EXPLAINING THE NAV DISCOUNT IN REIT PRICING

EVIDENCE FROM THE U.S.

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Explaining the NAV Discount in REIT Pricing – Evidence from the U.S.

Abstract:

This paper investigates the relationship between stock price and net asset value (NAV) for 71 real estate investment trusts (REITs) in the U.S. between Q1/1998 and Q4/2018. More specifically, by testing for cointegration, we look for evidence of a long-term equilibrium between stock price and NAV. We use the group-mean panel-dynamic ordinary least-squares (PDOLS) estimator and error correction model (ECM) is to observe the dynamic relationship between price and NAV. In addition, we estimate two fixed-effect models to regress NAV discount against a number of firm- and market-specific factors. Our results show a long-term equilibrium between stock price and NAV, as well as mean-reverting behavior towards this long-term equilibrium both over the long and the short term. By estimating fixed-effect models for firm- and market-specific factors we find that leverage, company size, liquidity, past performance, consumer confidence and business confidence are significantly correlated with U.S. REITs' NAV discounts.

Keywords:

REITs, Dynamic relationship, NAV discount, Closed-end fund puzzle, United States

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Contents

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1. Introduction

Real estate investments have attracted significant attention from academia due to their close relation to the economy and society as a whole. More specifically, real estate investment trusts (REITs) is an interesting topic that has been widely studied. A REIT is a special type of closed-end fund which focuses on real estate investments, and the shares of which are traded on the stock exchange. In the U.S., the Securities and Exchange Commission mandates that REITs must pay out 90% of their earnings as dividends, and REITs are not required to pay taxes on this proportion of their earnings. This structure is especially beneficial to small individual investors, as buying individual shares in REITs enables them to benefit from the regular and predictable cash flow produced by real estate without committing a substantial amount of capital typically needed for a direct real estate investment.

Since REITs have features of both real estate (real property) and stock (financial assets), the movements in the stock price of REITs, as well as the relationship between the stock price and net asset value (NAV) have received significant attention. Previous research has observed that REITs typically trade at a price that is different from the market value of the underlying property portfolio. This phenomenon of REITs trading at either a discount and premium to NAV is more generally known as the closed-end fund puzzle. It is thought that investors value REITs' higher liquidity compared to direct real estate investments, which contributes to the shares trading at a premium to NAV. Similarly, the management fees charged by REITs are thought to contribute to a NAV discount. There have been attempts to identify various firm- and market-specific factors that have an impact on REITs NAV discounts. Out of factors studied, leverage used can be considered to be of particular importance to REITs, as in 2012 the average level of leverage for REITs was 58%, compared to an average of 33% for closed-end funds in general.

By conducting an overview of existing literature on REITs' NAV discounts in different geographical regions, we find that there is space for additional research on the topic. Through this paper, we hope to contribute to research on REITs' NAV discounts in a number of ways. Firstly, in this paper we focus on REITs listed on U.S. stock exchanges for a time period spanning from Q1/1998 to Q4/2018. This period covers the global financial crisis, which originated from the U.S., and has had a serious global impact on both listed real estate markets and financial markets in general. In this study we are able to directly witness the trend in NAV discount in the U.S. starting from 2008. Secondly, in our study we investigate the relationship between stock price and NAV for U.S. REITs by both looking at patterns of cointegration between the variables, as well as at the effect of firm- and market-specific factors on the NAV discount. To our knowledge, this methodology offers a more thorough look into the price-NAV relationship compared to most previous studies.

In this paper, Section 2 provides an overview of existing research on relevant topics and shows how empirical results differ across regions. Section 3 presents the sample and the variables that were selected for our analysis. In Section 4 we provide explanations of the methodologies used, as well as an overview of the empirical results. In Section 5 we discuss our study and further explain our thoughts regarding the analysis. Finally, in Section 6 we offer concluding remarks along with economic implications, limitations and suggestions for future research.

2. Previous Research

2.1. An Introduction to Closed-end Fund Puzzle

2.1.1. Closed-end Fund Puzzle

A closed-end fund (CEF) is a publicly traded fund that makes investments into securities. It differs from an open-end fund in that its shares are traded on a secondary market instead of being directly traded with the fund itself. The CEF puzzle describes a frequently observed phenomenon where the stock price of a fund deviates from its net asset value (NAV). Zweig (1973) argues that CEF puzzle is the result of the investor expectations, which is also supported by Weiss (1989). Several researchers such as Lee et al. (1991) argue that these investor expectations are necessarily irrational, with deviations from NAV reflecting either optimistic or pessimistic sentiments of individual investors regarding future returns. Cherkes et al. (2008) attempt to find rational explanations for the CEF puzzle and argue that the NAV discount is created by the combined effect of liquidity benefits and management fees. According to them, investors value the added liquidity that CEFs provide relative to direct investments into securities, which causes the funds to trade at a premium to NAV. Similarly, investors see diminished value from management fees charged by the fund, which contributes to a NAV discount. Therefore, they suggest that the value of a CEF the sum of its NAV and its capitalized liquidity benefits less its capitalized management fees.

2.1.2. Real Estate Investment Trusts

Real estate belongs to a special category of assets where its value is not purely determined by the construction cost of the physical asset but is also affected by how well it facilitates the tenant's ability to utilize affiliated resources such as transportation, education, community, and scenery.

A REIT, or a real estate investment trust, can be defined as a closed-end fund that gathers capital by issuing shares, and which is managed and operated by a dedicated real estate investment institution that allocates investment returns proportionally to investors. Capital invested in REITs can be invested into different categories of real estate including residential, retail, office, hotel, and industrial properties. These investments provide returns through rental income and potential appreciation in the market value of the properties. In the U.S., REITs are required by the Securities and Exchange Commission to pay out 90% of their earnings as dividends, and they are also not required to pay tax for this proportion of their earnings. Therefore, REITs offer investors reliable and predictable cash flow. Compared to direct real estate investments, REITs have the following differentiating features:

1. A lower investment threshold. The amount of funds needed for purchasing individual shares in REITs is significantly lower compared to that required for direct real estate investments, making real estate investments more accessible to a larger number of small private investors

2. Diversification. The value of a direct real estate investment is dependent on a combination of property-specific factors, including renovation needs, rental income development, and vacancy levels. These factors expose the investor to a significant degree of idiosyncratic risk. Investing indirectly into a large property portfolio through REITs can be an efficient way of diversifying away such risk. (Nareit, 2019)

3. Lower operating expenses. When an investor makes a direct real estate investment, subsequent maintenance and operation of the property itself can be costly, as expenses such as those related to property caretaking, renovations, and leasing are incurred by the individual property. Additional costs such as those related to sourcing, conducting due diligence, arranging financing and negotiating a purchase agreement are also incurred when purchasing real estate. A real estate portfolio owned by a REIT is managed and operated by a specialized institution, resulting in economies of scale and subsequent savings to investors, even after accounting for REIT management fees.

4. Liquidity. In direct real estate investments, finding a buyer for an individual property is often time-consuming. As REITs' shares are traded on the stock exchange, trading is easier for investors, resulting in a significantly higher level of liquidity compared to direct real estate investments. (Nareit, 2019)

2.1.3. Real Estate Valuation

Real estate can be valued through a variety of methods. In this section, common valuation methods are covered.

