: TBI Cumulative Returns

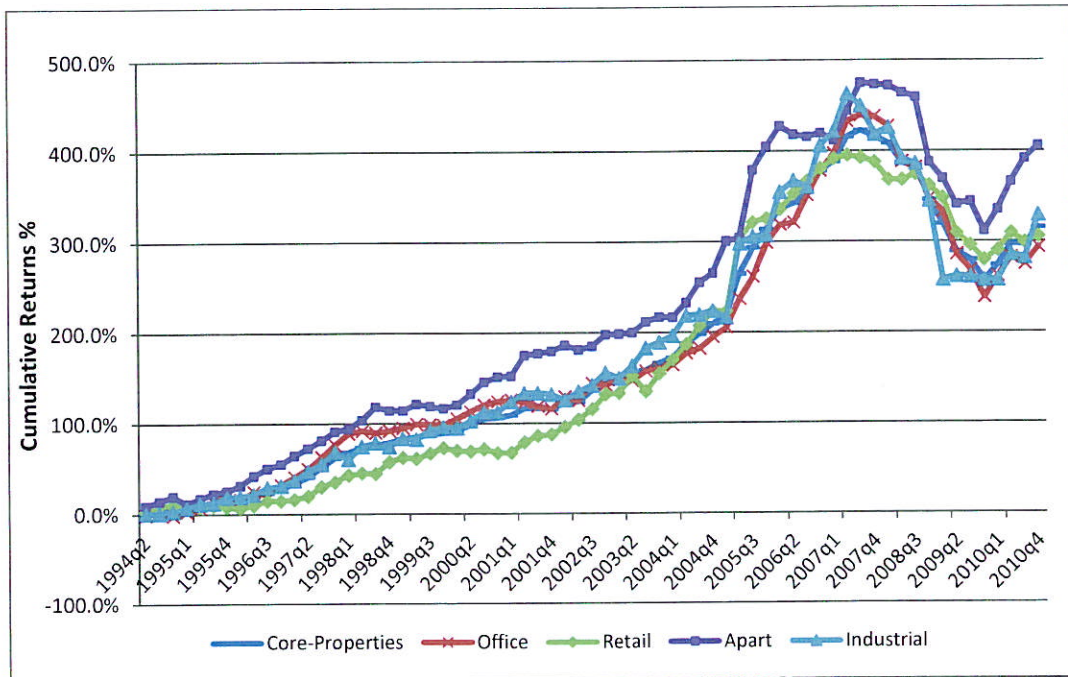


Figure 3: Cumulative Returns: All-Properties REIT Index vs. Core-Properties TBI

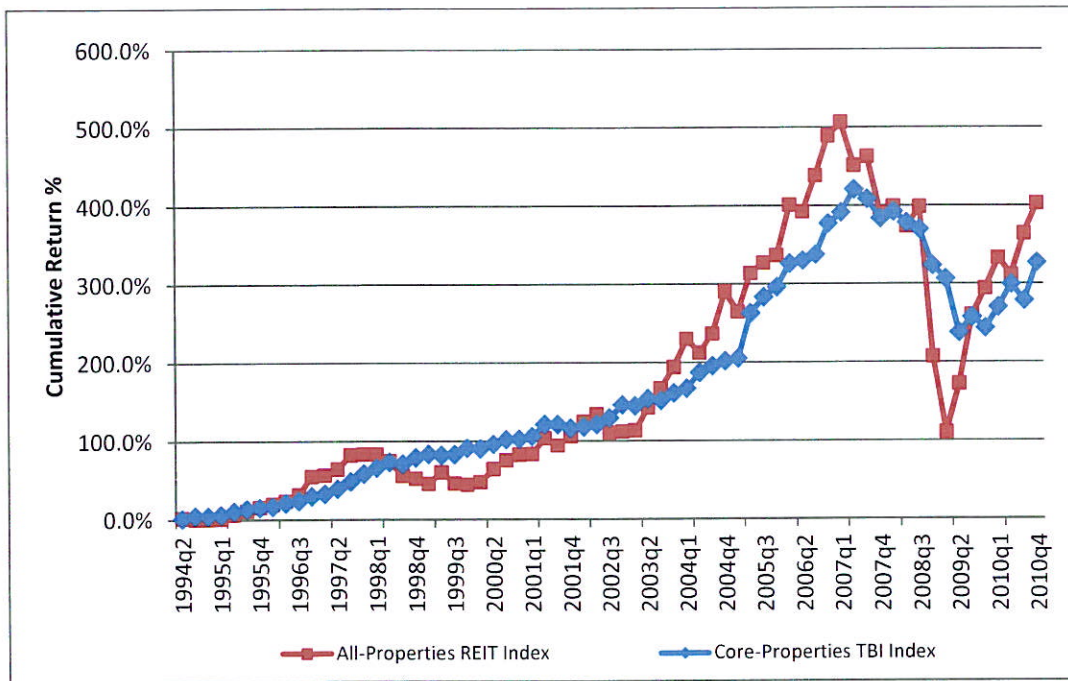


Figure 4: Cumulative Returns: Levered REITs

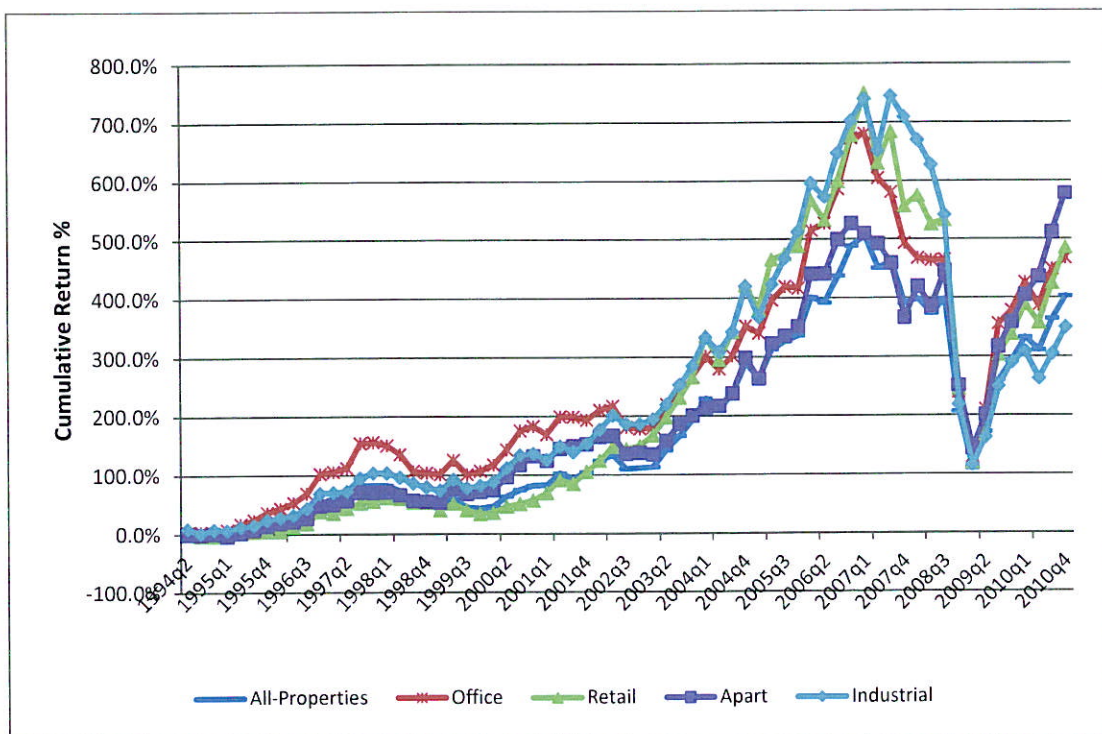


Figure 5: Components of REIT Capital Structures

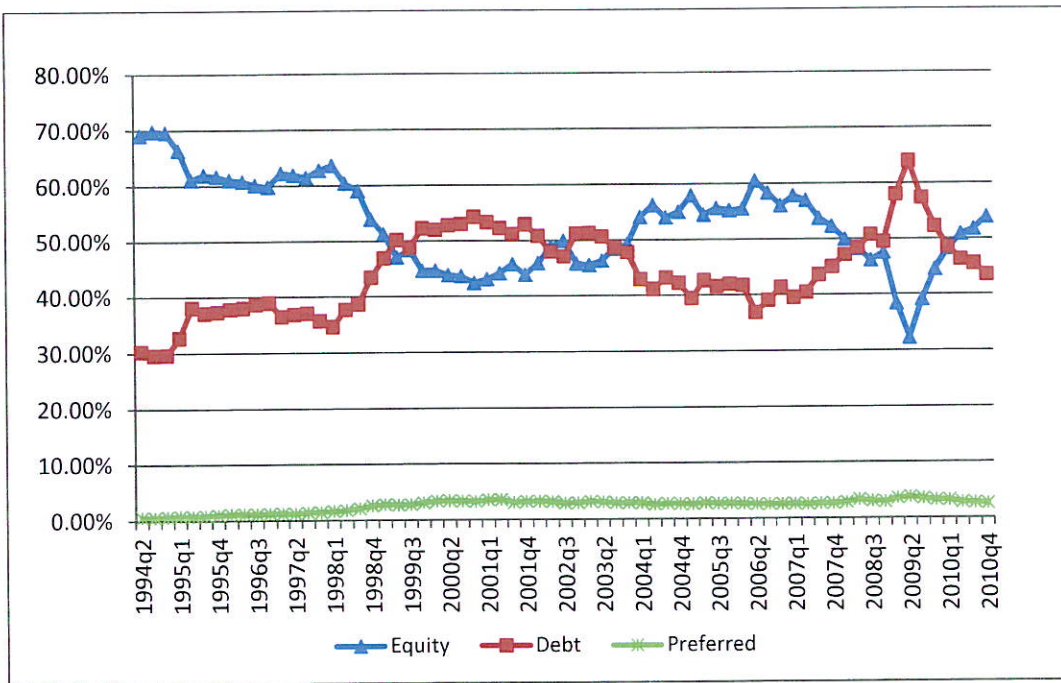


