Price Discovery in Real Estate Markets: A Dynamic Analysis

Abdullah Yavas
Elliott Professor of Business Administration
Penn State University
ayavas@psu.edu

and
Yildiray Yildirim
Assistant Professor of Finance
Syracuse University
yildiray@syr.edu

Abstract

Although the correlation between the public and private market pricing of real estate has generated considerable research effort, the methods utilized in previous studies have failed to capture the dynamic nature of this correlation. This paper proposes a new statistical method to address this issue. This method, known as the *dynamic conditional correlation GARCH model,* will enable us to study the dynamics of the correlation between the two markets over time and enrich our understanding of the public and private market pricing of real assets. We also differentiate among different real estate types. We find that the correlation between NAV returns and REIT returns is dynamic for all REIT types, except for the Office and Hotel REITs, and there is a strong degree of persistence in the series of correlation Our Granger-causality tests show that while Apartment, Hotel, Office, Self Storage and Diversified REIT prices lead their NAVs, the causality is not significant for the Industrial and Strip Center REITs. Furthermore, the causality is in the reverse direction for Mall REITs where NAVs lead REIT prices.

We are grateful to Jim Clayton, Joseph Pagliari and Dogan Tirtiroglu for their helpful comments and Real Estate Research Institute (RERI) for their financial support.

I. Introduction

One of the interesting puzzles in real estate is that publicly traded REITs often trade at values different than their underlying net asset value (NAV). Furthermore, the relationship between REITs and their NAV fluctuates through time. While REITs trade at a premium to their NAV in some periods, they trade at a discount to their NAV in some other periods. Understanding this REIT premium / discount has important implications for the study of the efficiency of the public versus private real estate markets.

The relative efficiency and performance of public and private real estate markets is also important for investors. If one market outperforms the other market or if prices in one market follow the prices in the other market, this will clearly impact the timing and magnitude of investments in the two property markets. Furthermore, financial decisions typically involve a trade-off between future risks and returns, and the major components of risk involve volatilities and correlations of assets in a portfolio. Thus, the construction of an optimal portfolio of two asset types, e.g., publicly versus privately traded real estate assets, requires an accurate estimate of volatilities and correlations between the returns of the two asset classes. A complicating factor here is that volatilities and second movements evolve over time in response to changes in the economy and arrival of new information. Volatilities and correlations measured from historical data will fail to capture changes in risk unless we utilize empirical methods that update estimates carefully and swiftly.

The objective of this study is to twofold. The first objective is to examine if there exists a unidirectional causality between REIT returns and NAV returns, with one market serving as a price discovery vehicle for the other market. Since different asset types could have different risk-return characteristics, our analysis differentiate among eight REIT types based on their asset holdings: Apartment, Hotel, Industrial, Mall, Office, Self Storage, Strip Center and Diversified.

The second objective of the paper is to investigate if the correlations of REIT and NAV returns are changing through time and whether or not the correlation between the two return series varies from one REIT type to another. For this, we utilize a new methodology that will allow us a drastically richer investigation of the correlation of returns between the public and private real estate markets. The methodology we will be utilizing is known as the dynamic conditional correlation multivariate GARCH (Generalized Autoregressive Conditional Heteroskedasticity) method.[1] This econometric technique enables us to measure risks dynamically and test for the direction and magnitude of volatility spillovers between the two markets. It also enables us to resolve the heteroskedasticity problem, hence avoid biased cross-market correlation coefficients, by providing estimation of correlation coefficients based on standardized residuals.

Our Granger-causality tests in general confirm earlier empirical results that price discovery takes place in the securitized public market. However, our results also show that there are variations among different property types. While Apartment, Hotel, Office, Self Storage and Diversified REIT returns lead their NAV returns, the causality is not significant for the Industrial and Strip Center REITs. Furthermore, the causality is in the reverse direction for Mall REITs where NAV returns leads REIT returns. Our dynamic conditional correlation GARCH tests confirm our expectation that the correlation between NAV and REIT returns changes over time. The correlation between NAV and

[1] The method was developed and extended in Engle (2002) and Engle and Sheppard (2001). Robert Engle was awarded 2003 Nobel Prize in Economics for his contribution to methods of analyzing economic time series with time-varying volatility *(ARCH).*

REIT returns is dynamic for each property type, except for Office and Hotel. We also find a strong degree of persistence in the series of correlation. Apartment and Diversified properties have the highest persistence while Industrial, Mall, Self Storage and Strip properties have a lower persistence in correlation.

The relationship between REIT returns and NAV returns has already been explored by a number of studies in the REIT literature.[2] However, as explained in detail in the methodology section of our paper, the methods utilized in these earlier studies suffer from a number of shortcomings in their attempts to capture the dynamic nature of the correlation between the public and private markets. This is clearly a serious constraint on the analysis since the correlation between the two markets is changing through time in response to developments in economic and market conditions.

We review the literature and offer a background on the REIT premium/puzzle in the next section. Empirical methodology is discussed in Section III. Section IV discusses the results. Section V offers some concluding remarks.

II. Literature Review and Background

The REIT premium / discount puzzle brings up an important and interesting question: which market, the securitized, indirect, public REIT market or the unsecuritized, direct, private market of the underlying properties discovers price more efficiently?

The evidence suggests that there exists Granger causality between the public and private real estate markets with the public market leading the private market in time. That

[2] Examples include Pagliari, Scherer and Monopoli (2005), Clayton and MacKinnon (2000), Ling and Ryngaert (1997) and Barkham and Geltner (1995).

is, the public market incorporates new information into price faster than the private market. This has been demonstrated for several countries, including US (Myer and Webb, 1993), United Kingdom (Barkham and Geltner, 1995) and Hong Kong (Newell and Chau, 1996). Barkham and Geltner (1995) find that the transmission of information from the public to private markets is faster in the UK than in the US, and suggest that this may be due to greater homogeneity of properties and larger scale of securitization of properties in the UK. Chau, McGregor and Schwann (2001) report that public market prices in Honk Kong lead private property prices by one quarter, which is in marked contrast to the lags of up to two years seen for the UK, Australian and US property markets. The authors attribute the difference to the structural and informational efficiency of the Hong Kong property markets compared with property markets in US, UK and Australia.

Benveniste, Capozza and Seguin (2001) argue that the REIT premium / puzzle is due to the tradeoff between liquidity benefits of securitization and costs associated with setting up and running a REIT. They report a liquidity premium of 12-22% for REITs relative to NAV for the 1985-1992 time period. Clayton and MacKinnon (2001a), examining the short-run relationship between REIT prices and their NAV for 1992-2000, also find evidence of a significant liquidity premium in REIT prices relative to their NAV. Their results indicate that liquidity benefit of REITs is valued more in a down private market than in an up one. They also report that sentiment plays a significant role in REIT prices and the timing of REIT equity offerings.

Subrahmanyam (2006) examines liquidity and order flow spillovers across NYSE stocks and REITs. The Granger-causality results indicate that stock market liquidity leads liquidity in REITs. Subrahmanyam argues that REITs serve as substitute investments for the stock market, which causes down-moves in the stock market to increase money flows to the REIT market. King (1966) suggests that 31% of the movements in REITs about their mean values could be attributed to general stock market movements.

The return comparison of publicly traded REITs versus privately held real estate was also the focus of Ling and Naranjo (2003). Ling and Naranjo (2003) argue that, due to infrequency of sales of the same property, NACREIF indexes are based on periodic property appraisal, hence suffer from measurement problems. These measurement problems severely weaken the ability of NACREIF indexes to capture risk-return characteristics of privately held commercial real estate. As an attempt to overcome these measurement problems, the authors utilize latent-variable statistical methods to estimate an alternative return index for privately held commercial real estate. They find that their alternative index is twice as volatile as the NACREIF total return index and often lead NACREIF returns, but it is less than half as volatile as the NAREIT equity index.

Two recent papers, Pagliari, Scherer and Monopoli (2005) and Riddiough, Moriarty and Yeatman (2005), compare performance of REIT index with that of NCREIF index as the measure of privately held real estate. Both studies show that when they control for the major differences between the two indices, the performance of the two indices converges. Riddiough, Moriarty and Yeatman (2005) uses data from 1980-1998 period and finds that controlling for property-type mix, fees, leverage, partial year financial data and appraisal smoothing differences between the two indices narrows the performance gap between the two indices from four percentage points to 3.08 percentage points, in favor of publicly traded real estate. The performance gap turns statistically insignificant in Pagliari, Scherer and Monopoli (2005) in the more recent time period 1993-2001 once the authors control for property-type mix, leverage and appraisal smoothing differences between the two indices.

Downs, Hartzell and Torres (2001) report evidence that information in the Barron's REIT column titled "The Ground Floor" has a significant impact on the price and trading volume of REITs mentioned in the column in the days following publication. The authors view this as a direct evidence of inefficiency in the REIT market.

Gentry, Jones and Mayer (2004) report that one can earn excess returns by buying REITs that trade at a discount to NAV, and shorting REITs that trade at a premium to NAV. They also argue that there is too much variation in the REIT premium/discount over time, and that it is unlikely that the REIT premiums and discounts reflect the investor sentiment hypothesis of Lee, Shleifer, and Thaler (1991).

One possible explanation for the dynamic correlation between the public and private markets is the changes in real estate market capital flows. Clayton (2003) reports that there exists a correlation between real estate performance and debt capital flows, and the link between property returns and mortgage flows has changed through time. Part of the reason for the boom in REITs and real asset values in recent years, for instance, has been the flow of capital to real estate class of investments due to downturns in stock markets. Examples include the stock market decline during the mild recession of the 1990s and the technology stock decline of the early 2000s.