When real estate is valued through discounted cash flow analysis, projected future revenue and expenses for the property are used to determine free cash flows for each time period in the future. Free cash flows for each period are the discounted to their present value using the cost of capital. The sum of these discounted cash flows equals the estimated value of the property. Discounted cash flow analysis is typically used by external appraisers when deriving the market value of the real estate portfolio held by a REIT. This valuation, which is typically conducted on an annual basis, is used to derive the NAV of a REIT. NAV, which represents the company's asset base net of leverage, is defined by Capozza and Lee (1995) as the sum of the market value of the firm's property portfolio and its other assets less the company's total liabilities.

Residential real estate can also be valued through the hedonic pricing model, which sets a value that is based on how the individual attributes of the property can provide value to home buyers. The concept of hedonic pricing is first introduced by Court (1939). Rosen (1974) builds a more systematic theoretical framework around the model. According to Rosen, the core idea of model is that consumers' willingness to pay for a specific product depends on the level of value that they can derive from the attributes of each product. Initially the hedonic pricing model was used to price durable consumer goods, until it was firstly introduced to real estate pricing in the study by Ridker and Henning (1967). In this sense, the value of a residential property can be derived from attributes such as apartment age, number of rooms, and accessibility to public facilities. When valuing real estate through the hedonic pricing model, a real estate property is divided into not only the physical space but also into affiliated resources which can be priced separately.

2.2. NAV Discount

A significant number of previous studies have focused on the NAV discount of closed-end funds, and more specifically REITs. These studies can be classified into distinct categories. Firstly, previous studies have looked at the long- and short-term dynamics of NAV discount over time. In analyzing how the NAV discount behaves in the long-term, the cointegration method is typically used to observe the relationship between NAV and stock price. Secondly, how the NAV discount of real estate funds is generated and maintained has attracted attention. The rational approach and noise trader approach are two common methods of explaining how the NAV discount is generated. The rational approach identifies firm-specific factors that have a significant effect on the NAV discount, while the noise trader approach observes the influence of irrational investors who make decisions based on the prevailing market sentiment instead of rational analysis. Furthermore, there are studies which aim to analyze and explain the rationale behind different levels of NAV discount and co-movements across different markets.

2.2.1. Price-NAV Dynamics

Within the general closed-end fund literature, it has been observed that NAV discounts vary widely over time. It is recognized that REITs generally trade at either a discount or a premium to NAV, and that this relationship fluctuates over time. Goebel and Ma (1993) find evidence of cointegration between stock prices and NAVs for listed REITs in the U.S. market in 1972-1992. Barkham and Ward (1999) also find proof of cointegration in the U.K in 1974-1994. Liow and Yeo (2018) find similar evidence for six different Asian listed real estate markets in 2004-2014. Together the studies provide evidence of the existence of a long-term equilibrium between stock price and NAV for REITs across different markets, and that the variables systematically mean-revert to this equilibrium. Gasbarro et al. (2003) find evidence of cointegration for equity and bond CEFs in the U.S. market in 1991-1996, implying that the existence of a long-term equilibrium is not limited to REITs, but can be observed for CEFs in general.

Previous research has also examined the patterns of mean-reversion towards the equilibrium. Liow and Yeo (2018) find that in the six observed Asian markets, 9% to 21% of the disequilibrium was corrected each quarter, while Barkham and Ward (1999) find the rate of correction to be 3% in the U.K. market. According to Lee et al. (1991) and Cuthbertson (1996), the movement of stock price and NAV around a long-term equilibrium may serve as evidence for the fact that positive or negative noise trader sentiment causes mean reversion through short-term corrections.

2.2.2. Rational Approach - Firm-specific Factors

The rational approach attempts to find rational explanations for the CEF puzzle by identifying firm-specific factors that have a significant effect on the NAV discount. Previous studies have attempted to determine these firm-specific factors based on the assumption that markets are efficient, investors are rational and stock prices accurately reflect information about the respective companies or funds. A number of variables most frequently used in previous studies to explain NAV discount through the rational approach are listed below.

2.2.2.1. Leverage

Leverage is defined as the ratio of a company's debt to its assets or equity. When leverage is high, the NAV discount may be affected in different ways. According to Morri and Benedetto (2009), a high leverage ratio can increase the level of discipline of a REIT's management, which lowers agency costs and thereby decreases NAV discount. Besides, a higher level of debt can also result in an increasing risk of financial distress and thus increase NAV discount. Compared to other closed-end funds, REITs are characterized by an average high level of leverage. In 2012, REITs had an average of 58% of total leverage (Nareit, 2018), while the figure was only 33% for all closed-end funds (Fidelity, 2012).

Earlier studies show different results related to the effect of leverage. A study by Barber (1996) finds a negative correlation between leverage level and NAV discount for real estate limited partnerships, but the magnitude of the effect varies depending on the model specification used. Clayton and MacKinnon (2001) also find a negative relationship for REITs by using debt-equity ratio as a proxy for leverage.

On the contrary, Anderson et al. (2001) show a positive correlation, indicating that REITs that have a greater proportion of debt tend to trade at a discount to NAV since higher leverage increases the default risk of REITs. Morri et al. (2005) find similar empirical results, attempting to remove the accounting effect of leverage by using unlevered NAV discount. This unlevered NAV discount is calculated by assuming that outstanding debt is repurchased by issuing new equity. The measure attempts to remove the accounting effects of debt so that the effects of other variables chosen can be better analyzed. Morri and Benedetto (2009) also show a positive correlation between leverage and NAV discount by using a sample from which the effect of tax shield has been removed.

2.2.2.2. Liquidity

Liquidity is defined as the speed at which a specific asset can be traded on the market, indicating the ease of trading this asset. Cherkes, Sagi, and Stanton (2005) find liquidity to be a significant factor in explaining CEF discounts, with higher liquidity correlating with a lower NAV discount. As mentioned earlier, the level of liquidity is also one of the main factors differentiating REITs from direct real estate property investments. Since direct real estate investments are by nature more illiquid compared to listed assets comprising the portfolio of a typical equity closed-end fund, we expect higher liquidity to be especially attractive to REIT investors.

Researchers use different proxies to represent the level of liquidity for REITs. Clayton and MacKinnon (2001) find that liquidity negatively affects discount by using the effective bid-ask spread as their proxy for liquidity, while Brounen and Laak (2005) find a similar correlation by utilizing the ratio of traded stock to total assets as their proxy.

2.2.2.3. Size

Size is defined as the book value of the company measured by its total assets. Similar to leverage, there is no clear consensus on how company size affects NAV discount, as changes in size might lead to different impacts on NAV discount. According to Barkham and Ward (1999), REITs of larger size tend to have lower liquidity, which results in greater NAV discount. On the contrary, Adams and Venmore-Rowland (1990) argue that it is likely for larger REITs to produce abnormal returns as they have better access to capital and attractive properties, leading to a lower NAV discount. Brounen and Laak (2005) detect that REITs size negatively affects NAV discount, while Clayton and MacKinnon (2000) find a positive correlation that larger REITs often trade at a premium to NAV. Also, studies by Barkham and Ward (1999) and Bond and Shilling (2004) do not find significant relationship of REITs size. What is more, previous studies also use different proxies for size, such as value of market total asset or market equity.

2.2.2.4. Performance

Performance is defined as the level of historical earnings for a company. Bleaney and Smith (2003) find that CEF returns in the past 12 and 24 months are negatively correlated with a NAV discount. Similar evidence is found for REITs, with most of the empirical results showing a negative relationship between performance and NAV discount as stock prices increase following a positive announcement of results and vice versa. A study by Morri et al. (2005) uses return on equity and monthly average total return as indicators for performance and finds that better performance contributes to a lower NAV discount.