Figure 6. Cumulative Returns: Levered vs. Unlevered REITs

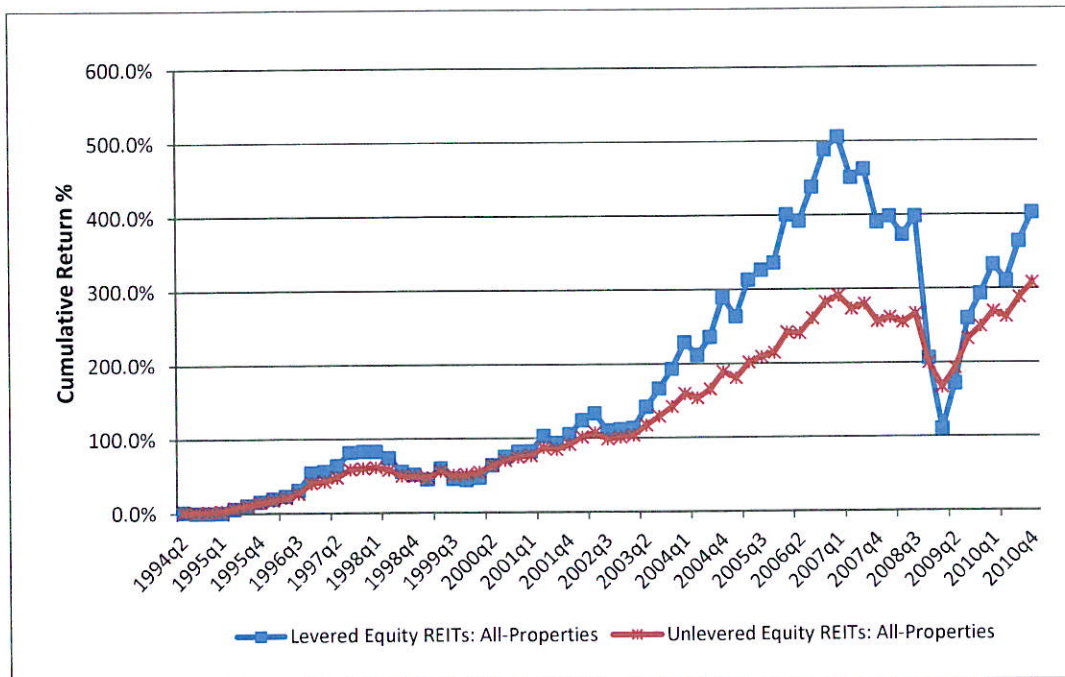


Figure 7: Number of REITs: All-Properties Index vs. Core-Properties Index

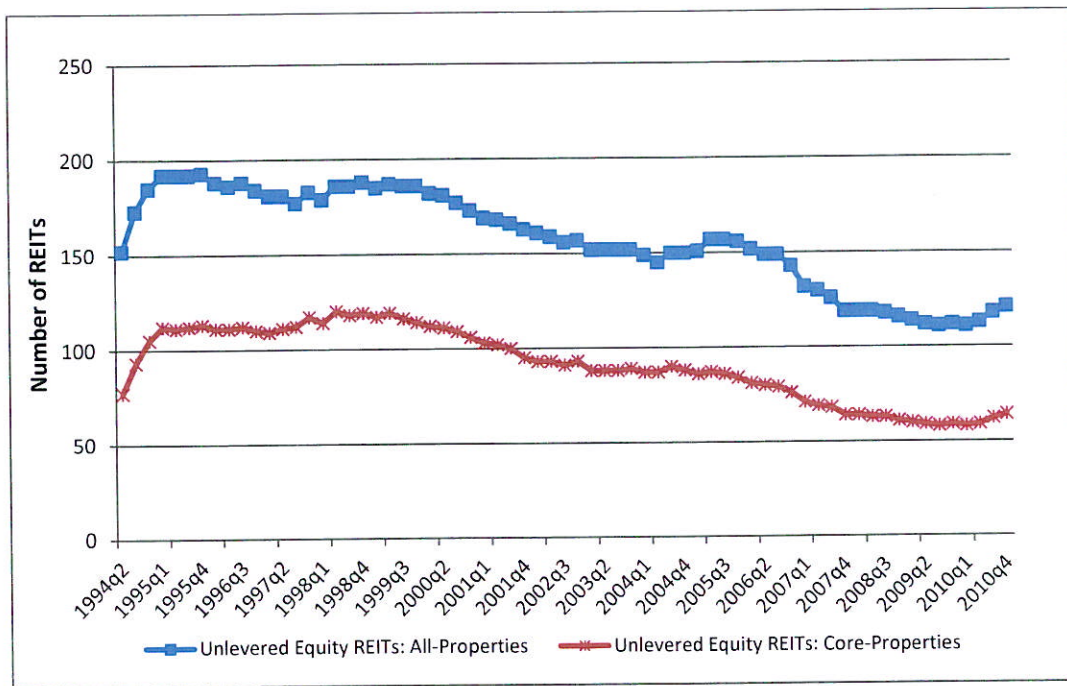


Figure 8: Core Focused REITs as a Percentage of Total

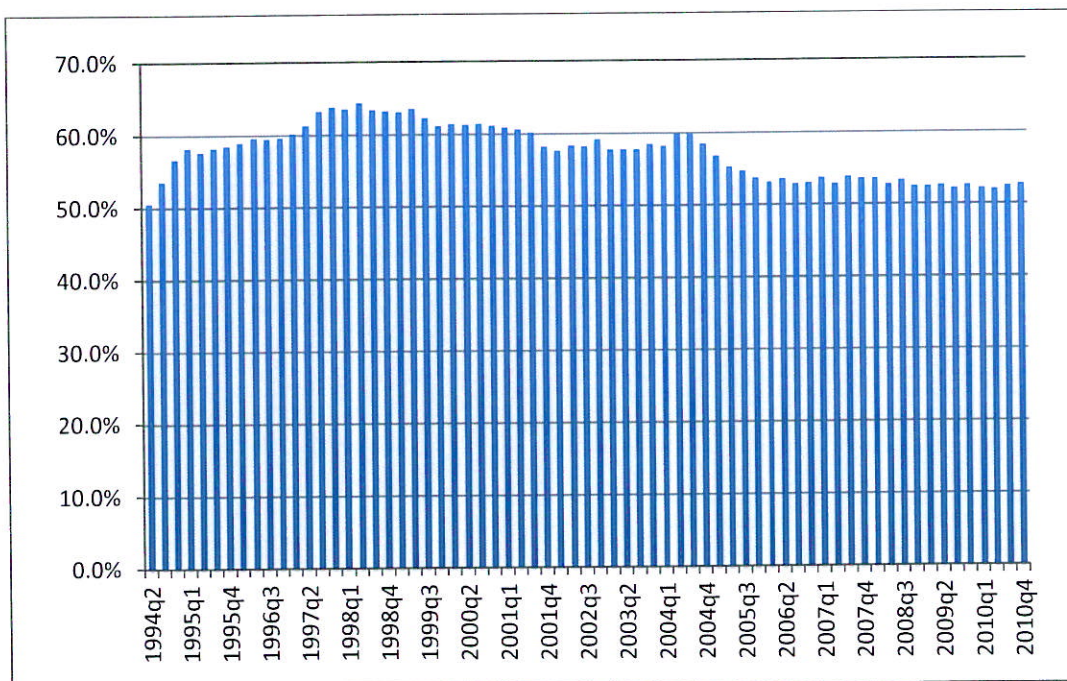


Figure 9: Cumulative Unlevered REIT Returns: All-Properties vs. Core-Properties