As stated earlier, the results of the current study confirm earlier results that price discovery takes place in the securitized public market. However, our results also show that there are significant variations among different property types. While REIT prices lead NAV values for Apartment, Hotel, Office, Self Storage and Diversified assets, price discovery for Mall properties takes place in the private market. We also find that the correlation between NAV and REIT returns is dynamic for each property type, except for Office properties.

The REIT premium/discount puzzle is similar in many ways to the closed-end fund puzzle. Most closed-end funds hold publicly traded securities and the investors can trade either in the closed-end fund's shares or directly in the underlying securities. Yet, closed-end fund share prices often differ from their NAV, sum of the values of the individual securities in the fund. There is an important difference between REITs and closed-end funds though; the NAV of a closed-end fund can be easily observed from the individual transaction prices of the securities held in the fund. REITs, on the other hand, own relatively illiquid assets.

As in the case of REIT premium/discount, the more challenging piece of the closed-end fund puzzle is the time-variation in the premium/discount. This led Lee, Shleifer, and Thaler (1991) to a behavioral explanation which claims that closed-end fund discounts are the result of sentiment-based trading by individual investors. Their argument is based on the fact that closed-end funds are mainly held by individuals and are generally avoided by the more sophisticated institutional investors. However, this argument does not hold for REITs since REITs enjoy a high level of institutional ownership. A recent study by Cherkes, Sagi and Stanton (2006) builds a theoretical model to offer a rational explanation for the questions of why closed-end funds generally trade at a discount to their NAV, and why investors are willing to buy a closed-end fund at a premium at its IPO, knowing that shortly after the IPO the fund will trade at a discount to its NAV.. They argue that closed-end funds offer a means for investors to invest in illiquid securities, and the observed behavior in the market is a result of the trade-off between the liquidity benefits and management fees of closed-end funds.[3]

In the next section, we discuss the methodology that we utilize to examine the relationship between the REIT returns and NAV returns. Our methodology allows us to investigate not only the price discovery in the two markets but also the time-variation in the correlation of the REIT and NAV return series.

III. Research Methodology

Given the objective of understanding the relationship between publicly traded REITs and their NAV, we explore two research questions. First is to examine if there exists a unidirectional causality between REIT returns and NAV returns, with one market serving as a price discovery vehicle for the other market. Second is to investigate the correlation of REIT and NAV returns over time

Price Discovery

In most of the previous empirical studies the lead lag relationship between the public market and the private market is examined by estimating granger causality regression where the returns in one market are explained by lagged, contemporaneous and lead returns in the other market (Chan (1992), Stoll and Whaley (1990). Lead-lag relationship between REIT and NAV returns are tested using the following bivariate VAR model:

[3] Cherkes, Sagi and Stanton (2006) also offer a nice review of the literature on this issue.

$$R_t^{NAV} = a + \sum_{i=1}^{N} b_i R_{t-i}^{NAV} + \sum_{i=1}^{N} c_i R_{t-i}^{REIT} + \varepsilon_t^{NAV} \qquad (1)$$

$$R_t^{REIT} = a + \sum_{i=1}^{N} b_i R_{t-i}^{NAV} + \sum_{i=1}^{N} c_i R_{t-i}^{REIT} + \varepsilon_t^{REIT} \qquad (2)$$

where R_t^{NAV} and R_t^{REIT} are the return series of REITs and NAVs in period t, respectively. The order of lag, *N*, is determined from the cross correlation relationship between the two markets. Furthermore, an F-test for the hypothesis c=0 in equation (1) and for b=0 in equation (2) is applied to test for the Granger causality. For example, if the null hypothesis c=0 in equation (1) is rejected, we conclude that the NAV returns are Granger caused by REIT returns, i.e., REIT returns lead NAV returns.

If current NAV returns are significantly correlated with past REIT returns, then we would conclude that the price discovery takes place in the REIT market, hence REIT returns lead NAVs. Similarly, if current NAV returns are significantly correlated with future REIT returns, then the price discovery takes place in the NAV market and NAV returns lead REIT returns. Unlike the previous studies on price discovery, we differentiate among different REIT types and test for price discovery for each property type.

Clayton and MacKinnon (2001b) argue that discrepancies between REIT prices and their NAV are caused by “noise” or “information”. The noise theory suggests that when REIT investors become irrationally pessimistic about the securities, the stock market value of the REIT becomes lower than the value of the underlying properties. On the other hand, information based explanation suggest that the securitized market is “more informationally efficient” than the underlying real estate market; i.e., new information is first discovered in the securitized market and causes the share values to rise or fall, and the movements in REIT prices can be used to forecast the future performance of the property market. A test of this argument requires a methodology that would enable us to estimate dynamic trajectories of correlation behavior for the two return series, REITs and NAV.

The Dynamic Conditional Correlation (DCC) Multivariate GARCH Model

Financial time series returns mostly exhibit time varying volatilities with non normal distributions. This problem is referred to as the hetoroskedasticity problem. The strength of the DCC model over alternative models is that it resolves the heteroskedasticity problem by basing the estimation of correlation coefficients on standardized residuals.

Understanding the interaction between two time series returns requires estimating the *current* correlation. The challenge in estimating the *current* volatility is to figure out how it relates to the existing data on past returns. Correlation analysis will measure the degree of contagion in the time series data for REITs and their NAV. One way to estimate the correlation is to use all the data available. This will assign a constant correlation between the two return series throughout time. However, this estimation method has a serious shortcoming; it assigns equal weight to all observations, whereas the informational content of the earlier observations may be less important for the estimations than the information included in the more recent observations.

A common method to compute the sample correlation involves the use of moving window analyses, also called rolling correlation estimation (as an example, see Clayton and McKinnon, 2002)). This method allows for correlations to change over time. Even though this method is simple to estimate and may capture the time-varying correlation, it has some serious weaknesses. First, it involves choosing an ad hoc window size for the estimation. Second, it weights all observations in the window equally, as in the case of constant correlation case, with the exception that it assigns zero weight for the observation not in the window. As pointed out above, assigning equal weights fails to capture the changing dynamics of correlation inside the window and the correlation estimates adjust slowly to new information. Failing to capture the changing volatility in returns in any given window, we will end up with biased correlation coefficient estimates. One implication of this problem, for instance, is that rolling correlation approach may have an upward bias during the high volatility periods in the market (see Forbes and Rigobon, 2002).

To overcome the shortcomings of the rolling correlation estimation, we adapt DCC GARCH approach proposed by Engle (2002) to estimate time varying co-movements between REIT and NAV returns. The advantage of DCC is that it accounts heteroskedasticity directly and is capable of estimating large time-varying covariance matrices for different assets or markets. In addition, it calculates the *current* correlation between REIT and NAV return series. This can be instrumental in pinpointing an event coming into one market and estimating the magnitude of the impact of this event in both markets.

The procedure for estimating this model involves two-stage estimation and is relatively straightforward. The first stage entails estimating a univariate GARCH model for the private and public real estate markets. The second stage employs transformed residuals from the first stage estimation to obtain a conditional correlation estimator.

This parameterization is shown to preserve the simple interpretation of the univariate GARCH model with an easy procedure to compute the correlation estimator. The standard errors for the first stage parameters are shown to be consistent while the standard errors for the correlation parameters can be modified in order to preserve consistency. DCC model allows us to analyze the correlation when there are multiple regime shifts in response to shocks, and crises in the market.

The DCC multivariate GARCH model assumes that returns (r_t) from k assets[4] are conditionally multivariate normal with zero mean and covariance matrix $H_t \equiv D_t R_t D_t$, where D_t is the $k \times k$ diagonal matrix of time varying standard deviations from the univariate GARCH models with $\sqrt{h_{ii,t}}$ on the ith diagonal. The elements of D_t are characterized by the GARCH(1,1) process:

$$h_{ii,t} = \omega_i + \alpha_i r_{it-p}^2 + \beta_i h_{it-p} \qquad \text{for} \qquad i = j \tag{3}$$

where i, j = 1,2 represents REIT and NAV returns, α_i represents the ARCH effect, or the short-run persistence of shocks to return i, β_i represents the GARCH effect, or the contribution of shocks to return i to long-run persistence, and where the property $\alpha_i + \beta_i < 1$ is maintained to ensure stationarity. R_t is the $k \times k$ matrix containing the conditional correlation of the standardized residuals, $\varepsilon_t = \frac{r_t}{D_t} = \frac{r_t}{\sqrt{h_{it}}}$. For $\rho_{ij,t}$ being the element of R_t and $i \neq j$, we have the conditional covariance of $h_{ij,t} = \rho_{ij,t}\sqrt{h_{ii,t}}\sqrt{h_{jj,t}}$, where $\rho_{ij,t} = \frac{q_{ij,t}}{\sqrt{q_{ii,t}}\sqrt{q_{jj,t}}}$ with $q_{ij,t}$ as the conditional covariance between the standardized

[4] In our case, k is equal to 2 and includes REIT and NAV returns.

residuals ε_{it} and ε_{jt}. The conditional covariance $q_{ij,t}$ is written as the following mean reverting process for DCC(1,1):

$$q_{ij,t} = (1-a-b)\overline{\rho_{ij}} + a\varepsilon_{it-1}\varepsilon_{jt-1} + bq_{ij,t-1},$$

where $\overline{\rho_{ij}}$ is the unconditional correlation between REIT and NAV returns. The parameters a and b are the DCC parameters that are estimated. These two parameters capture the effects of previous shocks and previous dynamic conditional correlations on current dynamic conditional correlations. If a and b equal to zero, then the constant correlation model is sufficient. Engle estimates the parameters from the below log-likelihood function:

$$L = -0.5\sum_{t=1}^{T}(k\log(2\pi) + \log(|D_t|^2) + r_t^{'}D_t^{-2}r_t) - 0.5\sum_{t=1}^{T}(\log(|R_t|) + \varepsilon_t^{'}R_t^{-1}\varepsilon_t - \varepsilon_t^{'}\varepsilon_t)$$

First term is the volatility component, and the second term is the correlation component.