However, a paper by Morri (2006) finds a positive correlation between NAV discount and dividend yield, which shows that the empirical result for performance can be different when using other variables as proxy.

2.2.2.5. Investment Activity

Investment activity is defined as the magnitude at which a company grows its assets under management through new investments within a specific period of time. Morri (2006) and Morri and Benedetto (2009) argue that REITs with delayed investment activity should experience a greater NAV discount. According to this argument, rational investors should value the fact that their capital flows quickly into real estate investments of higher expected return instead of being held on the REIT’s balance sheet. Therefore, REITs with a greater level of investment activity should have a lower NAV discount.

2.2.2.6. Management Fee

Management fees refer to the fees charged by the management of a REIT in exchange for managing the company. The management fee is typically a predetermined percentage of the assets under management. Cherkes et al. (2008) find that NAV discounts of closed-end funds are positively correlated with management fees charged by CEFs. They argue that investors see diminishing value as a result of higher management fees, which causes the share price to decline. Capozza and Lee (1995) find evidence that REITs’ NAV discounts are also positively correlated with management fees.

2.2.3. Noise Trader Approach - Market-specific Factors

Based on the irrational investor argument presented in the general CEF literature, the noise trader approach argues that in addition to the rational investors in the market who look at various firm-specific factors and avoid being affected by market sentiments, there are also noise traders who make investment decisions based on the market sentiment or fads. This approach is initially introduced by De Long et al. (1990). Compared to rational traders on the market, noise traders follow the market sentiment which is unpredictable and stochastic. Also, according to Cuthbertson (1996), the risk of noise traders is systematic, and it cannot be diversified away by rational traders.

Lee et al. (1991) argue that the noise trader effect can explain NAV discounts by emphasizing the difference between CEFs' shares and the underlying assets in the portfolio. More specifically, they argue that CEFs' shares are mainly held by noise traders while the underlying assets tend to be held by rational investors. Therefore, in the case of REITs, the systematic risk induced by noise traders could increase the risk of REITs shares, which could further negatively affect the price and increase NAV discount. Based on this theory, NAV discount can be a reasonable indicator of market sentiment.

Barkham and Ward (1999) investigate the noise trader approach by observing economic indicators by using indexed of expected inflation, business optimism and consumer optimism as proxies for the market sentiment. Using these market sentiment proxies and NAV discount, their result shows that expected inflation and industrial optimism significantly affect NAV discount while consumer optimism does not have a significant effect.

2.2.4. Regional NAV Discounts

Previous research shows that the levels of REITs' NAV discounts vary in different regions based on factors such as market development, cultural differences, government regulation, and consumer tastes.

2.2.4.1. United States

As the world's most developed financial market, the U.S. also has the largest number of REITs. Since U.S. securities are traded globally, market volatility experienced in the U.S. can influence other markets across the globe, which was seen during the global financial crisis of 2008. Partially due to the 1993 Revenue Reconciliation Act, U.S. REITs began to grow in popularity in the 1990s. Goebel and Ma (1993) find that U.S. REITs traded at a 23% NAV discount in 1972-1992. Capozza and Lee (1995) analyze U.S. REITs in 1985-1992, looking for factors correlated with NAV discount. Specifically, they sort REITs into categories such as retail, office, industrial, and logistics based on the companies' investment focus, and find that industrial and logistics REITs traded at larger NAV discounts compared to other categories.

2.2.4.2. Asia

Asia is a region which includes highly developed real estate markets such as Japan and Singapore as well as less developed markets such as Thailand, Malaysia, and the Philippines. Overall, listed real estate markets in Asia are growing at a fast pace, but are diverse and thus need to be treated separately.

Lee et al. (2013) study 23 listed REITs in Singapore in 2005-2010. Their results show that in Singapore, REITs on average traded at a discount to NAV. In addition, they find that liquidity as measured by trading volume was positive correlated with NAV discount in the short-run while the lagged trading volume was negatively correlated with NAV discount. Interestingly, they find that the correlation between NAV discount and liquidity vanished after the financial crisis in 2008.

Liew and Yeo (2018) analyze the dynamic relationship between price and NAV for Japan, Hong Kong, Singapore, Malaysia, the Philippines and Thailand. Among these markets, they show that listed real estate companies in Japan, Thailand and the Philippines traded at a premium to NAV on average, while Singapore, Hong Kong, and Malaysia traded at a discount to NAV on average. By examining mean-reverting and spillover effects, they show that six markets are correlated with each other, and that an unexpected change of price-to-NAV ratio in one market can have an impact on that of other markets.

2.2.4.3. Europe

In Europe, most countries with an active listed real estate market are developed countries such as the U.K., Germany, France, Netherland and Switzerland. What is more, most European markets are geographically connected, while most active listed real estate markets in Asia are separated by land or sea. In addition, the creation of the European Union has resulted in shared political and economic regulation throughout the EU member countries, which may have made listed real estate markets in Europe more interconnected.

Brounen and Laak (2005) investigate listed real estate in Europe and find that most of European property shares trade at an average discount to NAV of 36%. Rehkugler et al. (2012) combine the rational and noise trader approaches in their study of 10 European real estate markets in 2000-2007. They also show that on average, listed real estate in Europe traded at a discount to NAV except in 2005-2006. They also argue that market sentiment may have significantly affected the level of NAV discount in these markets.

3. Data

The data sample consists of 71 REITs listed in U.S. stock exchanges for an observation period of 84 quarters, running from Q1/1998 to Q4/2018. A total of 156 REITs was found for the full observation period. However, it was observed that several of the companies had either listed or delisted within the observation period, which restricted our ability to collect data for these companies for the full period. In addition, we found that a number of the companies only publish financial reports on a semi-annual basis, making it unfeasible to obtain quarterly data without interpolation. As a result, the sample collected and used consists of 71 companies that had complete data available for the full observation period.

Individual companies' financial statement items that were used to calculate NAV as well as explanatory variables used in the fixed-effects regression were collected through Thomson Reuters Datastream.

Due to poor availability of quarterly reported NAV values, we use estimated levered NAV values that have been calculated using REITs' balance sheet items. Estimated NAVs were calculated as follows:

$$NAV = \frac{Market\ Value\ of\ the\ Properties + Other\ Assets - Total\ Liabilities}{Number\ of\ Shares\ Outstanding} \quad (1)$$

Capozza and Lee (1995) suggest this proxy measure of NAV. We assume that the sum of market value of properties and other assets is equal to the total assets reported on each REIT's balance sheet. For total liabilities, we use the total liabilities item reported on each REIT's balance sheet. In order to confirm the validity of the proxy, we compared the NAV estimations to the available reported NAVs. We found that the average deviation between estimated and reported values was 2.01%. We concluded that the difference is small enough to make the estimated NAV a reasonable proxy for the reported NAV. The NAV discount measure, or NAVDISC that was used in the fixed-effects regression was calculated as follows:

$$NAVDISC = 1 - \frac{P}{NAV} \quad (2)$$

LEV, or leverage, is defined as a ratio of a company's reported long-term debt to its total assets. This measure of leverage essentially determines the percentage of total assets that a company would need to service its long-term obligations.

SIZE, or size, is defined as the natural logarithm of a company's reported total assets. A natural logarithm is used in order to reduce the scale of the values. This definition of size is also applied by Barkham and Ward (1999), Morri and Bendetto (2009) and Morri and Baccarin (2016).