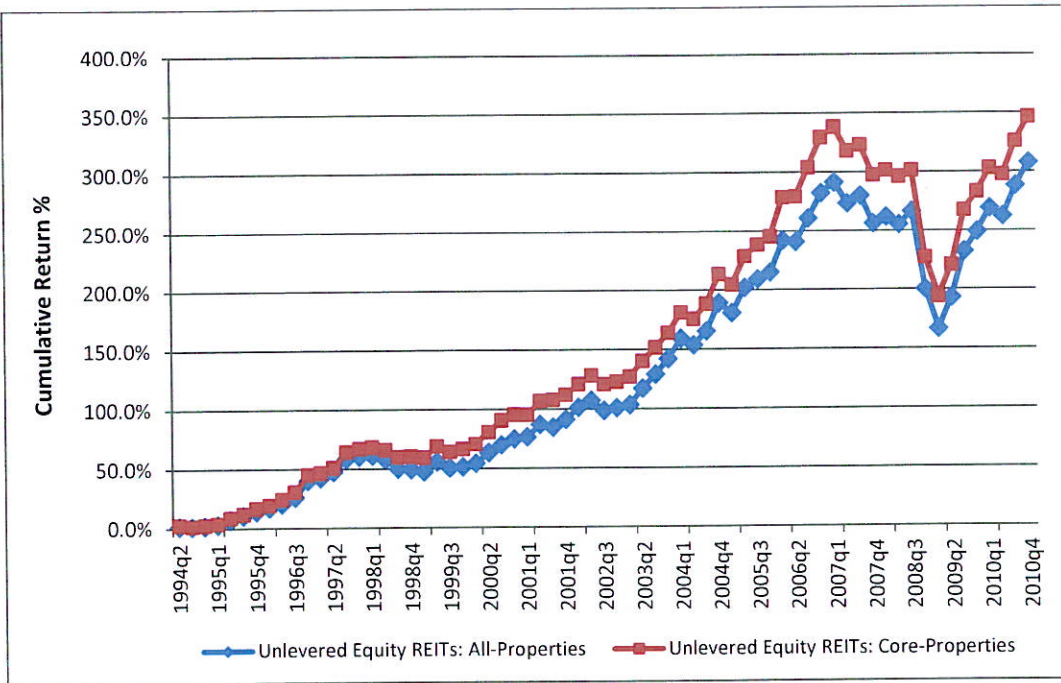


Figure 10: Cumulative Unlevered Returns on Core-Properties: REITs vs. TBI

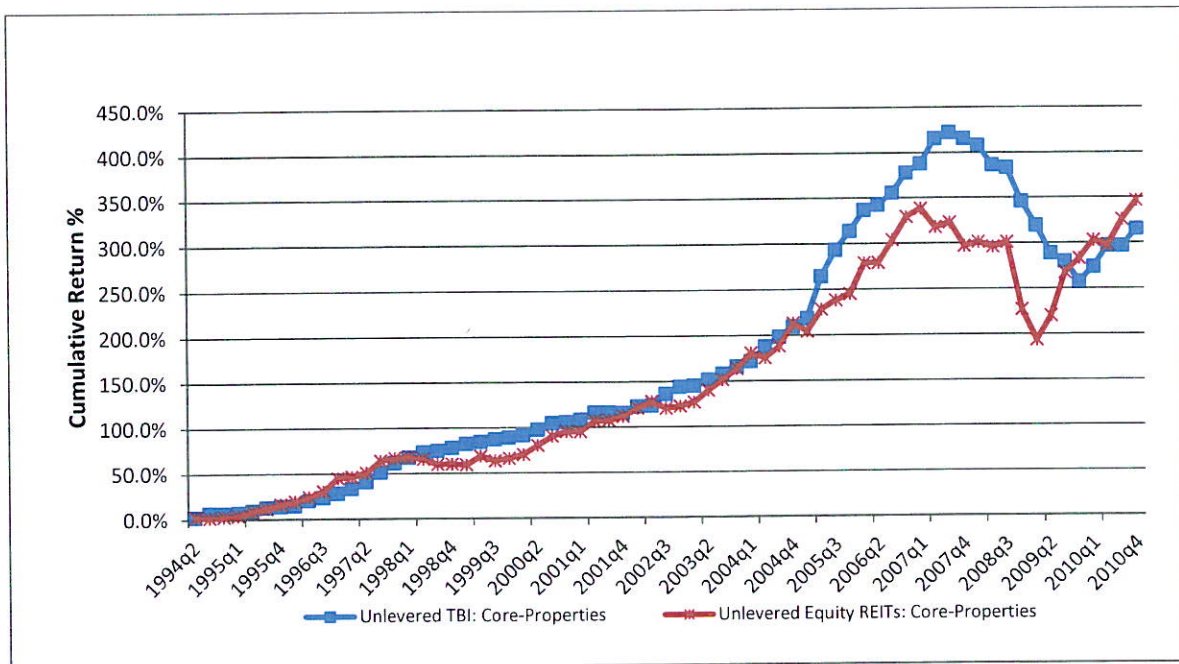


Figure 11: Cumulative Unlevered Apartment Returns: REITs vs. TBI

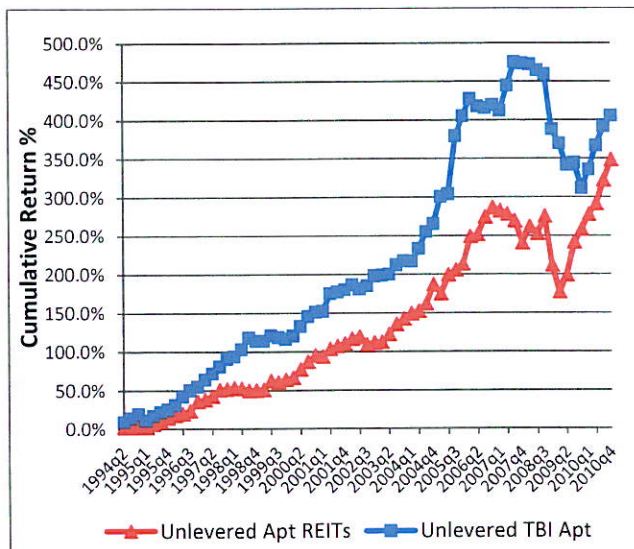


Figure 12: Cumulative Unlevered Industrial Returns: REITs vs. TBI

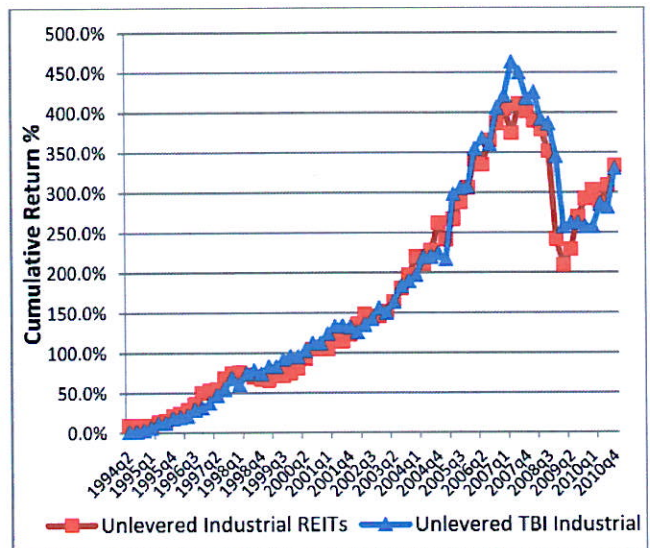


Figure 13: Cumulative Unlevered Office Returns: REITs vs. TBI