As stated earlier, the advantage of the DCC Multivariate GARCH model is that it preserves the simple interpretation of the univariate GARCH models while providing a consistent estimate of the correlation matrix (Kearney and Poti, 2003).

IV. Empirical Results

Data

The dataset in this research involves REIT prices and NAV values at the end of each month from January 1993 to February 2006. REIT prices are obtained from CRSP while NAV values are obtained from Green Street Advisors. Green Street Advisors calculates the NAV of a REIT by appraising the real estate holdings of that REIT. The appraisal of an income property is often done by using the direct capitalization approach where aggregate Net Operating Income of the REIT is divided by a weighted average capitalization rate.[5] Since NAV values are based on estimation, not on frequently repeated transactions data, NAV estimates will vary from one analyst to another.[6] The use of appraisals in determining NAV values is also being criticized for appraisal smoothing, which refers to the argument that appraisal-based estimates smooth changes in NAV values, which in turn causes downward bias in estimates of return volatility.

However, Green Street NAV data is widely used and highly regarded both in the academic literature and the industry. Two recent studies, for instance, provide evidence that NAV matters. Gentry and Mayer (2003) find that the ratio of REIT price to NAV has strong explanatory power in predicting whether managers issue or repurchase shares. Gentry, Jones and Mayer (2004) report that one can earn excess returns by buying REITs that trade at a discount to NAV, and shorting REITs that trade at a premium to NAV. Furthermore, a recent study finds that NAV estimates closely parallel NACREIF index.

The data includes eight different REIT types as classified according to the type of properties owned by these REITS: Apartment, Diversified, Hotel, Industrial, Mall, Office, Self Storage, and Strip Center. Total number of REITs is 109. For each REIT type we have a minimum of five and a maximum of twenty eight companies. Table (1) summarizes the descriptive statistics of the data. Table 1 suggests that REIT returns are relatively more volatility than NAV returns. Among the eight REIT types, only Hotel

[5] The capitalization rate varies from location to location, across property types, and over time. The capitalization rate used in the NAV estimations reflects the property mix (apartment, office, industrial, etc.), geographic location, and growth prospects of the property holdings of the REIT.

[6] The reason for the discrepancy between two NAV estimates is due to noise in the calculations of capitalization rates and net operating income. Cap rates are often obtained from surveys of players in local markets and the net operating income needs to be estimated from the REIT's financial statements.

REITs have a negative mean return. Moreover, NAV returns have a larger value of kurtosis, hence indicating less normality for NAV returns than REIT returns. Figure (1) and (2) illustrate the data. Figure (1) plots the monthly price series of eight different REIT types and corresponding NAVs. Figure (2) presents the monthly returns of all data series calculated as $\log\left(\frac{P_{i,t}}{P_{i,t-1}}\right)$, where $P_{i,t}$ is the price level *i*, *i*={REIT price, NAV}, at time *t*.

Table (2) summarizes the cross-correlation results of each REIT type. It shows that contemporaneously the REIT and NAV returns are significantly correlated for each REIT type. As seen from the table, Industrial properties have the highest correlation with coefficient 0.408 while Self Storage properties have the lowest correlation with coefficient 0.114. We have calculated the cross correlation for 20 months and found that both lead and lag variables are significant up to the 5^{th} lag, hence reported only those 5 lags in Table 2. For example, Apartment NAV returns are significantly correlated with lag 5 of REIT returns, suggesting that Apartment REIT returns may be leading their NAV returns by approximately 5 months. Based on the raw data, the results of Table 2 suggest that there may exist a lead-lag relationship between the public and private markets. However, further analysis needs to be carried out to confirm the results. In order to do so, we perform the Granger-causality tests of the two markets for different REIT types.

Price Discovery

The lead-lag relationship between the REIT and NAV returns is examined by estimating equations (1) and (2). Based on the cross-correlation results in Table (2), we use N=5 as the order of lags (N) to examine the price discovery in the public versus private markets for each of the eight REIT types.

Panels A and B of Table (3) summarize the regression results of equation (1) and (2), respectively. Parameters $(b_1, b_2, b_3, b_4, b_5)$ in Panel A represent the relationship between the NAV returns and their lag values while parameters $(c_1, c_2, c_3, c_4, c_5)$ capture the relationship between the NAV returns and the lag values of the REIT returns. Similarly, parameters $(b_1, b_2, b_3, b_4, b_5)$ in Panel B represent the relationship between the REIT returns and their lag values while parameters $(c_1, c_2, c_3, c_4, c_5)$ capture the relationship between the REIT returns and the lag values of the NAV returns.

Examining the upper half of Panel A, we find that one month lag values of Apartment REIT returns have a significant predictive power for the NAV returns in that market. This suggests that the public market leads the private market in the Apartment market. Similarly, the results for Diversified REITs suggest that the current NAV returns depend on the REIT returns from two months ago. For Hotel NAVs, two and four month lag values of REIT returns have a significant predictive power. While some lag values of REIT returns have significant predictive power for NAV returns for Mall, Office and Self Storage properties as well, none of the leg values of REIT returns can explain the NAV returns for Industrial and Strip Center properties.

The lower part of Panel A presents the Granger causality test results for the aggregate predictive power of the five lag values of REIT and NAV returns for the current NAV returns. The F-test values and the corresponding p-values indicate that the public market leads the private market for Apartment, Diversified, Hotel, Office and Self Storage properties, but not for Industrial, Mall and Strip Center properties.

Panel B of Table 2 indicates that past NAV returns do not generally have a significant predictive power for current REIT returns. The only exception is the one month lag values of NAV returns for Industrial properties. According to the F-values in the lower part of the table, none of the private markets for the eight property types leads the corresponding public market. The only significant lag relationship is between the past and current NAV returns for Malls.

Thus, the results of Table (3) in general confirm earlier empirical results that price discovery takes place in the securitized public market. However, our results also show that there are variations across different property types. While REIT returns lead NAV returns for Apartment, Diversified, Hotel, Office and Self Storage properties, such price discovery does not hold for Industrial, Mall and Strip Center properties.

Correlation Over Time

We next test to see if the correlations of REIT and NAV returns are changing through time and whether or not the correlation between the two return series varies from one property type to another. For this, we utilize the dynamic conditional correlation multivariate GARCH method. The method estimates the DCC parameters and the time varying conditional correlations among the variables of interest. The correlation of the two time series will always vary as the window of estimation changes, but may indicate only small fluctuations. Therefore, we first need to check if the correlations are dynamic and not constant.

Table (4) displays the univariate GARCH(1,1) and DCC parameters where $(\omega_1, \alpha_1, \beta_1)$ are GARCH(1,1) parameters for REIT series, $(\omega_2, \alpha_2, \beta_2)$ are GARCH(1,1) parameters for NAV series, and (a_1, a_2, b_1) are the DCC parameters. We test for DCC(m,n) model where m=1,2,3 and n=1,2. Later, we only report the best of each model by looking at each model's likelihoods. Table 4 shows that the correlation between NAV and REIT returns is dynamic for each property type, except for Office and Hotel. Furthermore, having a value of (a+b) close to 1 indicates that there is a strong degree of persistence in the series of correlation. Thus, Apartment and Diversified properties have the highest persistence while Industrial, Mall, Self Storage and Strip properties have low persistence in correlation.

As indicated earlier, the DCC GARCH approach enables us to estimate the *current* correlation between REIT and NAV return series. These estimates are displayed for each of the eight property types in Figure 4. For comparison purposes, we also present the estimates of correlations using the rolling estimation method in Figure 3. It is clear from figures 3 and 4 that the two methods yield strikingly different estimates. The two methods might produce not only different magnitude of the correlation for any given property type in any given period, they might also produce different signs of the correlation. Take, for instance, the Apartment market in early 2001. While the estimation of the correlation between REIT and NAV returns drops below zero under the rolling estimation method, it remains positive under the DCC GARCH approach. Thus, the difference between the two methods, and the implications for risk analysis of the two types of real estate ownership, can be significant.

The estimates of current correlation between the REIT and NAV return series can also help us identify the impact of a particular event or news release. As an example, consider the impact of the negative shock of September 11, 2001. The table below presents the correlation estimates in Figure 4 that corresponds to the four-month period around September 11th.