LIQ, or liquidity, is defined as a ratio of the average daily trading volume of a company's outstanding common stock to its total number of common stock outstanding. While some previous studies, such as Morri and Baccarin (2016) use the natural logarithm of average daily trading volume as a measure of liquidity, we decided to use a ratio in order to make the liquidity measure more comparable across companies.

PERF, or performance, is defined as a ratio of a company's quarterly reported net income to its total assets. The same measurement is used in a study by Morri and Bendetto (2009). We use net income reported on REITs' income statements, as well as total assets reported on REITs' balance sheets in our calculation.

INV, or investment activity, is defined as a ratio of a company's cash flow from investments to its total assets, which is also used in a previous study by Morri and Baccarin (2016). We use cash flow from investments reported on REITs' cash flow statements, as well as total assets reported on REITs' balance sheets in our calculation.

INF, or expected inflation, is a measure of household expectations regarding price changes in the coming 12 months. The measure uses quarterly averages of these survey results. The data is retrieved from the Federal Reserve Bank of St. Louis.

CCI, or consumer confidence index, is a measure of household confidence regarding their savings capacity, employment opportunities, and the general economy in the coming 12 months. The index uses quarterly averages of these survey results. Values below 100 indicate household confidence towards the future, while values below 100 indicate pessimism. CCI is used as a measure of sentiment by Barkham and Ward (1999). The data was retrieved from the OECD.

BCI, of business confidence index, is a measure of industry confidence regarding production developments, orders, and stocks of finished goods. The index uses quarterly averages of these survey results. Values below 100 indicate industry confidence towards the future, while values below 100 indicate pessimism. BCI is used as a measure of sentiment by Barkham and Ward (1999). The data was retrieved from the OECD.

Additional factors such as REIT management fees, operational risk, and insider ownership, while commonly thought of as being correlated with NAV discounts, were left out due to insufficient data or poor availability of a reasonable proxies. In the case of management fees, Capozza and Lee (1995) use General & Administrative (G&A) expenses reported on REITs' income statements as a proxy for management fees and find a significant correlation between this factor and NAV discount for U.S. REITs. However, as G&A also includes miscellaneous expenses such as those related accounting operations and office premises, we do not consider it to be an accurate proxy for management fees, and therefore choose not to include it in our list of variables.

Stock prices and trading volumes were collected through Yahoo Finance as daily observations. These daily observations were then averaged out to arrive at quarterly averages. Stock prices used were adjusted daily closing prices. Adjusted closing prices were used instead of normal closing prices in order to eliminate the effect of dividends and stock splits from the value of the stocks.

4. Methodology and Results

4.1. Descriptive Statistics

Table 1 provides a summary of the average NAV discount statistics for the sample companies during the observation period. The table shows that the sample has on average traded at a 28.2% premium to NAV in Q1/1998-Q4/2018, indicating a price-NAV ratio of 1.282. A majority, or 63.1% of quarters have been on premium. In addition, a majority, 62.0% of companies have mostly traded on premium. Graph 1 displays how the NAV discount of U.S. REITs has developed over the observation period. It shows that while U.S. REITs traded at a discount to NAV between 1998 and 2004, following this period the companies have mostly traded at a premium, with a 1-year long period of discount following the global financial crisis, and with an increase in the premium being observed towards Q4/2018. Despite the increasing premium towards the end of the observation period, it is clear that the price-NAV ratio remains relatively close to its long-term average throughout the observation period.

Table 1. Summary of Descriptive Statistics

Average NAV Discount/Premium (%)		Number (%) of Quarters with NAV Premium	Number (%) of Quarters with NAV Discount	Price-NAV Ratio	Number (%) of Companies with NAV Premium	Number (%) of Companies with NAV Discount
Mean	Standard Deviation					
-28.20 %	1.25	53 (63.1%)	31 (36.9%)	1.282	44 (62.0%)	27 (38.0%)

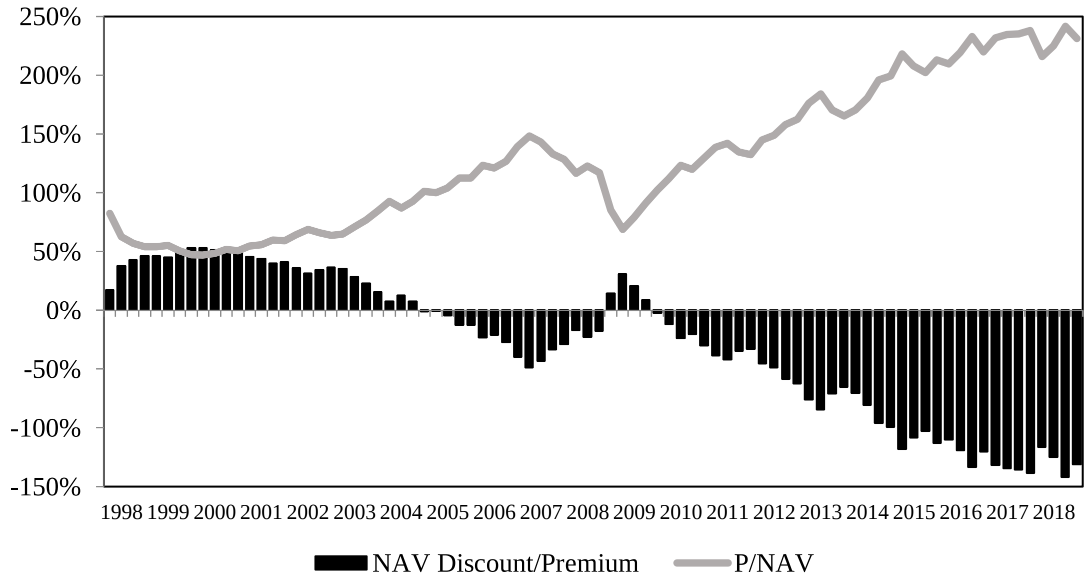

Figure 1. NAV Discount/Premium and P/NAV in Q1/1998-Q4/2018

4.2. Price-NAV Dynamics

4.2.1. Cointegration Test

We start by testing for the assumption that our variables are non-stationary by conducting unit root tests. Using a 5% significance level, the null hypothesis is not rejected and the tests indicate that both variables stock price and NAV are non-stationary, or I(1) (see appendix 8.1.). Based on this finding we assume that both stock price and NAV have a panel unit root for our sample. This means that we are able to test for cointegration between the variables.

A process is said to be integrated of order one, or I(1), when the first difference of that non-stationary process is stationary. Cointegration takes place when a linear combination of several I(1) series is stationary, or I(0) (Engle and Granger, 1987). In our study, the I(1) variables stock price and NAV will be cointegrated if their linear combination is I(0). Presence of cointegration between stock price and NAV would indicate that these variables move together over time, and that there exists a long-term equilibrium, towards which the linear combination converges over time. Cointegration between the variables is also essential when estimating an error correction model (ECM).

In order to ensure the robustness of results, we conduct three different tests for cointegration: Kao (1999), Pedroni (2004), and Westerlund (2007). All three tests are based on the following panel-data model where $t = 1, \dots, N$ indicates time and $i = 1, \dots, N$ indicates the panel:

$$y_{it} = x'_{it}\beta_i + z'_{it}\gamma_i + e_{it} \tag{3}$$

We place emphasis on the significant results of the Pedroni test, which implements a methodology similar to the Kao test but is more recently developed. We test for the null hypothesis that x_{it} and y_{it} are not cointegrated by testing for nonstationarity of the error term, e_{it}. The alternative hypothesis for the Pedroni test is that all panels are cointegrated.