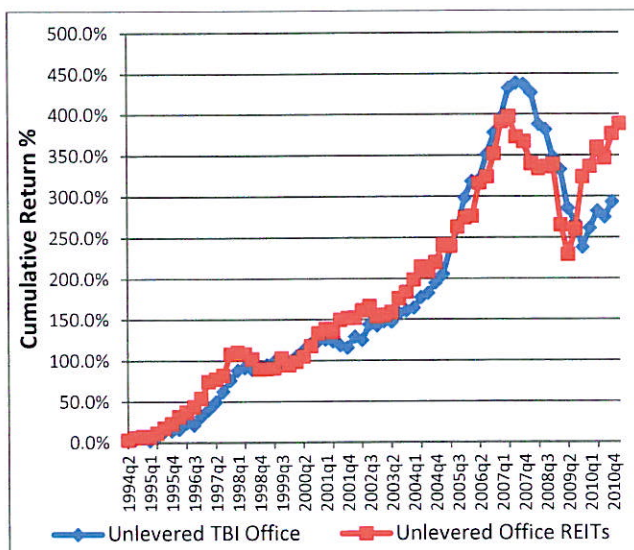


Figure 14: Cumulative Unlevered Retail Returns: REITs vs. TBI

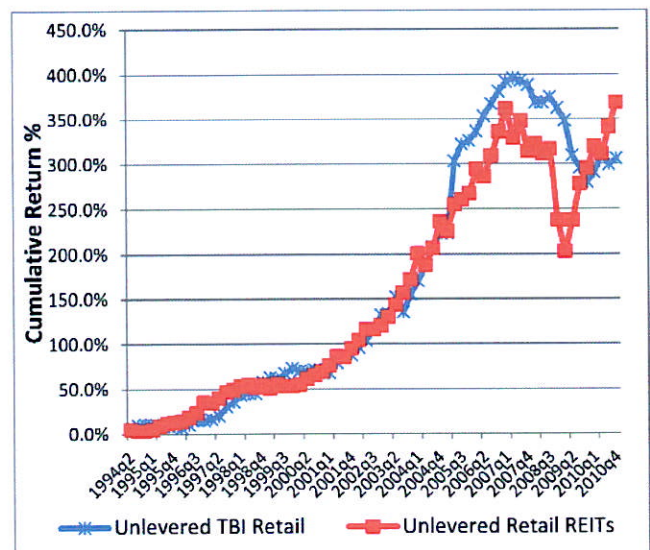


Figure 15: Cumulative Unlevered Returns: Core-Properties REIT Index vs. Private Equity Funds

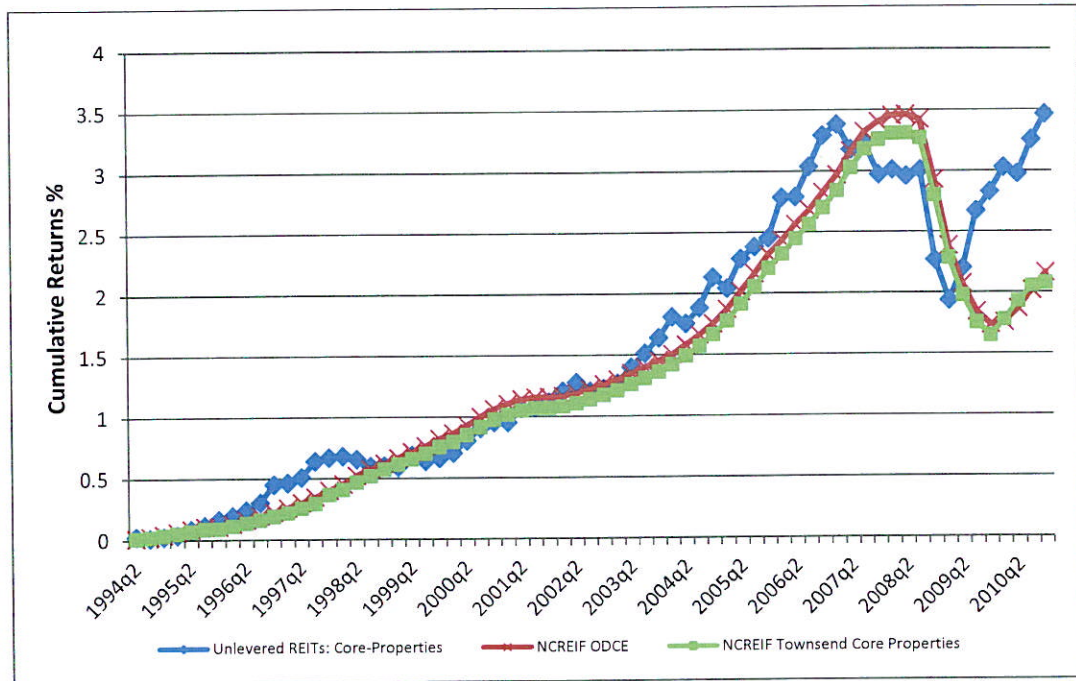
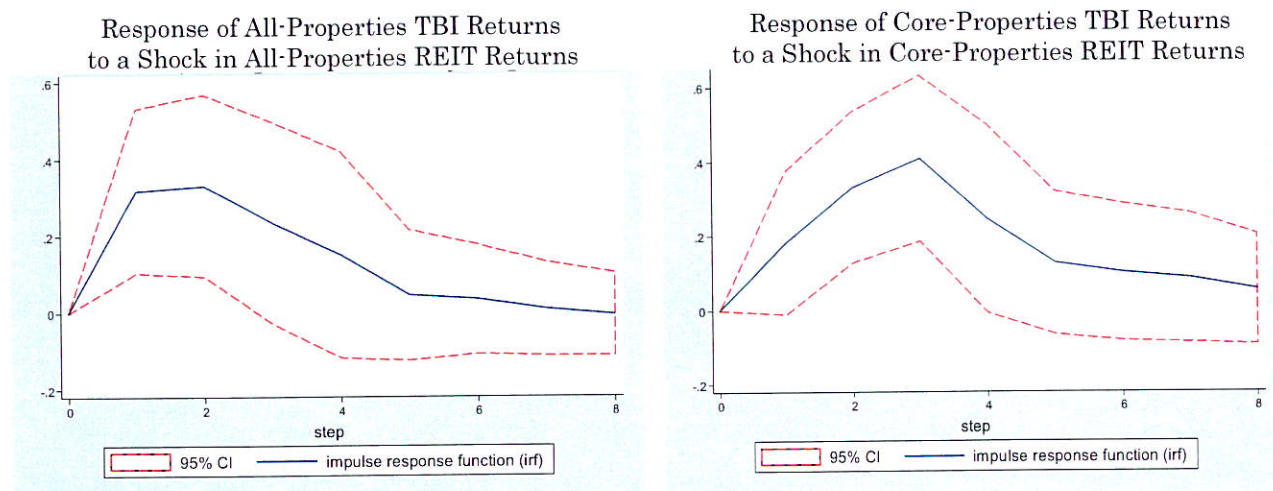
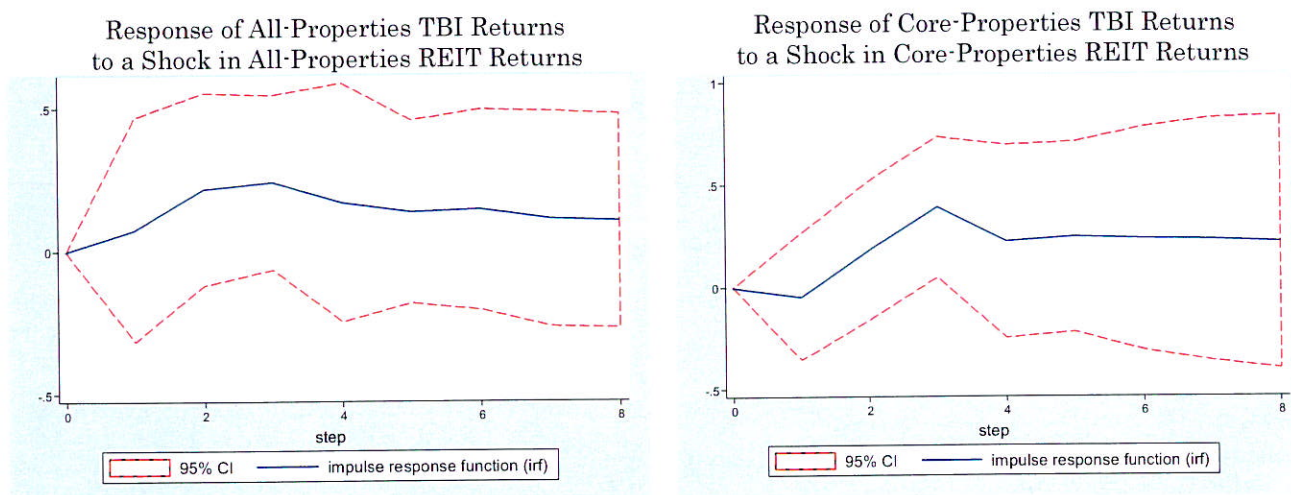