	Apartment	Strip	Storage	Mall	Office	Industrial	Hotel	Diversified
8/1/2001	0.186057	0.179266	0.143531	0.309018	0.250574	0.083289	0.306026	0.264809
9/1/2001	0.163528	0.167926	0.081974	0.188251	0.230385	0.541534	0.333916	0.251625
10/1/2001	0.196655	0.157541	0.186901	0.264514	0.236011	0.526375	0.286778	0.65196
11/1/2001	0.63056	0.185783	0.168656	0.85532	0.477614	0.459571	0.137319	0.579897

The correlation between REIT and NAV returns for Apartments, for instance, jumps from 16.3% on September 1st to 19.6% on October 1st and increases further to 63% on November 1st. Similarly, we see significant jumps in the correlation within a month or two for Mall, Office and Diversified REITs. There is a jump in the correlation for Industrial properties just prior to September 11th but no major changes after September 11th. The reaction in the Strip and Storage property markets is not as strong either. Interestingly, the correlation between the two return series for Hotel properties experiences a decline in the two months following September 11th.

Another time period that displays a significant movement in the correlation estimates in Figure 4 is the 1997-1998 period. The most relevant events in this time window were the East Asian crisis and Russian crisis. East Asian crisis started in Thailand in July 1997 and spread to other Asian countries in the following months. The Russian crisis erupted in the second half of 1998 though Russia started using some $30 billion in foreign exchange to defend the fixed exchange rate back in 1997 and did not begin to float the exchange rate until September of 1998. What we generally find for this time period is a relatively high correlation between the returns of public and private markets in 1997 followed by a sharp decline in 1998. Once again, however, different property types reacted differently to these crises. As illustrated in Figure 4, Storage and Strip property markets display almost opposite reaction than the other property types during these two crises.

V. Conclusion

The objective of this paper has been to investigate the relationship between REIT returns and NAV returns. For this purpose, we considered two issues. First, we studied whether there exists a unidirectional causality between REIT returns and NAV returns, with one market serving as a price discovery vehicle for the other market. Then, we examined an important component of the risk analysis, the correlation between the REIT and NAV returns. Unlike the earlier studies in the literature, we differentiated among different property types and examine if different property markets exhibit varying price discovery patterns. Furthermore, we utilized a new estimation method that enabled us to have more accurate estimates of the correlation between REIT and NAV return series over time.

Our Granger-causality tests in general confirm earlier empirical results that price discovery takes place in the securitized public market. However, our results also show that there are variations among different property types. While Apartment, Hotel, Office, Self Storage and Diversified REIT returns lead their NAVs, the causality is not significant for the Industrial and Strip Center REITs. Furthermore, the causality is in the reverse direction for Mall REITs where NAV returns lead REIT returns. Our dynamic conditional correlation GARCH tests confirm our expectation that the correlation between NAV and REIT returns changes over time. The correlation between NAV and REIT returns is dynamic for each property type, except for Office. We also find a strong degree of persistence in the series of correlation. Apartment and Diversified, properties have the highest persistence while Industrial, Mall, Self Storage and Strip properties have a lower persistence in correlation. These results have important implications for the construction of an optimal mix of different property types from private and public real estate markets.

References:

Barkham, R. and David G Geltner (1995) “Price Discovery in American and British Property Markets,” *Real Estate Economics*, 23, 21-44.

Benveniste, L., D. Capozza, and P. Seguin (2001), “The Value of Liquidity,” *Real Estate Economics*, 29:4, 633-660.

Brooks, C and S. Tsolacos (2000), “Does Orthogonalisation Really Purge Equity-Based Property Valuations of their General Stock Market Influences?” (2000) *Applied Economics Letters* 7, 305-309

Clayton, Jim (2003), “Capital Flows and Asset Values: A Review of the Literature and Exploratory Investigation in a Real Estate Context,” University of Cincinnati, working paper.

Chau, K. W., Macgregor, B. D. And Schwann, G. (2001) “Price discovery in the Hong Kong Real Estate Market,” *Journal of Property Research*, 18(3), 187–216.

Chan, K., 1992. A Further Analysis of the Lead-lag Relationship between the Cash Market and Stock Index Futures Market. *The Review of Financial Studies,* Vol.5, No.1, pp.123-152.

Chay, J.-B., and C. A. Trzcinka (1999), “Managerial performance and the cross-sectional pricing of closed-end funds,” *Journal of Financial Economics* 52, 379–408.

Cherkes, M., J. Sagi and R. Stanton (2006), “A Liquidity-Based Theory of Closed-End Funds,” Working Paper.

Clayton, J. and G. MacKinnon (2001b) “Explaining the Discount to NAV in REIT Pricing: Noise or Information?” RERI Working Paper.

Clayton, Jim and Greg MacKinnon (2000), “Explaining the Discount to NAV in REIT Pricing: Noise or Information?,” RERI funded working paper.

Clayton, J. and G. MacKinnon (2001a), “Liquidity, the Private Real Estate Cycle, Investor Sentiment and the Premium or Discount to Net Asset Value in REIT Pricing,” RERI Working Paper.

Downs, D., N. Guner, D. Hartzell and M. Torres (2001) “Why Do REIT Prices Change? The Information Content of Barron’s “The Ground Floor”,” *Journal of Real Estate Finance and Economics,* 22, 63-80.

Engle, Robert (2002), “Dynamic conditional correlation-A simple class of Multivariate GARCH models,” *Journal of Business and Economic Statistics,* 20.

Engle, Robert and Kevin Sheppard, 2001, “Theoretical and empirical properties of dynamic conditional correlation multivariate GARCH,” NBER Working Papers 8554.

Forbes, K. and R. Rigobon, 2002, "No contagion, only interdependence: Measuring stock market comovements," *Journal of Finance*, 57, 265-302.

Geltner, David, Bryan D. MacGregor and Gregory M. Schwann (2003), "Appraisal Smoothing and Price Discovery in Real Estate Markets," *Urban Studies*, 40,1047–1064.

Gentry W.M. and C. J. Mayer (2003), "The Effects of Share Prices Relative to 'Fundamental' Value on Stock Issuances and Repurchases," Columbia University Working Paper.

Gentry W.M., C. M. Jones and C. J. Mayer (2004), "REIT Reversion: Stock Price Adjustments to Fundamental Value," Columbia University Working Paper.

Kearney, Mark Andreas and Valerio Poti (2003), "DCC-GARCH Modelling of Market and Firm-level Correlation Dynamics in the Dow Jones Eurotoxx50 Index," Working Paper, Trinity College Dublin.

King, B.F. (1966), "Market and Industry Factors in Stock Price Behavior," *Journal of Business* 39, 139-190.

Lee C. M. C., A. Shleifer and R. H. Thaler (1991), "Investor Sentiment and the Closed-End Fund Puzzle," *Journal of Finance* 46, 75-109.

Ling, David and M. Ryngaert, 1997, "Valuation Uncertainty, Institutional Involvement, and the Underpricing of IPOs: The Case of REITs," *Journal of Financial Economics*, 43, 433-456.

Ling, D., and A. Naranjo (2003) "The dynamics of REIT capital flows and returns," *Real Estate Economics* 31, 405-434.

Newell, G. and Chau, K. W. (1996) "Linkages between direct and indirect property performance in Hong Kong," *Journal of Property Finance*, 7(4), 9–30.

Ong, Seow-Eng and Tien-Foo Sing (2002), "Price Discovery between Private and Public Housing Markets" *Urban Studies*, 39, 57– 67.

Pagliari, J. L. Jr., K. A. Scherer and R. T. Monopoli (2005), "Public versus Private Real Estate Equities: A More Refined, Long-Term Comparison," *Real Estate Economics*, 33, 147-187.

Pontiff, J., (1996), "Costly arbitrage: Evidence from closed-end funds," *Quarterly Journal of Economics* 111, 1135–1151.

Riddiough, T. J., M. Moriarty, and P. J. Yeatman, (2005), "Privately Versus Publicly Held Asset Investment Performance," *Real Estate Economics*, 33, 121-146.

Shleifer, Andrei and Robert W. Vishny (1997), “The limits of arbitrage,” *Journal of Finance,* 52(1):35-55.

Stoll, H.R., and R. E. Whaley (1990), “The Dynamics of Stock Index and Stock Index Futures Returns,” *Journal of Financial and Quantitative Analysis,* Vol.25, No.4, pp. 441-468.

Subrahmanyam, A. (2006) “Liquidity, Return, and Order Flow Dynamics Linkages Between REITs and the Stock Market,” University of California at Los Angeles working paper.

Table 1: Summary statistics for monthly REIT and NAV return series.

	Apartment		Hotel		Mall		Self Storage	
	REIT	NAV	REIT	NAV	REIT	NAV	REIT	NAV
N	133	133	65	65	133	133	108	108
Minimum	-0.1028	-0.0805	-0.4965	-0.2742	-0.2166	-0.1345	-0.1584	-0.0475
Maximum	0.1034	0.0998	0.1802	0.2733	0.0987	0.1368	0.1217	0.0682
Mean	0.0029	0.0041	0.002	-0.0033	0.0074	0.0061	0.0055	0.0068
Median	0.0056	0.0021	0.0185	0	0.0092	0.0022	0.0085	0
Std Dev.	0.037	0.0217	0.1057	0.0718	0.0466	0.0299	0.0452	0.0146
Skewness	-0.0369	0.2347	-2.0317	-0.6296	-1.0467	0.1098	-0.5397	1.0767
Kurtosis	0.3961	5.804	8.2421	7.3668	3.2943	7.6634	1.221	4.857

	Diversified		Industrial		Office		Strip Center	
	REIT	NAV	REIT	NAV	REIT	NAV	REIT	NAV
N	133	133	116	116	132	132	133	133
Minimum	-0.1714	-0.063	-0.2122	-0.1733	-0.2211	-0.0776	-0.197	-0.107
Maximum	0.1329	0.0832	0.1094	0.0759	0.1104	0.0625	0.0797	0.0655
Mean	0.0015	0.0032	0.005	0.0047	0.0049	0.0049	0.0031	0.0027
Median	0.0042	0	0.0067	0.0026	0.0126	0.0025	0.0053	0.0008
Std Dev.	0.0429	0.0169	0.0474	0.0253	0.0456	0.0213	0.0398	0.0233
Skewness	-0.7151	0.5316	-1.1642	-2.784	-1.2665	-0.2492	-1.5416	-1.3287
Kurtosis	3.1226	6.491	4.2298	22.5187	4.618	3.3802	6.2459	7.1546

Table 2:

$\rho(NAV_t, REIT_{t+k})$ is the cross-correlation coefficient between current NAV returns and past REIT returns (for negative lags) and future REIT returns (for positive lags). This analysis is based on the raw data.