For the Pedroni test, Philips-Perron and Augmented Dickey-Fuller statistics are significant at a 1% level, while Modified Phillips-Perron is not very significant. Based on these results, we argue that there is evidence of cointegration across some, but not all panels. We conclude that cointegration is strong enough to warrant an estimation of the panel DOLS and error correction models.

Table 2. Pedroni Test for Cointegration

		Modified Phillips-Perron t	Phillips-Perron t	Augmented Dickey-Fuller t
Pedroni test for cointegraion	Statistic	0.86	2.57	3.50
	p-value	0.19	0.01	0.00

4.2.2. Long-term Effects

We test for evidence of convergence of the stock price and NAV towards a long-term equilibrium by using the group-mean panel-dynamic ordinary least-squares (PDOLS) estimator introduced by Pedroni (2004). This estimator can be used with cointegrating non-stationary variables. The estimator is averaged along a panel's between-dimensions, which can be advantageous compared to within-dimension estimators in cases where heterogeneity in slopes is expected. A significant long-term coefficient indicates that the Price-NAV converges towards an equilibrium in the long-term to the extent indicated by the coefficient.

In the Pedroni panel DOLS, a default number of 2 lags was used. The results show that the slope coefficient 0.962 is positive and near but not equal to 1, and that it is statistically significant at a 1% level. The implication of this finding is that over the long run, price-NAV for U.S. REITs converges near an equilibrium.

Table 3. Pedroni Panel Dynamic Ordinary Least Squares

	Parameters	
Panel DOLS (group-mean)	Coefficient	0.962
	t-Statistic	37.300

Note: Number of lags used in PDOLS: 2

4.2.3. Short-term Effects

We estimate an error correction model (ECM), which a restricted version of an autoregressive distributed lag (ARDL) model assuming that there exists a constant long-term relationship between the dependent and independent variables. The ECM includes an error correction term (ECT), which captures corrections to stock price in disequilibrium and ensures that stock price and NAV return to a long-term equilibrium path. The size of the ECT coefficient thus shows the extent of the correction in each time period.

The ECM models are mean-group (MG) estimator introduced by Pesaran and Smith (1995) and the pooled mean-group (PMG) estimator introduced by Pesaran, Shin, and Smith (1999). The MG estimator is an ECM applicable to dynamic heterogeneous panel data. The PMG estimator combines both pooling and averaging and is similar to the MG estimator except that it constrains long-term estimators to be equal across groups.

For the PMG and MG models, the null hypothesis is that Price does not cause NAV and vice versa. The PMG and MG were both negative and statistically significant, at a 5% level and a 1% level respectively. The results indicate that 0.9% and 4.2% of the previous disequilibrium between actual and fundamental long-term price-NAV is corrected for in each quarter.

Table 4. PMG and MG Panel Error Correction Models

	Parameters	
Panel Dynamics ECM (PMG)	Coefficient	-0.009
	Standard Error	0.005
	p-statistic	0.054
	Parameters	
Panel Dynamics ECM (MG)	Coefficient	-0.042
	Standard Error	0.007
	p-statistic	0.000

We also test for Granger causality between stock price and NAV by conducting a Granger causality test that has been adapted to panel data by Dumitrescu & Hurlin (2012). In the Granger causality test we can test whether x Granger causes y by estimating the following model:

$$y_{it} = a_i + \sum_{k=1}^{K} y_{ik} y_{it-k} + \sum_{k=1}^{K} \beta_{ik} x_{it-k} + \varepsilon_{it} \quad \text{with i} = 1, \dots, \text{T and t} = 1, \dots, \text{T} \qquad (4)$$

If the current value of x is predicted by lagged values of y after lagged values of y have been added into the model, then we can assume that y Granger causes by x. It is also possible to have y and x interchanged to observe a causal relationship in the other direction, as well as a potential bi-causal relationship. It should be emphasized that statistical correlation does not imply causation and the fact that a variable Granger causes the other does not mean that there is an actual causal effect.

A Granger causality test was performed in order to observe the existence of a causal relationship between stock price and NAV. We conclude that there exists a significant homogeneous bi-causal relationship between stock price and NAV at a 1% level. This implies that both stock price and NAV have predictive lead-lag effects on each other. Furthermore, stock prices appear to have more predictive power on NAV than vice versa.

Table 5. Dumiterscu-Hurlin Granger Non-Causality Test

	Null Hypothesis	W-Stat	Zbar-Stat
Lag 3	P does not homogeneously cause NAV	7.530	15.584
	NAV does not homogeneously cause P	5.046	7.037

4.3. Explaining NAV Discount

4.3.1. Fixed-effects Model

A panel regression can be estimated using either a random-effects (RE) or a fixed-effects (FE) model. A RE model can be used to analyze the impact of time-invariant variables, while the FE model can be used to analyze the impact of variables that vary over time. The FE model assumes that there is no correlation between the time-varying characteristics and other individual characteristics.

We estimate two fixed-effects models that regress NAV discount against leverage, size, liquidity, performance, and investment activity as well as expected inflation, consumer confidence and industry confidence. The first regression focuses on firm-specific factors, while the second regression focuses on market-specific factors. According to previous research these market-specific factors may serve as evidence in support of the noise trader sentiment, However, we do not assume these factors to indicate noise trader sentiment, as there may also rational explanations for why price-NAV is influenced by market-specific factors. The regressors were chosen due their prevalence in previous studies and evidence of significant correlation, allowing for comparative evaluation of results. Other measures, such as management fees, operational risk, and insider ownership were left out due to difficulties in obtaining data and due to a lack of evidence supporting the significance of these factors. The firm-specific fixed-effects model is estimated as follows:

$$(y_{it} - \bar{y}_i) = \alpha + \beta_1(LEV_{it} - \overline{LEV_i}) + \beta_2(SIZE_{it} - \overline{SIZE_i}) + \beta_3(LIQ_{it} - \overline{LIQ_i}) + \beta_4(PERF_{it} - \overline{PERF_i}) + \beta_5(INV_{it} - \overline{INV_i}) + v_i + \varepsilon_{it} \quad (5)$$

The fixed-effects regression focusing on firm-specific factors shows that variables LEV, SIZE, LIQ and PERF are significant at a 1% level in explaining variation in NAVDISC, while INV is not a significant explanatory factor. Furthermore, NAVDISC is negatively correlated with LEV. SIZE and PERF, while it is positively correlated with

LIQ. The overall fit, or R^2 for the model is relatively low at 0.119, indicating that the included variables fail to explain a significant amount of variation in NAVDISC.