Figure 16: Impulse Response Functions

Panel A: VAR Specifications Excluding Asset Pricing Control Variables



Panel B: VAR Specifications Including Asset Pricing Control Variables



The impulse response functions are generated from a generalized one standard deviation change (i.e., shock) in each noted return series.

Table 1
Return Statistics: Public and Private Real Estate Markets

This table provides summary statistics for private real estate market returns (panels A and B) and levered and unlevered equity REITs returns (panels C, D, and E, respectively) over the 1994Q2-2010Q4 sample period. Panel A reports summary statistics for total returns, net of estimated management fees, on our constructed Core-Properties NPI index (which excludes hotels), along with the constituent multifamily, office, industrial, and retail NPI indices. Panel B reports summary statistics for total returns, net of management fees, on our constructed aggregate Core-Properties TBI index, along with the constituent multifamily, office, industrial, and retail TBI indices. We use the same property-type weights to construct our Core-Properties TBI index as are used to construct our NPI Core-Properties index. Panel C reports descriptive statistics for our All-Properties levered REIT index, obtained directly from FTSE-NAREIT, and for each levered property type index. Panel D contains summary statistics on our constructed, unlevered, all property types index as well as on the four core property type indices; panel E reports summary statistics for our unlevered core index. Geometric means and standard deviations are reported on an annualized basis. Autocorrelations are based on quarterly returns.

	Mean Return	Standard Deviation	Auto- Correlation
<u>Private Market Returns</u>			
Panel A:			
Aggregate NPI: Core-Properties	8.12%	4.99%	0.85
Apartment	8.59%	5.21%	0.84
Office	8.10%	5.78%	0.84
Industrial	8.51%	5.10%	0.82
Retail	8.24%	4.52%	0.76
Panel B:			
Aggregate TBI: Core-Properties	8.88%	7.10%	0.55
Apartment	10.16%	9.15%	0.23
Office	8.52%	9.13%	0.36
Industrial	9.09%	11.43%	0.02
Retail	8.72%	9.22%	0.17
<u>Levered Equity REIT Returns</u>			
Panel C:			
Aggregate: All-Properties	10.12%	21.41%	0.19
Apartment	12.11%	21.45%	0.14
Office	10.92%	24.31%	0.25
Industrial	9.39%	23.23%	0.29
Retail	11.13%	24.58%	0.13
<u>Unlevered Equity REIT Returns</u>			
Panel D:			
Aggregate: All-Properties	8.76%	9.92%	0.17
Apartment	9.29%	9.66%	0.11
Office	9.73%	10.73%	0.25
Industrial	9.05%	11.39%	0.20
Retail	9.44%	10.18%	0.08
Panel E:			
Aggregate: Core-Properties	9.34%	9.79%	0.20

Table 2
Number of REITs in Our Constructed Real Estate Indices

This table lists the number of REITs using various data filters at the end of each year over the 1994Q2-2010Q4 sample period. Column A reports the number of REITs used in the construction of the Equity REITs Value Weighted index reported by CRSP-Ziman. Column B reports the number of equity REITs in our constructed sample at the beginning of the fourth quarter of each year before merging with Compustat to obtain the accounting data necessary to delever firm-level REIT returns. Column D reports the number of equity REITs in our constructed sample at the beginning of the fourth quarter of each year after merging with Compustat. Column F reports the number of equity REITs in our Core-Properties index in the fourth quarter of each year based on quarterly classifications from CRSP-Ziman.

	(A)	(B)	(C)	(D)	(E)	(F)	(G)
	CRSP- Ziman REIT Universe	Self- Constructed Sample Before Compustat	(A)-(B)	Self- Constructed Sample After Compustat	(B)-(D)	Number of Core Focused REITs	(D)-(F)
Year							
1994	196	189	7	185	4	105	80
1995	196	196	0	193	3	113	80
1996	190	191	-1	184	7	110	74
1997	194	185	9	183	2	117	66
1998	190	192	-2	188	4	119	69
1999	185	189	-4	186	3	114	72
2000	170	179	-9	173	6	106	67
2001	163	169	-6	163	6	95	68
2002	158	158	0	157	1	93	64
2003	153	156	-3	152	4	89	63
2004	158	152	6	150	2	88	62
2005	159	161	-2	156	5	84	72
2006	142	149	-7	143	6	76	67
2007	119	124	-5	119	5	64	55
2008	116	116	0	116	0	61	55
2009	113	112	1	112	0	59	53
2010	125	121	4	121	0	64	57

Table 3
Sensitivity of Results to Selected Sample Period

This table reports annualized quarterly returns over three sample periods. Our benchmark for property-level quarterly returns in the private commercial real estate market is the NCREIF Property Index (NPI) produced by the National Council of Real Estate Investment Fiduciaries (NCREIF: www.ncreif.com). Our benchmark for quarterly returns in the equity REIT market is obtained from the CRSP-Ziman database (www.crsp.com/products/ziman.htm).

	Annualized Total Returns		
	1990Q1 - 1994Q1	1994Q2 - 2010Q4	1990Q1 - 2010Q4
CRSP-Ziman Equity REITs	11.53%	10.22%	10.49%
NCREIF NPI	-1.21%	8.95%	6.81%
Difference	12.74%	1.27%	3.68%

Table 4
Descriptive Statistics on Asset Pricing Variables

This table reports descriptive statistics for our asset pricing control variables: the annualized yield on three-month U.S. Treasury securities (*TBILL3M*), the annualized slope of the Treasury term structure of interest rates (*TERMSPREAD*), the annualized spread between yields on BAA rated and AAA rated corporate bonds (*DEFSPREAD*), and quarterly inflation (*INFL*). We also include the three Fama-French risk factors: *MKT*, *SMB*, and *HML* augmented by a return momentum factor, *MOM*, and a liquidity factor, *LIQ_PS*. *MKT* is the total return on the value-weighted stock market portfolio, as measured by the Center for Research in Securities Pricing (CRSP), minus the corresponding quarterly return on U.S. Treasury securities from CRSP. *SMB* is defined as the total return on a portfolio of small cap stocks in excess of the return on a portfolio of large cap stocks. *HML* is the total return on stocks with book-to-market value ratios in excess of the returns on a portfolio of stocks with low book-to-market ratios. *MOM* is the total return on a portfolio of stocks with high prior returns in excess of stocks with low prior returns. *LIQ_PS* is Pastor and Stambaugh's (2003) liquidity innovation factor. *DIVYLD* is the dividend yield on equity REITs from NAREIT and *CAPRATE* is each quarter's weighted average capitalization rate across apartment, industrial, office, and retail properties where the weights are the proportion of total market value corresponding to each property type. Capitalization rates are obtained from the American Council of Life Insurers (ACLI). The sample period spans 1994:Q2-2010:Q4. Descriptive statistics are reported in decimal form. ***, **, and * represent 1%, 5%, and 10% significance levels respectively.