	Apartment	Diversified	Hotel	Industrial	Mall	Office	Self Storage	Strip Center
Lag k	ρ	ρ	ρ	ρ	ρ	ρ	ρ	ρ
-5	0.140*	-0.128	-0.081	-0.136	-0.172*	-0.202*	-0.045	-0.033
-4	-0.081	0.035	0.026	-0.050	0.282*	-0.050	-0.079	0.053
-3	0.115	-0.119	-0.108	-0.159*	-0.211*	-0.142	-0.074	-0.085
-2	0.093	-0.033	0.123	-0.049	0.087	0.074	0.138	-0.076
-1	0.208*	0.018	0.035	-0.068	-0.045	0.052	-0.069	0.189*
0	0.165*	0.221*	0.306*	0.408*	0.268*	0.232*	0.114	0.178*
1	0.108	0.113	0.169	-0.039	0.053	0.300*	0.073	0.093
2	0.111	0.204*	0.544*	0.047	0.160	0.229*	0.070	0.118
3	0.034	0.013	0.116	0.049	0.053	0.122	0.115	0.088
4	0.000	-0.118	0.159	0.031	-0.052	-0.079	-0.127	-0.026
5	-0.108	0.117	-0.074	-0.005	0.049	0.051	0.272*	0.023

* Significant at 5% level. Asymptotic standard errors can be approximated as the square root of the reciprocal of the number of observations (i.e. 0.0867 for 133 observations).

Table 3:

Panel A:

$$R_t^{NAV} = a + \sum_{p=1}^{5} b_p R_{t-p}^{NAV} + \sum_{p=1}^{5} c_p R_{t-p}^{REIT} + \varepsilon_t^{NAV}$$

b_1, b_2, b_3, b_4, b_5 are the coefficients of past NAV returns and c_1, c_2, c_3, c_4, c_5 are the coefficients of past REIT returns. t-statistics of these coefficients are given in parenthesis below the estimates (e.g. c_1 for Apartment is significant at 5% level suggest the fact that previous month's of REIT return has an explanatory power for the following month's NAV return). We have also documented the F-values of granger causality test and corresponding. p-values are given in the parenthesis (e.g. for Apartment, REIT return leads NAV return at 6.03% significance; for Mall, previous months NAV return has an impact on current NAV return at 8.58% significance, whereas REIT return leads NAV return at 13.06% significance). These results suggest that we find price discovery in REIT return of Apartment, Diversified, Hotel, Office and Self Storage.

	Apartment	Diversified	Hotel	Industrial	Mall	Office	Self Storage	Strip Center
constant	0.0028	0.0027	-0.0081	0.0063	0.0035	0.0028	0.0034	0.0023
	(1.3953)	(1.6487)	(0.9634)	(2.3361)*	(1.2040)	(1.4818)	(1.8195)	(1.0231)
b_1	0.0150	0.0183	-0.2229	-0.0420	-0.1665	0.0961	0.1343	-0.0917
	(0.1599)	(0.1929)	(1.3653)	(0.3921)	(1.7574)	(1.0102)	(1.3584)	(0.9708)
b_2	-0.0160	0.0546	-0.2087	-0.2475	0.0688	0.0061	0.0283	-0.0453
	(0.1728)	(0.5892)	(1.3492)	(2.2824)*	(0.7205)	(0.0660)	(0.2789)	(0.4528)
b_3	0.1028	-0.0676	-0.0016	-0.1603	-0.0523	-0.1291	0.0223	0.0078
	(1.1109)	(0.7272)	(0.0103)	(1.4554)	(0.5473)	(1.3978)	(0.2182)	(0.0756)
b_4	0.1186	0.1294	-0.1534	-0.0473	0.2513	0.2573	0.0379	0.0289
	(1.2838)	(1.4157)	(1.2511)	(0.4304)	(2.6324)*	(2.7942)*	(0.3698)	(0.2818)
b_5	-0.0195	-0.0344	-0.0566	-0.1460	0.1251	-0.0249	0.2126	0.0094
	(0.2084)	(0.3764)	(0.4564)	(1.3258)	(1.2594)	(0.2728)	(2.0706)*	(0.0934)
c_1	0.1338	0.0569	0.1291	-0.0211	0.0923	0.1548	0.0306	0.0753
	(2.4835)*	(1.5710)	(1.4718)	(0.3659)	(1.5122)	(3.8637)*	(0.9597)	(1.3283)
c_2	0.0426	0.0842	0.4332	0.0817	0.1329	0.0911	0.0287	0.0795
	(0.7481)	(2.2533)*	(4.9792)*	(1.3402)	(2.1364)*	(2.1116)*	(0.8967)	(1.3717)
c_3	0.0601	0.0054	0.1207	0.0851	0.0644	0.0470	0.0127	0.0703
	(1.0626)	(0.1442)	(1.0661)	(1.3964)	(1.0395)	(1.0961)	(0.3941)	(1.2000)
c_4	-0.0832	-0.0619	0.2468	0.0529	-0.0818	-0.0733	-0.0411	-0.0125
	(1.4733)	(1.6419)	(2.4066)*	(0.8578)	(1.3151)	(1.7060)	(1.2987)	(0.2134)
c_5	0.0623	0.0419	0.0244	0.0508	-0.0223	0.0130	0.0792	0.0147
	(1.1114)	(1.1056)	(0.2249)	(0.8459)	(0.3590)	(0.3005)	(2.4837)*	(0.2504)
N	128	128	60	111	127	127	103	128
R^2	0.1248	0.1115	0.4134	0.0858	0.1442	0.2367	0.1801	0.0437
Granger causality test								
NAV	0.5998	0.6381	1.0634	1.622213	2.7013	1.9857	1.6008	0.2258
	(0.7002)	(0.6710)	(0.3920)	(0.161015)	(0.0240)*	(0.0858)**	(0.1677)	(0.9507)
REIT	2.1864	2.3949	5.7794	0.880852	1.7412	4.4880	2.0998	0.9689
	(0.0603)**	(0.0416)*	(0.0003)*	(0.496906)	(0.1306)	(0.0009)*	(0.0724)**	(0.4398)

* *Significant at 5% level*
** *Significant at 10% level*

Panel B:

$$R_t^{REIT} = a + \sum_{p=1}^{5} b_p R_{t-p}^{NAV} + \sum_{p=1}^{5} c_p R_{t-p}^{REIT} + \varepsilon_t^{REIT}$$

b_1, b_2, b_3, b_4, b_5 are the coefficients of past NAV returns and c_1, c_2, c_3, c_4, c_5 are the coefficients of past REIT returns. T-statistics of these coefficients are given in parenthesis below the estimates. We have also documented the F-values of granger causality test and corresponding. p-values are given in the parenthesis Granger causality test results suggest that the NAV return leads REIT returns for Mall at 5% significance, suggesting price discovery only in Mall's NAV.