Table 6. Fixed-effects Model - Firm-specific Factors

Estimators	Coefficient	Standard Error	t-value	P > |t|
Constant	9.810	0.417	23.53	0.000***
LEV	-1.543	0.112	-13.83	0.000***
SIZE	-0.435	0.019	-22.29	0.000***
LIQ	13.629	2.357	5.78	0.000***
PERF	-2.768	0.478	-5.79	0.000***
INV	0.148	0.130	1.14	0.253
R Squared				0.119
Prob > F				0.000

Note: *, ** and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

The fixed-effects regression focusing on market-specific factors shows that BCI and CCI are significant at 1% and 5% levels respectively, while INF is not a significant explanatory factor. Furthermore, the coefficient for CCI is positive, while the coefficient for BCI is negative. The overall fit, or R^2 for the model is 0.175, which is higher than the R^2 of 0.119 for the firm-specific factor model. This indicates that the included market-specific factors explain a greater amount of the variation in NAVDISC compared to the included firm-specific factors. The market-specific fixed-effects model is estimated as follows:

$$(y_{it} - \bar{y}_i) = \alpha + \beta_1(INF_{it} - \overline{INF}_i) + \beta_2(CCI_{it} - \overline{CCI}_i) + \beta_3(BCI_{it} - \overline{BCI}_i) + v_i + \varepsilon_{it} \quad (6)$$

Table 7. Fixed-effects Model - Market-specific Factors

Estimators	Coefficient	Standard Error	t-value	P > | t |
Constant	11.152	4.462	2.50	0.014**
INF	0.103	0.084	1.23	0.223
CCI	0.070	0.032	2.16	0.034**
BCI	-0.184	0.045	-4.06	0.000***
R Squared				0.175
Prob > F				0.001

Note: *, ** and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

5. Discussion

5.1. Descriptive Statistics

We find that the ratio between stock price and NAV changes throughout the observation period, with REITs in our sample on average trading at a premium to NAV for a clear majority, or 63.1% of the observed quarters. These results are consistent with existing literature showing that REITs' stock prices fluctuate around their NAVs. The results also imply that U.S. REITs are likely to offer returns that at least in the short term differ from the change in value of their respective underlying real estate portfolios. In addition, the results may indicate that stock prices of U.S. REITs are not efficient with respect to NAVs of the respective companies in the short term.

We also find that REITs in our sample trade at an average premium to NAV of 28.2%. For the U.S. listed real estate market, Goebel and Ma (1993) find that REITs trade at a discount to NAV of 23% during the observation period of 1972-1992, suggesting a difference of 51.2% between the periods of 1972-1992 and 1998-2018. This discrepancy in findings suggests a shift in the long-term price-NAV ratio in the U.S. market within the period of 1972 to 2018. According to Anoruo and Braha (2010), the 1993 Revenue Reconciliation Act made large-scale REIT investments more desirable for institutional investors and had a considerable impact on the time series properties of U.S. REITs. An increase in investor demand can be expected to drive up stock prices and contribute to the stocks trading at a premium to NAV. Therefore, we present this legislative change as a potential explanation for the shift from an average NAV discount to an NAV premium over the past decades.

More recently Liow and Yeo (2018) find that on aggregate, listed real estate companies in six Asian markets traded at a slight premium to NAV between 2004 and 2014, with discounts observed between Q4/2008 and Q2/2009, a time period coinciding with the global financial crisis. We also observe a similar trend of increasing discounts for U.S. REITs over the same time period. Liow and Yeo also find evidence of market-spanning spillover effects in the price-NAV relationship, suggesting that individual listed real estate markets in Asia are highly interconnected. We interpret the fact that listed real estate markets in the U.S. and Asia are displaying similar price-NAV patterns as potential evidence of increased globalization in listed real estate investments as well as in institutional ownership. It may also serve as evidence for the existence of spillover effects from the U.S. market to Asian markets during the global financial crisis.

In addition, we observe a trend of an increasing premium from Q3/2009 towards the end of the observation period. According to Clayton and MacKinnon (2002), an increase in the NAV premium may reflect the fact that REITs have an improved availability of growth opportunities through external business activities such as acquisitions. The period following the global financial crisis has been characterized by both low interest rates and high liquidity, contributing to a lower cost of financing for U.S. REITs. We therefore suggest that the trend of an increasing premium may reflect improved growth opportunities for U.S. REITs following the global financial crisis.

5.2. Price-NAV Dynamics

We find that some panels in our sample are cointegrated, which is in line with findings of previous studies and supports the idea that the value of REITs' shares is connected to the value of their underlying assets in the long term. It also indicates that stock price and NAV move together over time, with a linear combination of the variables converging towards a long-term equilibrium.

By performing a dynamic OLS estimation, we find that the long-term coefficient is slightly below one, which indicates that nearly all of the temporary disequilibrium between stock price and NAV is corrected over the long-run. This is in line with our expectations as well as previous findings by Barkham and Ward (2009) and Liow and Yeo (2018). Based on this finding, we argue that stock prices of U.S. REITs may be rational with respect to their NAVs over the long run in a sense that price-NAV converges to a point where it is nearly equal to an equilibrium.

The error correction model shows evidence of short-term correctional movements which can be interpreted as adjustments towards an equilibrium between individual quarters. This is in line with the findings of Liow and Yeo (2018) who find evidence of short-term correctional movements in Asian listed real estate markets. The result also implies that a similar effect can be observed across different geographical regions, indicating that the effect may not be market-specific but rather something that is characteristic to listed real estate.

According to Lee et al. (1991), the movement of CEFs' stock price and NAV around a long-term equilibrium serves as evidence for the fact that positive or negative noise trader sentiment causes mean reversion through short-term corrections. Cuthbertson (1996) make the same argument specifically for REITs. Therefore, the fact that we find convergence towards an equilibrium both in short and the long term may also offer evidence in support of the noise trader hypothesis in explaining the relationship between stock price and NAV for U.S. REITs.

We find that for U.S. REITs, quarterly short-term adjustment towards an equilibrium takes place at a rate of between 0.9% and 4.2%. However, for Asian listed real estate the adjustment occurs at a much faster rate of between 9% to 21%. While this may to some extent be a result of the two studies having different observation periods, if the correction movements are interpreted as being caused by noise trader sentiment, the discrepancy can also potentially be a sign of a difference in the magnitude of the noise trader effect in the respective markets, with the U.S. exhibiting a weaker noise trader effect compared to Asia.

We also find that there exists a bi-causal relationship between stock price and NAV in the U.S. market. A potential explanation for how past NAV affects stock price is by signaling to investors that the value of the underlying portfolio has changed. Investors respond to this signal by trading the REIT's stock until the value change is reflected in the stock price. Past stock prices may affect NAVs by affecting the cost of financing available to the firm. If a REIT's management observes that its stock price has increased, the management may decide to raise more financing and make additional investments or make improvements to existing properties, thereby increasing the REIT's NAV.

A bi-causal relationship is also observed Liow and Yeo (2018), who made a similar finding in Asian markets, and who further hypothesize that NAV would be a stronger predictor of stock prices in rapidly growing Asian markets compared to more slowly developing markets such as Europe. In their paper, while the relationship between stock price and NAV is bi-causal, NAV explains more of the variation in stock price than vice versa. We find support for the hypothesis of Liow and Yeo, as we find that in the U.S. market, it is in fact stock prices that appear to explain more of the variation in NAV than vice versa.

Barkham and Ward (1999) present the idea that the value of real estate shares lead NAVs. However, they find that stock price does not cause NAV in the U.K. market, but only vice versa. This contradicts our findings of a bi-causal relationship, and also serves as a potential sign that the bi-causal relationship between stock price and NAV may be market-dependent.

5.3. Factor Analysis

5.3.1. Firm-specific Factors

We find that leverage is a significant variable and negatively correlated with NAV discount, which corresponds to the results by Barber (1996) and Clayton and MacKinnon (2001). Although previous studies by Anderson et al. (2001) and Morri and Benedetto (2009) show a positive relationship, the findings of Barber and Clayton and MacKinnon may be more expected in developed markets such as the U.S. In these markets, higher leverage may have a more explicit impact on a firm's performance by increasing the level of management discipline.