Variable	Mean	Median	Std Dev	Min	Max	Autocorrelation (-1)
<i>TBILL3M</i>	0.034	0.044	0.020	0.001	0.062	0.95***
<i>TERMSPREAD</i>	0.016	0.015	0.012	-0.006	0.036	0.91***
<i>DEFSPREAD</i>	0.009	0.008	0.005	0.006	0.030	0.85***
<i>INFL</i>	0.006	0.006	0.009	-0.039	0.025	-0.13
<i>MKT</i>	0.017	0.027	0.091	-0.223	0.206	0.06
<i>SMB</i>	0.010	0.002	0.055	-0.108	0.191	0.03
<i>HML</i>	0.006	0.002	0.082	-0.320	0.239	0.17
<i>MOM</i>	0.015	0.016	0.098	-0.398	0.260	0.12
<i>LIQ_PS</i>	-0.001	0.019	0.118	-0.286	0.333	-0.06
<i>DIVYLD</i>	0.061	0.063	0.015	0.036	0.094	0.86***
<i>CAPRATE</i>	0.082	0.087	0.010	0.061	0.094	0.96***

Table 5
Unit Root Tests on Return Series

This table reports Augmented Dickey-Fuller, DF-GLS and Phillips-Perron unit root tests on the various return series. The null hypothesis is that the return series contains a unit root. The sample period spans 1994:Q2-2010:Q4. P-values are reported in parentheses. ***, **, and * represent 1%, 5%, and 10% significance levels respectively.

Return Series	Augmented DF	DF-GLS	Phillips-Perron	Autocorrelations	
				(-1)	(-2)
<i>Unlevered Equity REIT Returns</i>					
<i>All-Properties</i>	(0.000)***	(0.000)***	(0.000)***	0.17	-0.03
<i>Core-Properties</i>	(0.000)***	(0.009)***	(0.000)***	0.20*	-0.03
<i>Apartment</i>	(0.000)***	(0.477)	(0.000)***	0.11	0.01
<i>Industrial</i>	(0.000)***	(0.000)***	(0.000)***	0.20*	0.03
<i>Office</i>	(0.000)***	(0.002)***	(0.000)***	0.25**	-0.04*
<i>Retail</i>	(0.000)***	(0.008)***	(0.000)***	0.08	0.03
<i>TBI Returns</i>					
<i>All-Properties</i>	(0.004)***	(0.000)***	(0.000)***	0.08	0.30**
<i>Core-Properties</i>	(0.054)*	(0.005)***	(0.001)***	0.55***	0.48***
<i>Apartment</i>	(0.004)***	(0.015)**	(0.000)***	0.23*	0.28**
<i>Industrial</i>	(0.000)***	(0.000)***	(0.000)***	0.02	0.13
<i>Office</i>	(0.053)*	(0.009)***	(0.000)***	0.36***	0.48***
<i>Retail</i>	(0.000)***	(0.000)***	(0.000)***	0.17	0.19

Table 6
VAR Results: Unlevered Equity REIT and TBI Returns using All- and Core-Properties

This table presents results obtained from estimating our unrestricted bivariate VAR models using REIT and TBI returns for All- and Core-Properties as endogenous variables. An unrestricted p^{th} -order Gaussian VAR model can be represented as:

$$Y_t = \mu + \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} + \dots + \Phi_p Y_{t-p} + e_t,$$

The lag-length of the VAR is chosen by using AIC, SBIC, and the likelihood ratio criterion for various choices of p . We find that four lags provide the best fit. With four lags and a TBI return series starting date of 1994Q2, the estimated sample period spans 1995:Q2-2010:Q4. P-values are reported in parentheses. ***, **, and * represent 1%, 5%, and 10% significance levels respectively.

Panel A: Individual Lags

Variables	All-Properties		Core-Properties	
	<i>REITRET</i>	<i>TBIRET</i>	<i>REITRET</i>	<i>TBIRET</i>
<i>Constant</i>	0.022** (0.011)	0.001 (0.882)	0.022** (0.011)	-0.000 (0.943)
<i>REITRET_{t-1}</i>	0.202 (0.127)	0.315*** (0.004)	0.212 (0.130)	0.133* (0.064)
<i>REITRET_{t-2}</i>	-0.059 (0.680)	0.360*** (0.002)	-0.070 (0.626)	0.199*** (0.007)
<i>REITRET_{t-3}</i>	0.000 (1.000)	0.233* (0.058)	-0.074 (0.623)	0.215*** (0.005)
<i>REITRET_{t-4}</i>	0.038 (0.806)	0.106 (0.397)	0.058 (0.716)	0.067 (0.408)
<i>TBIRET_{t-1}</i>	-0.075 (0.648)	-0.303** (0.024)	0.008 (0.977)	0.106 (0.450)
<i>TBIRET_{t-2}</i>	0.042 (0.804)	0.123 (0.373)	0.059 (0.821)	0.128 (0.337)
<i>TBIRET_{t-3}</i>	-0.075 (0.608)	0.167 (0.163)	0.058 (0.818)	0.148 (0.251)
<i>TBIRET_{t-4}</i>	-0.003 (0.981)	0.019 (0.879)	-0.141 (0.537)	0.006 (0.957)
Adjusted R ²	-0.097	0.257	-0.085	0.458

Panel B: Joint Significance

Variables	All-Properties		Core-Properties	
	<i>REITRET</i>	<i>TBIRET</i>	<i>REITRET</i>	<i>TBIRET</i>
<i>REITRET_{t-1 to t-4}</i>	0.181 (0.641)	1.013*** (0.000)	0.125 (0.525)	0.613*** (0.001)
<i>TBIRET_{t-1 to t-4}</i>	-0.112 (0.954)	0.005* (0.087)	-0.016 (0.982)	0.388* (0.068)

Table 7
VAR Results: Unlevered Equity REIT and TBI Returns by Property Type

This table presents joint coefficient results obtained from estimating our unrestricted bivariate VAR models using REIT and TBI returns for Apartment, Industrial, Office, and Retail property types as endogenous variables. An unrestricted p^{th} -order Gaussian VAR model can be represented as:

$$Y_t = \mu + \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} + \dots + \Phi_p Y_{t-p} + e_t,$$

The lag-length of the VAR is chosen by using AIC, SBIC, and the likelihood ratio criterion for various choices of p . We find that four lags provide the best fit. With four lags and a TBI return series starting date of 1994Q2, the estimated sample period spans 1995:Q2-2010:Q4. P-values are reported in parentheses. ***, **, and * represent 1%, 5%, and 10% joint significance levels respectively.