	Apartment	Diversified	Hotel	Industrial	Mall	Office	Self Storage	Strip Center
constant	0.0021	0.0034	0.0058	0.0117	0.0070	0.0068	0.0078	0.0033
	(0.6018)	(0.8100)	(0.3796)	(2.3785)*	(1.5561)	(1.5479)	(1.2874)	(0.8864)
b_1	0.2296	0.0455	0.1864	0.0057	0.0597	0.1346	-0.1944	0.3162
	(1.4289)	(0.1859)	(0.6249)	(0.0290)	(0.4078)	(0.6103)	(0.5985)	(2.0099)*
b_2	0.2247	-0.1386	0.3846	-0.1346	0.0314	0.1670	0.4925	-0.0873
	(1.4119)	(0.5791)	(1.3611)	(0.6783)	(0.2127)	(0.7746)	(1.4765)	(0.5242)
b_3	0.0682	-0.2529	-0.0140	-0.4589	-0.2925	-0.2911	-0.2098	-0.1365
	(0.4298)	(1.0531)	(0.0485)	(2.2786)*	(1.9801)*	(1.3590)	(0.6243)	(0.7906)
b_4	-0.0018	0.1396	0.0993	-0.2493	0.4091	0.1246	-0.2798	0.1064
	(0.0112)	(0.5915)	(0.4431)	(1.2399)	(2.7736)*	(0.5836)	(0.8297)	(0.6221)
b_5	-0.2682	-0.2126	-0.1021	-0.3462	-0.2094	-0.4075	-0.1142	-0.0720
	(1.6692)	(0.8997)	(0.4508)	(1.7182)	(1.3644)	(1.9281)	(0.3383)	(0.4289)
c_1	-0.0947	-0.0693	0.0969	-0.2869	-0.0415	-0.0153	-0.0568	0.0387
	(1.0250)	(0.7409)	(0.6046)	(2.7163)*	(0.4405)	(0.1644)	(0.5420)	(0.4103)
c_2	-0.0659	0.0343	-0.1728	-0.0399	-0.0036	0.0053	0.1049	-0.1167
	(0.6749)	(0.3550)	(1.0872)	(0.3574)	(0.0370)	(0.0534)	(0.9962)	(1.2097)
c_3	0.0896	0.0639	-0.1471	0.0737	0.0777	0.0877	0.0316	0.0199
	(0.9242)	(0.6563)	(0.7115)	(0.6612)	(0.8109)	(0.8809)	(0.2991)	(0.2043)
c_4	-0.0276	0.0180	-0.1011	0.0338	-0.0731	-0.0857	-0.0437	-0.0246
	(0.2849)	(0.1848)	(0.5396)	(0.2996)	(0.7604)	(0.8597)	(0.4198)	(0.2516)
c_5	-0.0473	-0.1577	-0.1401	-0.0404	0.0514	-0.0969	-0.0069	-0.0224
	(0.4917)	(1.6094)	(0.7065)	(0.3679)	(0.5365)	(0.9686)	(0.0658)	(0.2285)
N	128	128	60	111	127	127	103	128
R^2	0.0715	0.0652	0.0858	0.1435	0.1472	0.0932	0.0584	0.0673
Granger causality test								
NAV	1.2040	0.5225	0.5122	1.6568	3.4022	1.2954	0.7214	1.2034
	(0.3116)	(0.7588)	(0.7657)	(0.1521)	(0.0066)*	(0.2707)	(0.6090)	(0.3119)
REIT	0.6342	0.7786	0.5081	1.6667	0.4782	0.5126	0.3028	0.3521
	(0.6740)	(0.5670)	(0.7687)	(0.1496)	(0.7919)	(0.7663)	(0.9101)	(0.8800)

* *Significant at 5% level*

Table 4:

Table below displays the results of our DCC model for monthly return series of REITs and NAVs for different property types where ($\omega_1, \alpha_1, \beta_1$) are GARCH(1,1) parameters for REIT series, and ($\omega_2, \alpha_2, \beta_2$) are GARCH(1,1) parameters for NAV series, and (a_1, a_2, b_1) are the DCC parameters. These parameters are estimated from $h_{it} = \omega_i + \alpha_i r_{it-p}^2 + \beta_i h_{it-p}$ where i = {REIT return series, NAV return series} and parameter a, b are the DCC parameters estimated from

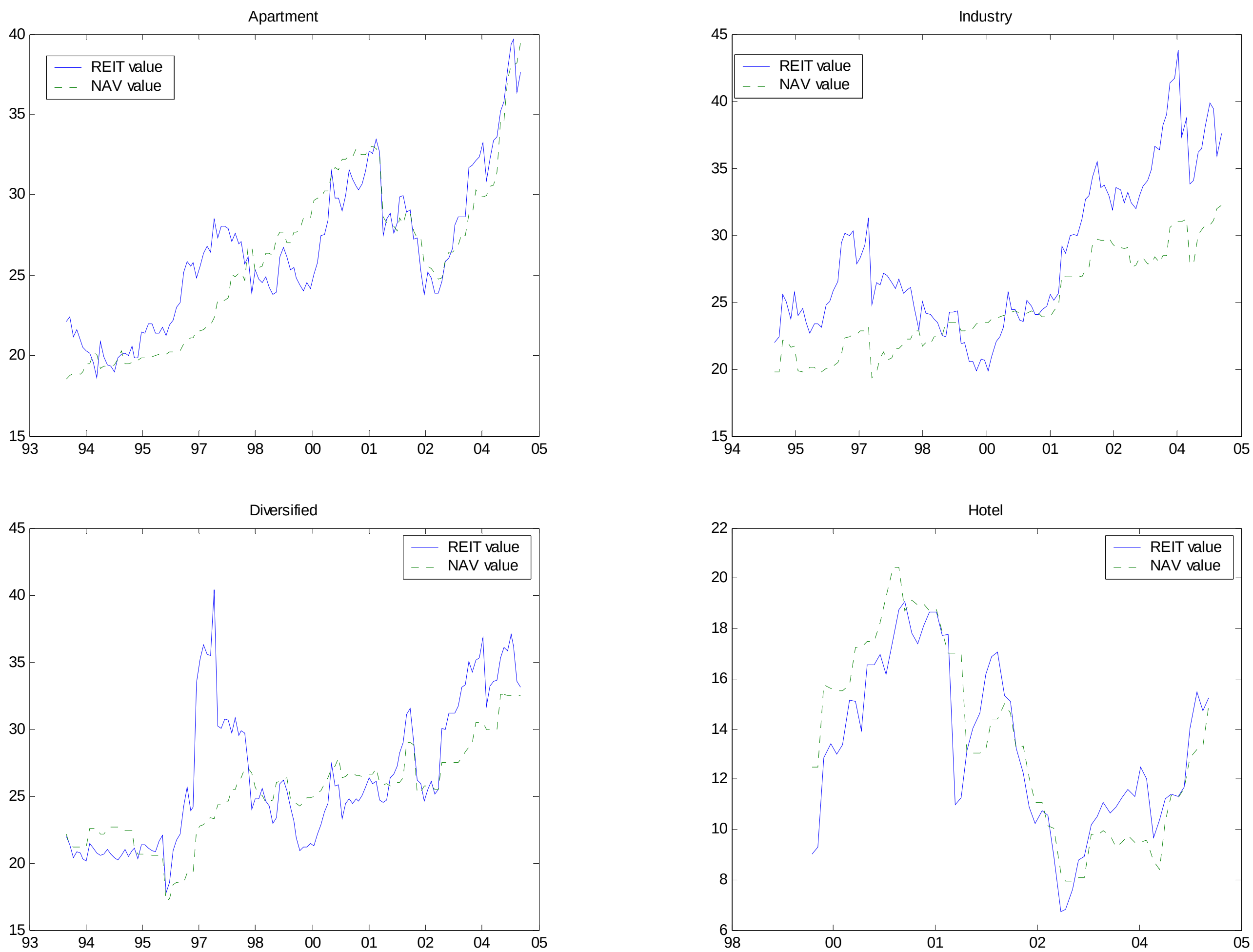
$$q_{ij,t} = (1 - a - b)\overline{\rho_{ij}} + a\varepsilon_{it-1}\varepsilon_{jt-1} + bq_{ij,t-1}.$$

Significant *a, b* parameters confirm that we should not assume constant correlations. Furthermore, having a value of (*a*+*b*) close to 1 indicates the strong degree of persistence in the series of correlation. For Mall, Self Storage and Strip Center, DCC(2,1) was significant. Therefore, we have a_1, a_2 and b_1 reported for these properties.

	Apartment DCC(1,1)	Diversified DCC(1,1)	Hotel DCC(1,1)	Industrial DCC(1,1)	Mall DCC(2,1)	Office DCC(1,1)	Self Storage DCC(2,1)	Strip Center DCC(2,1)
ω_1	0.0012*	0.0018*	0.0109*	0.0023*	0.0018*	0.0020*	0.0019*	0.0011*
α_1	0.0191*	0.0069	0.0000	0.0666*	0.1842*	0.0000	0.0948*	0.3740*
β_1	0.0698*	0.0000	0.0000	0.0000	0.0000	0.0481*	0.0000	0.0000
ω_2	0.0005*	0.0003*	0.00509*	0.0007*	0.0008*	0.0005*	0.0002*	0.0005*
α_2	0.0000	0.0000	0.0000	0.0000	0.1344*	0.0000	0.2871*	0.0000
β_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0349*	0.0000
a_1	0.0798*	0.2130*	0.00002*	0.5036*	0.0602*	0.0000	0.0000	0.0000
a_2					0.0225		0.1022*	0.1496*
b_1	0.8341*	0.6046*	0.000008	0.0000	0.0000	0.0000	0.0000	0.0000