In addition, we find that when REITs have a higher level of liquidity, they tend to have a higher NAV discount, which conflicts with a number of previous studies about liquidity showing the opposite trend. We offer three potential explanations for this result. Excess liquidity may be one reason why higher liquidity leads to higher NAV discount, especially in the U.S. market which has the largest number of REITs in the world. Excess liquidity refers to a situation where the supply of capital in the market exceeds the general growth rate of the economy, translating into inflating asset prices. Rational investors may perceive unusually high liquidity as a signal of a potential pricing bubble, leading to lower stock prices and subsequently to a higher NAV discount.

It may also be that U.S. REITs with more liquid shares have a lower cost of capital, which enables these companies to invest into properties with a lower expected rate of return, leading to a less profitable portfolio. In this case, a high level of liquidity would be perceived as negative by investors, leading to an increased NAV discount.

Furthermore, we observe that in previous studies on the impact of liquidity, observation periods tend to end before the 2008 global financial crisis. Since the 2008 financial crisis is heavily connected with the real estate market and liquidity of funds played an important role in this crisis, the relationship between liquidity and NAV discount may have been affected to a great extent. In their study of 23 Singaporean REITs in 2005-2010, Lee et al. (2013) show that while liquidity was significant and correlated with NAV discount in 2005-2007, the correlation between NAV discount and liquidity vanished after the financial crisis in 2008. Therefore, the fact that our study also includes observations for the post-crisis period may help explain the result.

We also find a negative correlation between size and NAV discount, which indicates that larger REITs in the U.S. tend to trade at a premium to NAV. Comparing our finding with those of previous studies, we find that previous studies support our finding of negative correlation, even when using different measures for size, showing that this negative relationship is robust over different time periods and measures used. Adams and Venmore-Rowland (1990) argue that larger companies tend have easier access to higher quality assets, leading to accumulation of a more attractive real estate portfolio. This may be one of the factors explaining the negative correlation.

Studies such as Morri and Baccarin (2016) that have analyzed the impact of company performance on NAV discount indicate that better performance is a positive sign to investors, which increases a REIT's stock price and correlates with a lower NAV discount. Our regression result provides further support for this view as the coefficient that we find is significant and negative.

Our empirical result does not show a significant relationship between the level of investment activity and NAV discount. On the other hand, Morri (2006) and Morri and Benedetto (2009) find a significant and negative correlation between investment activity and NAV discount, and argue that investors are less willing to allocate the capital into funds that are less active in making investments into real estate and expanding the REIT's portfolio. A potential explanation for our insignificant regression result may be that due to the listed real estate market in the U.S. being highly developed, investors that allocate capital into REITs may act also be more educated and rational and place more value on the quality of a REIT's investments instead of the activity level. This argument also assumes that high-quality investment opportunities are limited, and that a high level of investment activity is associated with making investments that are less attractive. In this case, a REIT's investment activity may not have a significant impact on its NAV discount.

While we find that nearly all of the analyzed variables have a significant coefficient, we also find that the R^2 of our regression model is only 11.9%, which is lower than the goodness of fit found in most of previous studies. For example, Morri and Baccarin (2016) study the effect of rational factors on the NAV discount in France, the Netherlands and the U.K., and find an adjusted R^2 of 36.2% for U.K., 68.9% for the Netherlands and 66.9% for France. Although the goodness of fit of our regression appears to be low, there are some potential explanations. The factors chosen in this paper are not exactly the same as in other studies, so a difference in goodness of fit, regardless of the extent, is expected. What is more, Morri and Baccarin (2016) argue that in more established REIT markets such as the U.K., a set of firm-specific factors explains less of the variation of NAV discount compared to less established markets. Therefore, the fact that we observe rational firm-specific factors to have a lower level of explanatory power in the U.S. REIT market, which is the most well established on a global level, may also be expected.

5.3.2. Market-specific Factors

Our model also includes three different factors which reflect the market sentiment, and our regression shows that two out of these three factors are significant and correlated with NAV discount.

We find that industrial optimism, which is measured by an index of industry surveys, has a significant negative correlation with NAV discount, indicating that an increase in industry confidence is marked by a decrease in NAV discount. This finding is both expected and consistent with the previous research by Barkham and Ward (1999). However, we find a difference in the magnitude of the effects. Whereas Barkham and Ward find a coefficient of -0.519 for U.K. REITs, we find a smaller coefficient of -0.184 for U.S. REITs. This may imply that market sentiment in the U.K. is more correlated with industrial optimism compared to the U.S.

We also find consumer optimism, which is derived from an index of consumer surveys, to be significant and positively correlated with NAV discount. This finding indicates that an increase in consumer confidence is marked by an increase in NAV discount. The finding does not match our initial expectation, as we expect noise trader sentiment to improve as a result of an increase in consumer confidence.

The regression does not indicate a significant relationship between expected inflation and NAV discount. Therefore, we conclude that NAV discount is not correlated with expectations of inflation in the U.S. market. Our results stand in contrast to the findings of Barkham and Ward (1999) who find that inflation expectations in the U.K. are positively correlated with NAV discount. This may indicate that the effect of inflation expectations is market-dependent.

We find an R^2 of 17.5%, with indicates that 17.5% of the variation in NAV discount is correlated with the three market-specific factors. This result is much lower compared to that of Barkham and Ward, who find an R^2 of 74.1%. It is important to note that these empirical results do not serve as a proof of the noise trader hypothesis. According to Barkham and Ward (1999), these economic factors only serve as proxies for the noise trader sentiment, and only indirectly affect NAV discount.

6. Conclusion

In this paper we focus on the relationship between stock price and NAV of U.S. REITs in a time period spanning from Q1/1998 to Q4/2018. More specifically, we look for evidence of cointegration and mean-reversion over the short and the long-term, as well as Granger causality between the two variables. We also estimate two distinct fixed-effects models in order to gauge the effects of both firm- and market-specific factors on this price-NAV relationship. As a large proportion of past research has focused on observations before the 2008 global financial crisis, the fact that our observations also cover the post-crisis period can offer new insights.

We find that stock price and NAV of U.S. REITs are not directly proportional but that REITs either trade at a discount or a premium to NAV throughout the observation period. This is consistent with REIT as well as general closed-end fund literature. Furthermore, we find that the relationship changes over time. In the past two decades, U.S. REITs have mostly traded at a premium to NAV, with NAV discounts observed between Q1/1998 and Q3/2004 as well as for a 1-year period following the financial crisis. This stands in contrast to a study by Goebel and Ma (1993), who find that between 1972 and 1992, U.S. REITs mostly traded at a discount to NAV, suggesting a shift in the average price-NAV ratio from 1972 to 2018. We suggest that a potential explanation may be the 1993 Revenue Reconciliation Act, which made REITs more desirable for institutional investors, potentially contributing to an increased NAV premium.

We also find evidence of cointegration, indicating a long-term equilibrium between stock price and NAV for U.S. REITs. In addition, the linear combination of the variables appears to exhibit mean-reverting behavior towards this long-term equilibrium both over the short and the long term. This may be interpreted to indicate that stock prices of U.S. REITs are rational with respect to their NAVs in the long run, despite trading at a disequilibrium over the short run. The variables also appear to granger cause each other with stock price having a greater effect on NAV than vice versa.