Variables	Apartment		Industrial		Office		Retail	
	<i>REITRET</i>	<i>TBIRET</i>	<i>REITRET</i>	<i>TBIRET</i>	<i>REITRET</i>	<i>TBIRET</i>	<i>REITRET</i>	<i>TBIRET</i>
<i>REITRET</i> _{<i>t-1 to t-4</i>}	-0.110 (0.886)	0.719*** (0.007)	-0.152 (0.344)	0.974*** (0.003)	0.123 (0.213)	0.655*** (0.000)	0.227 (0.830)	0.795*** (0.000)
<i>TBIRET</i> _{<i>t-1 to t-4</i>}	0.189 (0.570)	0.196 (0.618)	0.432 (0.604)	-0.230* (0.082)	-0.018 (0.807)	0.362** (0.048)	-0.034 (0.279)	0.239 (0.176)
Adjusted R ²	-0.073	0.186	-0.026	0.180	-0.029	0.407	-0.055	0.233

Table 8
VAR Results with Asset Pricing Control Variables: Unlevered Equity REIT and TBI Returns using All- and Core-Properties

This table presents results obtained from estimating our unrestricted bivariate VAR models using REIT and TBI returns for All- and Core-Properties as endogenous variables with exogenous asset pricing control variables. An unrestricted p^{th} -order Gaussian VAR model can be represented as:

$$Y_t = \mu + \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} + \dots + \Phi_p Y_{t-p} + e_t,$$

The lag-length of the VAR is chosen by using AIC, SBIC, and the likelihood ratio criterion for various choices of p . We find that four lags provide the best fit. With four lags and a TBI return series starting date of 1994Q2, the estimated sample period spans 1995:Q2-2010:Q4. The set of exogenous asset pricing control variables included in the VAR estimation are the yield on three-month U.S. Treasury securities (*TBILL3M*), the slope of the Treasury term structure of interest rates (*TERMSPREAD*), the spread between yields on BAA rated and AAA rated corporate bonds (*DEFSPREAD*), and inflation (*INFL*). We also include the three Fama-French risk factors: *MKT*, *SMB*, and *HML* augmented by a return momentum factor, *MOM*, and a liquidity factor, *LIQ_PS*. *MKT* is the total return on the value-weighted stock market portfolio, as measured by the Center for Research in Securities Pricing (CRSP), minus the corresponding quarterly return on U.S. Treasury securities from CRSP. *SMB* is defined as the total return on a portfolio of small cap stocks in excess of the return on a portfolio of large cap stocks. *HML* is the total return on stocks with high ratios of book-to-market value in excess of the returns on a portfolio of stocks with low book-to-market ratios. *MOM* is the total return on a portfolio of stocks with high prior returns in excess of stocks with low prior returns. *LIQ_PS* is Pastor and Stambaugh's liquidity innovation factor. We also include dividend yields (*DIVYLD*) on equity REITs from NAREIT and weighted average capitalization rates (*CAPRATE*) derived from ACLI property type data. P-values are reported in parentheses. ***, **, and * represent 1%, 5%, and 10% significance levels respectively.

Panel A: Individual Lags

Variables	All-Properties		Core-Properties	
	<i>REITRET</i>	<i>TBIRET</i>	<i>REITRET</i>	<i>TBIRET</i>
<i>Constant</i>	-0.038 (0.684)	-0.056 (0.486)	-0.084 (0.331)	-0.077* (0.100)
<i>REITRET_{t-1}</i>	0.337 (0.134)	0.075 (0.703)	0.326 (0.128)	-0.033 (0.777)
<i>REITRET_{t-2}</i>	0.187 (0.347)	0.224 (0.199)	0.157 (0.427)	0.142 (0.183)
<i>REITRET_{t-3}</i>	0.184 (0.199)	0.242* (0.054)	0.100 (0.480)	0.244*** (0.001)
<i>REITRET_{t-4}</i>	0.065 (0.670)	0.107 (0.424)	0.081 (0.598)	0.011 (0.892)
<i>TBIRET_{t-1}</i>	-0.165 (0.284)	-0.450*** (0.001)	-0.053 (0.824)	0.065 (0.611)
<i>TBIRET_{t-2}</i>	-0.008 (0.963)	-0.046 (0.751)	0.232 (0.331)	0.207 (0.106)
<i>TBIRET_{t-3}</i>	-0.003 (0.983)	0.129 (0.337)	0.062 (0.785)	0.130 (0.285)
<i>TBIRET_{t-4}</i>	0.218 (0.134)	0.033 (0.797)	-0.001 (0.998)	0.038 (0.747)
<i>TBILL3M_{t-1}</i>	-1.018 (0.330)	-1.082 (0.238)	-0.306 (0.760)	-0.197 (0.714)
<i>TERMSPREAD_{t-1}</i>	-0.076 (0.961)	-1.750 (0.197)	0.655 (0.652)	-0.045 (0.954)
<i>DEFSPREAD_{t-1}</i>	-0.359 (0.900)	-1.904 (0.450)	1.099 (0.681)	0.146 (0.919)
<i>INFL_{t-1}</i>	1.696** (0.019)	0.838 (0.185)	1.633** (0.016)	0.969*** (0.008)
<i>MKT_{t-1}</i>	0.035 (0.770)	0.049 (0.642)	0.007 (0.950)	0.054 (0.392)
<i>SMB_{t-1}</i>	-0.455*** (0.002)	-0.064 (0.630)	-0.378*** (0.008)	-0.009 (0.903)
<i>HML_{t-1}</i>	-0.148 (0.336)	-0.020 (0.882)	-0.187 (0.184)	-0.009 (0.908)
<i>MOM_{t-1}</i>	-0.246* (0.054)	0.016 (0.888)	-0.287** (0.019)	-0.003 (0.966)

LIQ_PS_{t-1}	0.122* (0.069)	0.030 (0.615)	0.089 (0.165)	0.014 (0.682)
$CAPRATE_{t-1}$	-0.451 (0.786)	3.032** (0.037)	-0.229 (0.891)	1.426 (0.111)
$DIVYLD_{t-1}$	1.927 (0.114)	-1.625 (0.129)	1.565 (0.197)	-0.602 (0.355)
Adjusted R ²	0.030	0.237	0.031	0.466

Panel B: Joint Significance

Variables	All-Properties		Core-Properties	
	$REITRET$	$TBIRET$	$REITRET$	$TBIRET$
$REITRET_{t-1 \text{ to } t-4}$	0.773 (0.486)	0.648 (0.326)	0.665 (0.630)	0.365** (0.011)
$TBIRET_{t-1 \text{ to } t-4}$	0.043 (0.495)	-0.334** (0.013)	0.240 (0.826)	0.440* (0.063)

Table 9
VAR Results with Asset Pricing Control Variables: Unlevered Equity REIT and TBI Returns by Property Type

This table presents joint coefficient results obtained from estimating our unrestricted bivariate VAR models using REIT and TBI returns for Apartment, Industrial, Office, and Retail property types as endogenous variables with exogenous asset pricing control variables. An unrestricted p^{th} -order Gaussian VAR model can be represented as:

$$Y_t = \mu + \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} + \dots + \Phi_p Y_{t-p} + e_t,$$

The lag-length of the VAR is chosen by using AIC, SBIC, and the likelihood ratio criterion for various choices of p . We find that four lags provide the best fit. With four lags and a TBI return series starting date of 1994Q2, the estimated sample period spans 1995:Q2-2010:Q4. The set of exogenous asset pricing control variables included in the VAR estimation are the yield on three-month U.S. Treasury securities (*TBILL3M*), the slope of the Treasury term structure of interest rates (*TERMSPREAD*), the spread between yields on BAA rated and AAA rated corporate bonds (*DEFSPREAD*), and inflation (*INFL*). We also include the three Fama-French risk factors: *MKT*, *SMB*, and *HML* augmented by a return momentum factor, *MOM*, and a liquidity factor, *LIQ_PS*. *MKT* is the total return on the value-weighted stock market portfolio, as measured by the Center for Research in Securities Pricing (CRSP), minus the corresponding quarterly return on U.S. Treasury securities from CRSP. *SMB* is defined as the total return on a portfolio of small cap stocks in excess of the return on a portfolio of large cap stocks. *HML* is the total return on stocks with high ratios of book-to-market value in excess of the returns on a portfolio of stocks with low book-to-market ratios. *MOM* is the total return on a portfolio of stocks with high prior returns in excess of stocks with low prior returns. *LIQ_PS* is Pastor and Stambaugh's liquidity innovation factor. We also include dividend yields (*DIVYLD*) on equity REITs from NAREIT and weighted average capitalization rates (*CAPRATE*) derived from ACLI property type data. P-values are reported in parentheses. ***, **, and * represent 1%, 5%, and 10% joint significance levels respectively.