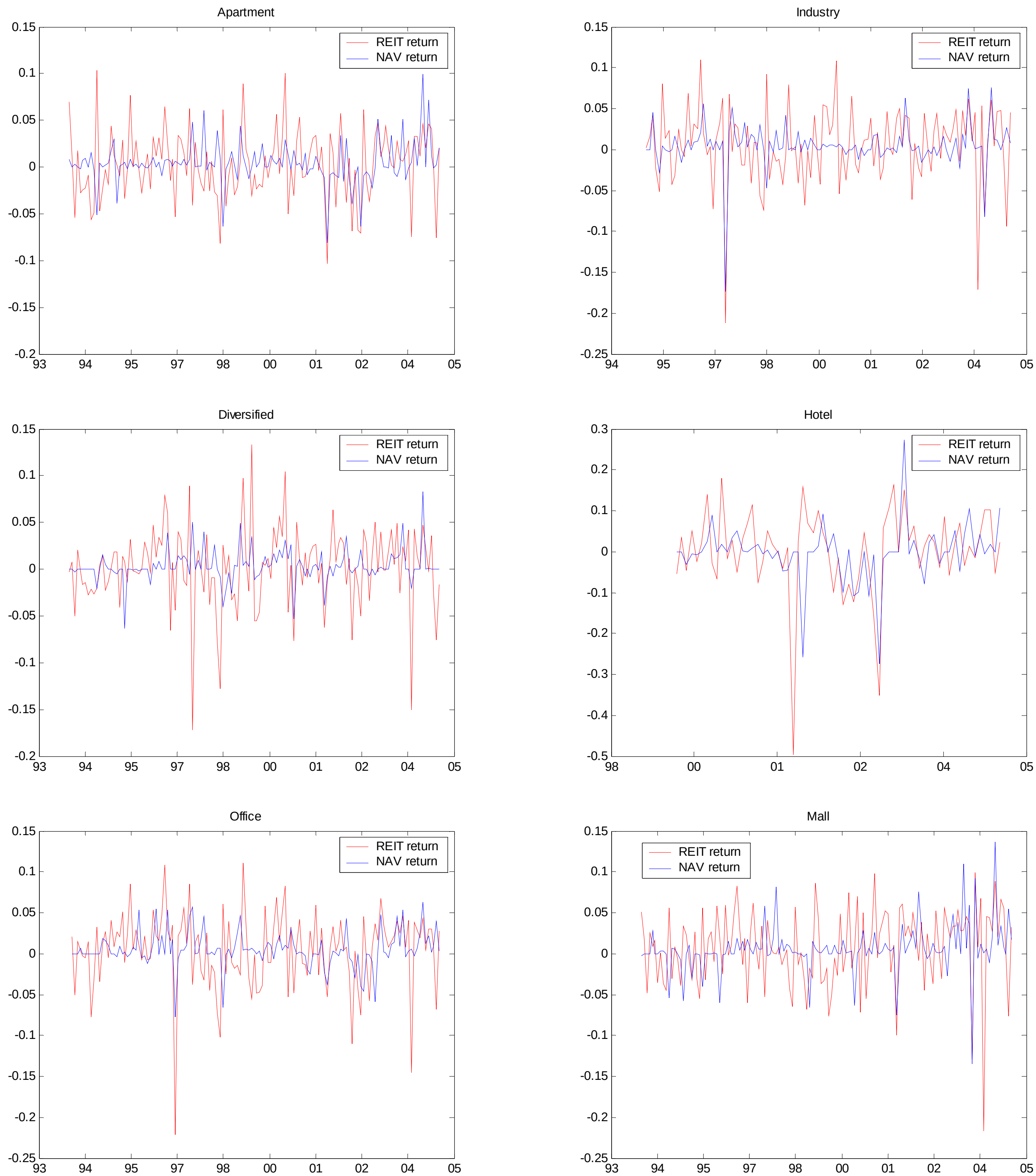
* *Significant at 5% level*

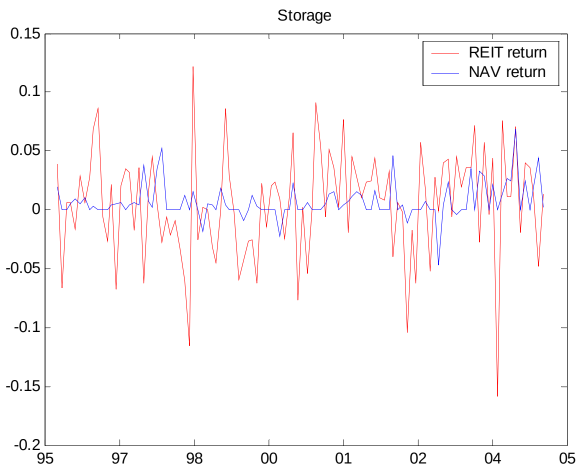
Figure 1: REIT and NAV series




Office
REIT value
NAV value
Mall
REIT value
NAV value
Storage
REIT value
NAV value
Strip
REIT value
NAV value

Figure 2: Monthly returns series of REIT and NAV prices




Storage
REIT return
NAV return
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
95
97
98
00
01
02
04
05

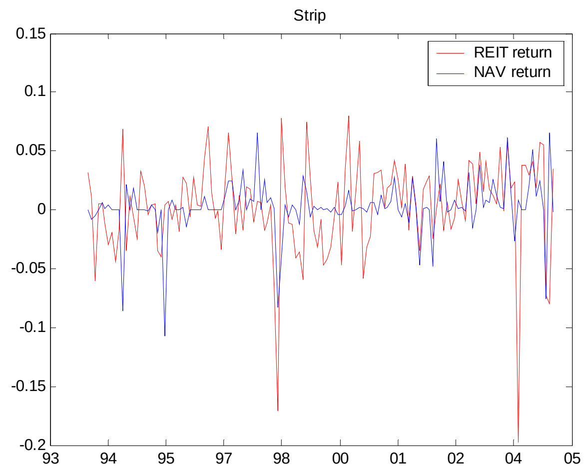
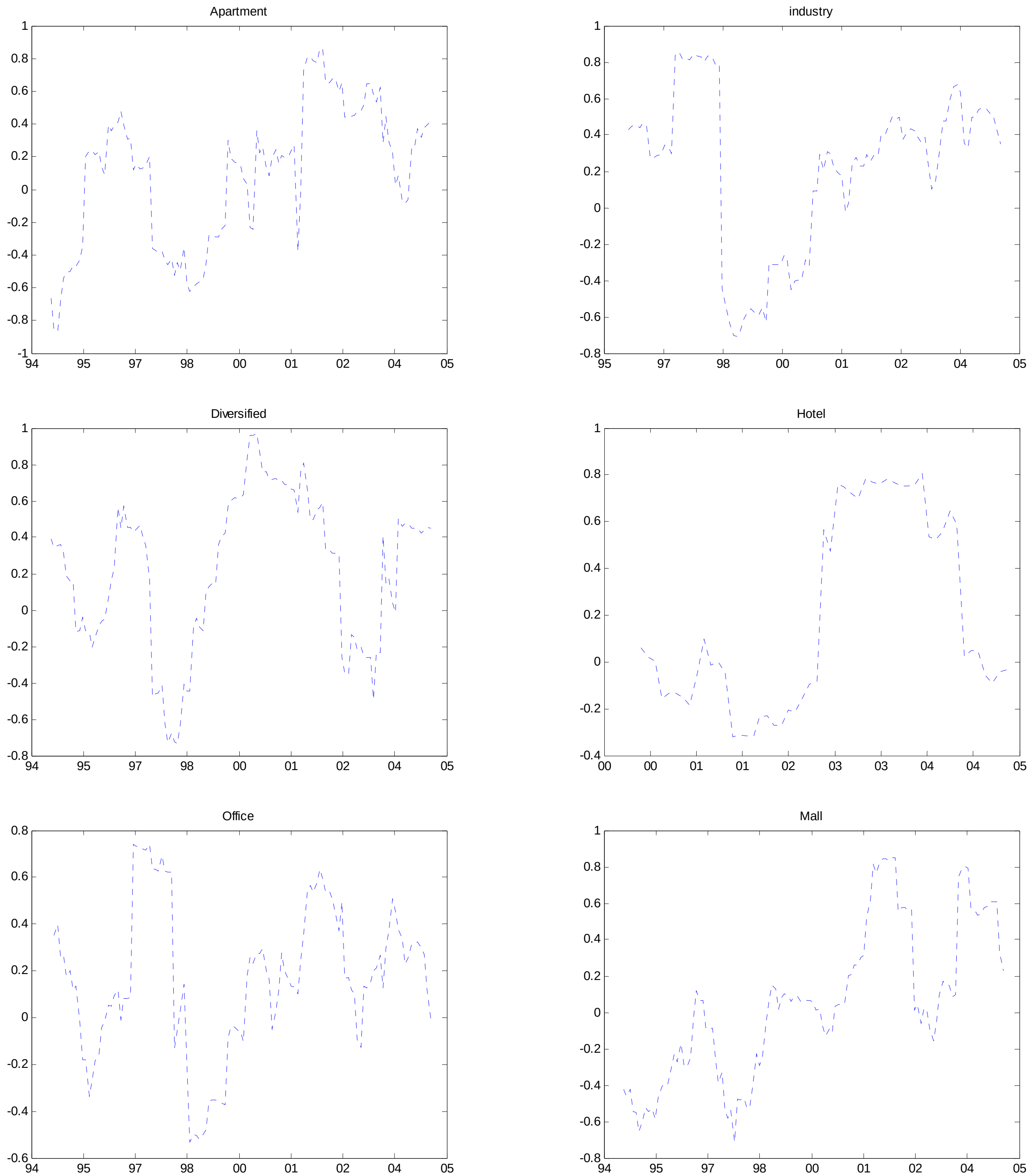
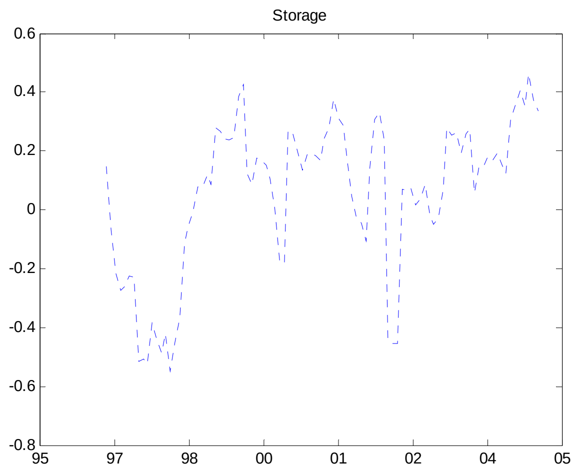

Strip
REIT return
NAV return
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
93
94
95
97
98
00
01
02
04
05

Figure 3: Rolling estimation of correlation coefficients based on 1 year window.