We go on to find potential firm-specific explanations for this variation in the price-NAV ratio by running a fixed effects model. We find that out of the included firm-specific factors, leverage, size, liquidity and performance have significant effect on the price-NAV ratio, while investment activity is not significant. While leverage, size, and performance are negatively correlated with NAV discount, liquidity is found to be positively correlated. The fact that liquidity is positively correlated is an unexpected finding. We offer excess liquidity, the global financial crisis, and REITs' shift to less attractive investment opportunities as potential explanations for this finding.

For market-specific factors, we find that consumer confidence and business confidence have a significant effect on the price-NAV ratio, while expected inflation is not significant. Business confidence has a negative correlation with NAV discount, which is both expected and in line with a previous finding by Barkham and Ward (1999) for the U.K. market. Consumer confidence was found to have a positive correlation with NAV discount, which was unexpected and contradicts previous findings.

Our findings have a number of practical economic implications. It is often assumed that REITs are less volatile compared to many other types of equities as the value of their stocks is closed tied to the value of the underlying real estate portfolio. However, the fact that we observe wide variation in the price-NAV ratio throughout the observation period shows that prices tend to deviate from this underlying value, though we are also able to see signs of mean reversion both in the short and the long run. In addition, we find that higher liquidity is correlated with a greater NAV discount for U.S. REITs, which contradicts the findings for several other markets. This may imply that the link between liquidity and NAV discount is more nuanced and more dependent on the time period and market in question than previously assumed.

We acknowledge that our paper suffers from a number of limitations. Due to limited availability of data for the full time period, we were only able to cover a sample of 71 REITs in total, resulting in a relatively small sample size. Even though we found that the included REITs are diverse in terms of real estate category and size, it may be that our sample doesn't present a fully accurate picture of the true population of U.S. REITs. We also did not analyze the effects of the global financial crisis in more detail, even though we expect that it may have had a significant impact on NAV discounts. In addition, a number of firm- and market-specific factors such as management expenses that have been deemed as significant by previous studies were left out from out study due to poor availability of data and inadequacy of suitable proxies.

We observed that for the time period following the global financial crisis, U.S. REITs on average traded at a discount NAV, and the same phenomenon was also observed in the Asian listed real estate market as shown by Liow and Yeo (2018). As the financial crisis originated from the U.S, we believe that this finding may serve as evidence that listed real estate markets are becoming more interconnected globally, and that there may have been a potential spillover effect between the U.S. and Asian markets following the financial crisis. As previous studies have only observed inter-market spillover effects within a single geographical region, we suggest that future studies could look at spillover effects on a global basis. Future studies can also focus on explaining the unexpected positive correlation found between liquidity and NAV discount in the U.S.

7. References

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8. Appendix

8.1. Unit Root Tests

We test for the assumption that our variables are non-stationary by conducting a unit root test. Non-stationary variables are characterized by a changing mean, variance or auto-covariance. Non-stationarity may be caused by a deterministic trend, a systematic upward movement in the variables, or a stochastic trend, which appears as a consequence of randomness in the variables. These trends can be shown using unit root processes. We carry out three different tests by Levin, Lin, and Chu (LLC), Im, Pesaran, and Shin (IPS), and Choi.

The LLC tests for presence of unit roots in homogeneous panels and assumes that there is a common unit root process so that the autoregressive coefficient is identical across all cross-sections. The IPS tests for presence of unit roots in heterogeneous panels, allowing autoregressive coefficients to vary across cross-sections. Compared to the LLC and Fisher-type tests, the IPS test also allows for the option of some but not all of the individual series of having unit roots. The Choi fisher-type test combines panel-specific p-values and similar to IPS, tests for presence of unit roots in heterogeneous panels.

The IPS, LLC and Fisher-type unit root tests were performed to test for stationarity of variables stock price and NAV. Null hypothesis in all tests is that the tested variables are non-stationary. Using a 5% significance level, the null hypothesis is not rejected and all three tests indicate that both variables stock price and NAV are non-stationary, or I(1). Based on this we assume that both stock price and NAV have a panel unit root for our sample.

Table 8. IPS, LLC and Fisher-type Unit Root Tests

n = 71	Im, Pesaran, and Shin (IPS)	Levin, Lin and Chu (LLC)	Fisher-type P-stat
	t-statistic	t-statistic	t-statistic
P	-0.35	5.28	70.20
NAV	-1.13	2.52	136.80

Note: The critical values for 10%, 5% and 1% are -1.64, -1.67 and -1.73 respectively.

8.2. Kao and Westerlund Cointegration Tests for Robustness

The tests have the same null hypothesis that x_{it} and y_{it} are not cointegrated by testing for nonstationarity of the error term, e_{it}. The alternative hypothesis for the Kao test is that all panels are cointegrated, while for Westerlund the alternative hypothesis is that some panels are cointegrated. The tests also implement different types of tests for the nonstationarity of e_{it}. The Kao test assumes a homogeneous cointegrating vector β_i that is constant across all panels. It estimates panel-specific means and does not allow for time-trends. In contrast, the Westerlund test allows for heterogeneous cointegrating vectors that are panel-specific. For the Kao test, Modified Dickey-Fuller and Augmented Dickey-Fuller are significant at a 10% and a 1% level, while Dickey-Fuller, Unadjusted modified Dickey-Fuller and Unadjusted Dickey-Fuller gave are not very significant. Furthermore, the Variance ratio in the Westerlund test is not very significant.

Table 9. Kao Test for Cointegration

Kao Test for Cointegration		Modified Dickey-Fuller t	Dickey-Fuller t	Augmented Dickey-Fuller t	Unadjusted modified Dickey-Fuller t	Unadjusted Dickey-Fuller t
	Statistic	-1.48	-0.19	-2.34	0.24	0.97
	p-value	0.07	0.42	0.01	0.41	0.17

Table 10. Westerlund Test for Cointegration

Westerlund Test for Cointegration		Variance ratio
	Statistic	0.72
	p-value	0.24

8.3. Hausman Test for Robustness

The specification test developed by Hausman (1978) tests for correlation between regressors and unique errors. The null hypothesis is that no correlation between regressors and unique errors, or u_i exists. We use the Hausman test to determine whether a RE or a FE regression should be used to estimate the rational factor model. If there is no correlation, then no systematic difference between RE and FE exists, in which case both FE and RE are consistent but FE is not efficient. If correlation is observed, then FE is consistent but RE is inconsistent, in which case FE is preferred. We also use the Hausman test to test for difference between MG and PMG estimators in determining short-term effects in the price-NAV ratio.

A Hausman test was performed to test for the difference between estimators MG and PMG. The calculated Hausman statistic is 0.660 and the Chi Square p-value is 0.418. We fail to reject the null hypothesis and conclude that the difference between the estimators is not systematic. Therefore, we include results for both MG and PMG.

Table 11. Hausman Specification Test

Estimators	MG	PMG	Difference
NAV	-0.439	1.634	-2.073
Chi Square			0.660
Prob > Chi Square			0.418

A Hausman test was performed for the rational factor estimation in order to test the difference between a fixed-effects or a random-effects GLS regression. As regressors in the sentiment estimation do not vary across cross-sections, a fixed-effects model was used. We find that for the rational factor estimation, differences between fixed- and random-effects coefficients are significant. Therefore, we reject the null hypothesis and conclude that the fixed-effects model is preferred.

Table 12. Hausman Specification Test

Estimators	Fe	Re	Difference
LEV	-1.543	-1.538	-0.005
SIZE	-0.435	-0.421	-0.014
LIQ	13.629	13.443	0.186
PERF	-2.768	-2.784	0.016
INV	0.148	0.147	0.001
Chi Square			44.020
Prob > Chi Square			0.000