Variables	Apartments		Industrial		Office		Retail	
	<i>REITRET</i>	<i>TBIRET</i>	<i>REITRET</i>	<i>TBIRET</i>	<i>REITRET</i>	<i>TBIRET</i>	<i>REITRET</i>	<i>TBIRET</i>
<i>REITRET</i> _{<i>t-1</i> to <i>t-4</i>}	0.296 (0.630)	0.512*** (0.001)	0.220 (0.442)	0.245 (0.420)	0.547 (0.339)	0.494* (0.084)	0.111 (0.916)	0.203 (0.316)
<i>TBIRET</i> _{<i>t-1</i> to <i>t-4</i>}	0.289** (0.041)	-0.152 (0.229)	0.819 (0.279)	0.070*** (0.003)	0.163 (0.332)	0.361* (0.089)	0.057 (0.179)	0.307** (0.042)
Adjusted R ²	0.166	0.237	0.040	0.258	0.110	0.353	0.044	0.215

Table 10
GARCH Results Using All-Properties and Core-Properties Index Returns

This table presents GARCH model estimates using public and private market returns. The GARCH model can be represented as:

$$R_t = \sum_{i=1}^N \gamma_i X_{it} + \theta f(h_t) + \varepsilon_t$$

$$\varepsilon_t \sim N(0, h_t)$$

$$h_t = \alpha_0 + \sum_{i=1}^{NAR} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{NML} \beta_j h_{t-j} + \sum_{k=1}^{NGT} \phi_k g_{kt}$$

where:

X_{it} = is a set of explanatory variables,
 h_t = is the conditional variance (GARCH),
 g_{kt} = is a set of explanatory variables.

The explanatory variables, X_{it} , are economic and other variables (including lagged returns) that impact returns over time, while g_{kt} are variables that impact the variance of returns. In general, the conditional variance, h_t , captures the relation between the volatility of returns and explanatory variables, including its past values (GARCH(1)). The estimated ϕ coefficients provide direct information on the relation between the conditional variance and the explanatory variables, including past returns. The γ coefficients and θ provide information on the mean effect (i.e., return effects through the explanatory variables and through a variance effect – the mean effect (M) GARCH-M). If $NM4=0$, the model becomes a pure ARCH model. ARCH models allow the residuals to have a variable variance and still have a zero conditional mean. With two lags and a TBI return series starting date of 1994Q2, the estimated sample period spans 1994:Q4-2010:Q4. The set of exogenous asset pricing control variables included in the VAR estimation are the yield on three-month U.S. Treasury securities (*TBILL3M*), the slope of the Treasury term structure of interest rates (*TERMSPREAD*), the spread between yields on BAA rated and AAA rated corporate bonds (*DEFSPRE4D*), and inflation (*INFL*). We also include the three Fama-French risk factors: *MRKT*, *SMB*, and *HML* augmented by a return momentum factor, *MOM*, and a liquidity factor, *LIQ_PS*. *MRKT* is the total return on the value-weighted stock market portfolio, as measured by the Center for Research in Securities Pricing (CRSP), minus the corresponding quarterly return on U.S. Treasury securities from CRSP. *SMB* is defined as the total return on a portfolio of small cap stocks in excess of the return on a portfolio of large cap stocks. *HML* is the total return on stocks with high ratios of book-to-market value in excess of the returns on a portfolio of stocks with low book-to-market ratios. *MOM* is the total return on a portfolio of stocks with high prior returns in excess of stocks with low prior returns. *LIQ_PS* is Pastor and Stambaugh's liquidity innovation factor. We also include dividend yields (*DIVYLD*) on equity REITs from NAREIT and weighted average capitalization rates (*CAPR47E*) derived from ACLI property type data. P-values are reported in parentheses. ***, **, and * represent 1%, 5%, and 10% joint significance levels respectively.

Panel A: GARCH Estimates: All-Properties

Variables	All-Properties					
	<i>TBRET</i> (1)	<i>TBRET</i> (2)	<i>TBRET</i> (3)	<i>RETRRET</i> (1)	<i>RETRRET</i> (2)	<i>RETRRET</i> (3)
Return Equation						
<i>Constant</i>	0.015** (0.014)	-0.003 (0.967)	-0.026 (0.725)	0.020*** (0.000)	-0.014 (0.885)	-0.026 (0.839)
<i>TBRET_{t-1}</i>	0.051 (0.718)	-0.154 (0.293)	-0.156 (0.385)	-0.148 (0.293)	-0.139 (0.460)	-0.012 (0.957)
<i>TBRET_{t-2}</i>	0.076 (0.593)	-0.216 (0.193)	-0.217 (0.288)	0.014 (0.939)	0.086 (0.730)	0.053 (0.812)
<i>RETRRET_{t-1}</i>	0.091 (0.404)	0.005 (0.974)	-0.161 (0.277)	0.220* (0.061)	0.272 (0.210)	0.273 (0.259)
<i>RETRRET_{t-2}</i>	0.238* (0.082)	0.140 (0.479)	0.157 (0.395)	-0.002 (0.968)	0.103 (0.587)	0.111 (0.636)
Asset Pricing Controls	No	Yes	Yes	No	Yes	Yes
Variance Equation						
<i>Constant</i>	-0.001 (0.496)	-0.002 (0.341)	0.001 (0.762)	0.001 (0.782)	0.001 (0.357)	0.001 (0.395)
<i>Residual(-1)²</i>	-0.063 (0.366)	-0.051 (0.490)	0.317 (0.404)	-0.123** (0.048)	-0.137** (0.039)	-0.123 (0.233)
<i>GARCH(-1)</i>	1.139*** (0.000)	1.145*** (0.000)	0.621 (0.156)	1.163*** (0.000)	1.148*** (0.000)	0.480 (0.490)
<i>TBRET_{t-1}</i>						-0.010 (0.370)
<i>TBRET_{t-2}</i>						-0.002 (0.894)
<i>RETRRET_{t-1}</i>			-0.007* (0.095)			
<i>RETRRET_{t-2}</i>			0.009* (0.068)			
Adjusted R ²	0.145	0.044	0.027	-0.027	-0.004	0.053

Panel B: GARCH Estimates: Core-Properties

Variables	Core-Properties			
	<i>TBIRET</i> (1)	<i>TBIRET</i> (2)	<i>TBIRET</i> (3)	<i>REIRET</i> (1) <i>REIRET</i> (2) <i>REIRET</i> (3)
Return Equation				
<i>Constant</i>	0.005*** (0.000)	-0.043 (0.417)	-0.042 (0.557)	0.023*** (0.000)
<i>TBIRET</i> _{<i>t</i>-1}	0.268** (0.053)	0.177 (0.183)	0.159 (0.527)	-0.051 (0.621)
<i>TBIRET</i> _{<i>t</i>-2}	0.137 (0.366)	0.093 (0.568)	0.184 (0.285)	-0.038 (0.852)
<i>REIRET</i> _{<i>t</i>-1}	0.172 (0.118)	-0.135 (0.296)	-0.162 (0.296)	0.090 (0.647)
<i>REIRET</i> _{<i>t</i>-2}	0.143 (0.131)	0.072 (0.573)	0.104 (0.535)	0.310 (0.173)
Asset Pricing Controls	No	Yes	Yes	0.005 (0.980)
				No Yes
Variance Equation				
<i>Constant</i>	-0.001 (0.576)	0.001*** (0.000)	0.002 (0.307)	0.001 (0.624)
<i>Residual</i> (-1) ²	-0.095* (0.058)	0.057 (0.302)	-0.012 (0.935)	-0.099 (0.397)
<i>GARCH</i> (-1)	1.158*** (0.000)	-1.141*** (0.000)	0.451 (0.403)	0.613 (0.539)
<i>TBIRET</i> _{<i>t</i>-1}				0.468 (0.594)
<i>TBIRET</i> _{<i>t</i>-2}				-0.006 (0.433)
<i>REIRET</i> _{<i>t</i>-1}			0.003 (0.245)	-0.004 (0.778)
<i>REIRET</i> _{<i>t</i>-2}			[^]	
Adjusted R ²	0.359	0.371	0.381	-0.019 0.045 0.064

[^] Only 1 lag in this estimate as it did not converge with two lags.