Storage
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
95
97
98
00
01
02
04
05

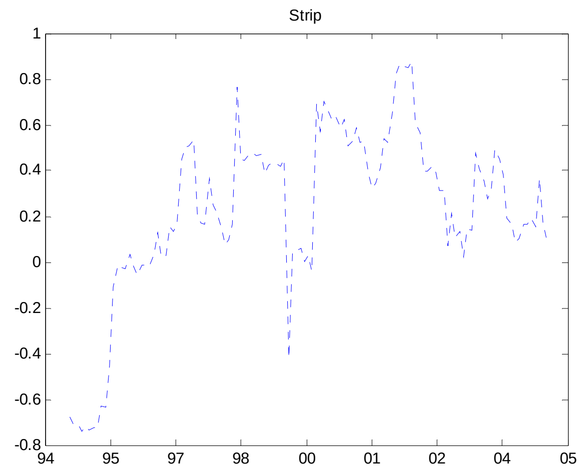
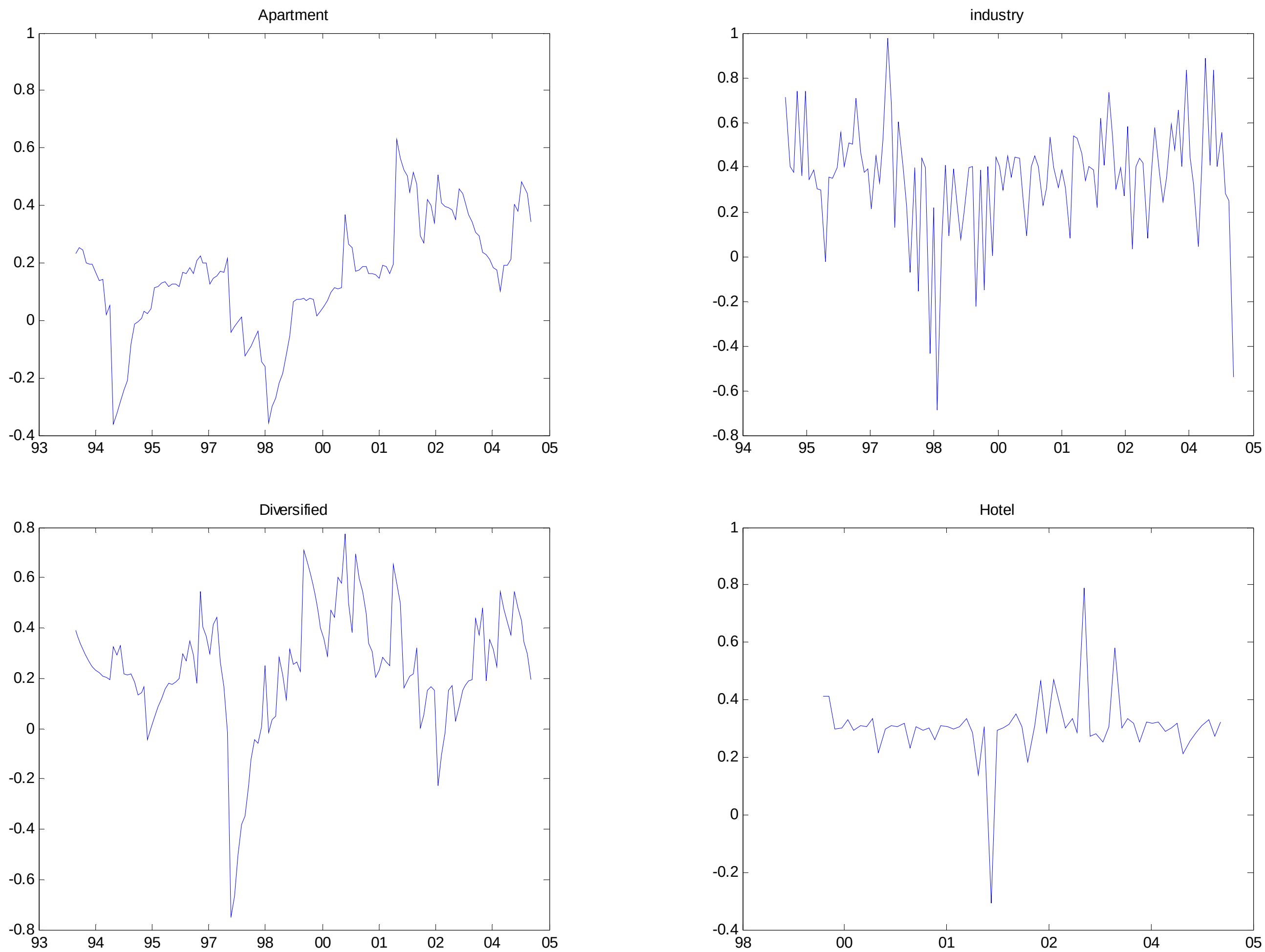
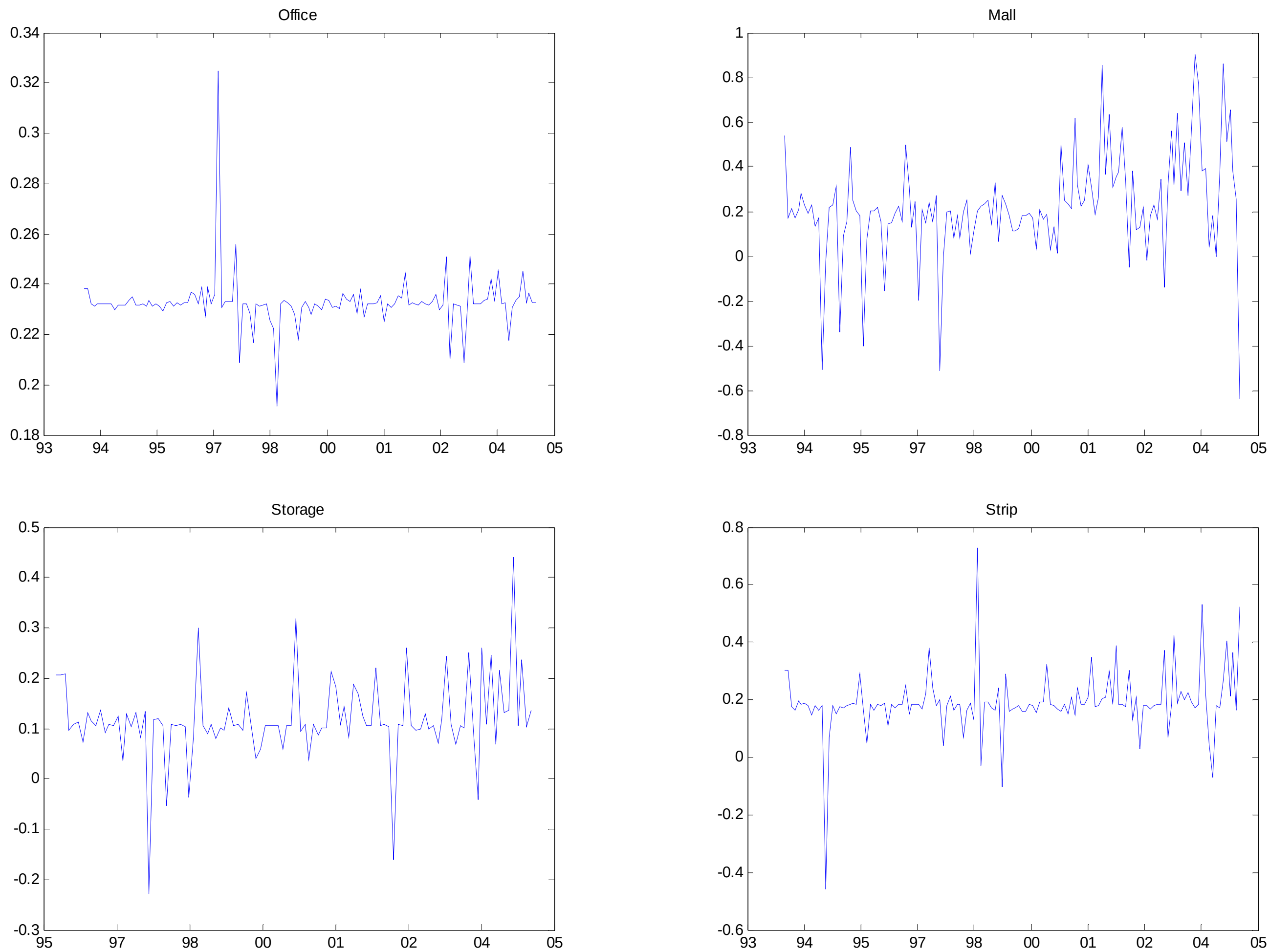

Strip
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
94
95
97
98
00
01
02
04
05

Figure 4: Dynamic correlation of REIT and NAV returns.

Based on the results of Table 3, the figures below display the presence of dynamic correlation for all REIT types except for Apartments. The absence of dynamic correlation for Office properties suggest that the correlation of REIT and NAV return series for Office properties is constant throughout time.




Office
0.34
0.32
0.3
0.28
0.26
0.24
0.22
0.2
0.18
93 94 95 97 98 00 01 02 04 05
Mall
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
93 94 95 97 98 00 01 02 04 05
Storage
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
95 97 98 00 01 02 04 05
Strip
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
93 94 95 97 98 00 01 02 04 05