LAPPEENRANTA UNIVERSITY OF TECHNOLOGY

School of Business and Management

Master’s Programme in Strategic Finance and Business Analytics

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The Dynamic Relationship Between the REIT and S&P 500 Returns During 21st Century in the U.S.

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Abstract

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Title:	The Dynamic Relationship Between the REIT and S&P 500 Returns During 21st Century in the U.S.
Faculty:	LUT School of Business and Management
Master's Programme:	Strategic Finance and Business Analytics
Year:	2017
Master's Thesis:	Lappeenranta University of Technology, 73 pages, 17 tables, 8 figures and 4 appendices
Examiners:	Postdoctoral researcher Jan Stoklasa Professor Mikael Collan
Keywords:	REIT, Real Estate Investment Trust, dynamic relationship, vector autoregression, rolling window VAR, Granger causality

Real Estate Investment Trusts have been growing rapidly since the early 90s to the point where in August 2016 they were declared to have their own industry classification in major market indices, as they were separated from the "financials" classification. The evidence whether REITs should be seen as a real estate investment or more like common stock is mixed, and the results vary depending on the time horizon, time period and methodology used. This master's thesis examines the short-term dynamic relationship between REIT and S&P 500 returns in furtherance of understanding the extraordinary nature of REIT as an asset class in comparison with common stocks more profoundly. The goal is to understand how much S&P 500 is influencing REIT returns in the U.S. Understanding the time-varying dynamics between REIT and S&P 500 returns will aid investors in portfolio allocation decision-making.

The methodology in this thesis is based on vector autoregressive (VAR) models. The short-term relationship is examined with VAR model, followed by impulse response graphs and variance decomposition tables to aid in the interpretation of a fitted VAR model. In addition, the Granger causality test was used to examine the linear predictive causality between REIT and S&P 500 returns. The financial crisis was taken into account by dividing the data sample into three subcategories: before crisis, crisis and after crisis samples. Each subcategory was analysed with VAR, impulse response graphs, variance decomposition tables and the Granger causality test. Ultimately, a rolling window VAR model of 36 months was implemented for the whole data sample to grasp the time-varying relationship between REIT and S&P 500 returns to compensate for possible comparability issues of the results for periods of different lengths, and to avoid possible non-stationarity problems with relatively low amount of observations during financial crisis sub-period. The possible long-term relationship was also tested with Johansen cointegration test.

The results show that there exists only a short-term relationship between REIT and S&P 500 returns and the relationship is highly time-varying. Before finance crisis, S&P 500 returns Granger caused REIT returns and the 1-month lagged S&P 500 returns were found to be the most significant parameter explaining REIT returns. Also during financial crisis S&P 500 was highly influencing REIT returns, but a few years after crisis the relationship diminished. After finance crisis S&P 500 returns were no longer Granger causing REIT returns and lagged S&P 500 returns had no explanatory power explaining REIT returns. Moreover, the relationship between REIT and S&P 500 returns is now weaker than ever since 2000, indicating that the Real Estate Investment Trusts should be seen as an own asset class rather than a common stock asset in the short-term.

Tiivistelmä

Tekijä:	Hannu Rauhamaa
Tutkielman nimi:	Kiinteistösijoitustrustien ja S&P 500:n tuottojen dynaaminen suhde 2000-luvulla Yhdysvalloissa
Tiedekunta:	LUT School of Business and Management
Pääaine:	Strategic Finance and Business Analytics
Vuosi:	2017
Pro gradu -tutkielma:	Lappeenrannan teknillinen yliopisto, 73 sivua, 17 taulukkoa, 8 kuvaa ja 4 liitettä
Tarkastajat:	Tutkijatohtori Jan Stoklasa Professori Mikael Collan
Hakusanat:	Kiinteistösijoitustrusti, dynaaminen suhde, VAR, liikkuva VAR, Granger-kausaliteetti

Kiinteistösijoitustrustit ovat kasvaneet voimakkaasti 90-luvun alun jälkeen niin paljon, että elokuussa 2016 REIT -yritykset saivat oman toimialaluokituksen isoimmissa markkinaindekseissä, kun ennen ne olivat listattuina finanssiyhtiöiden joukkoon. Tutkimukset siitä, pitäisikö REIT-kiinteistösijoitusyhtiöt nähdä samalla tavalla kuin suorat kiinteistösijoitukset, vai kuten tavalliset osakkeet, ovat ristiriitaisia. Empiiriset tulokset ja johtopäätökset riippuvat hyvin paljon aikajänteestä, tutkimuksen ajanjaksosta ja käytetyistä menetelmistä. Tämä pro gradu –tutkielma tutkii lyhyen aikavälin dynaamista suhdetta kiinteistösijoitustrustien ja S&P 500 –indeksin tuottojen välillä ja syventää ymmärrystä REIT –omaisuuslajin ainutlaatuisesta luonteesta verrattuna tavallisiin pörssiosakkeisiin. Tavoitteena on tutkia kuinka paljon S&P 500 vaikuttaa REIT:ien tuottoihin Yhdysvalloissa. Syvällisempi ymmärrys REIT ja S&P 500:n välisestä ajassa muuttuvasta suhteesta auttaa sijoittajia tekemään päätöksiä portfolion hajautuksesta.

Tutkimusmenetelmä perustuu vektoriautoregressio (VAR) –malleihin. Lyhyen aikavälin suhdetta tutkitaan VAR –mallilla ja siitä johdetuilla impulssivaste-testillä (impulse response) ja varianssin hajoamisanalyysillä (variance decomposition) tulosten tulkinnan tueksi. Lisäksi lineaarista ennustavaa kausaliteettia REIT ja S&P 500:n tuottojen välillä tutkittiin Grangerin kausaliteettitestillä. Finanssikriisi otettiin huomioon jakamalla tutkimuksen data kolmeen eri alakategoriaan, ennen kriisiä, kriisin aikana ja jälkeen kriisin –kategorioihin, ja jokainen alakategoria analysoitiin vektoriautoregressio –mallilla, impulssivaste –testillä, varianssin hajoamisanalyysilla ja Granger-kausaliteettitestillä. Lopuksi koko data analysoitiin 36:n kuukauden liikkuvalla VAR –mallilla. Liikkuvan VAR –mallin tarkoituksena oli ymmärtää omaisuuslajien välistä aikariippuvaista suhdetta paremmin ja kompensoida mahdolliset tulosten vertailukelpoisuusongelmat johtuen eri pituisista alakategorioista, sekä välttää mahdolliset epästationaarisuusongelmat finanssikriisi –alakategoriassa johtuen verrattain vähäisten havaintojen lukumäärästä. Mahdollinen pitkän aikavälin suhde omaisuuslajien välillä otettiin myös huomioon ja se testattiin Johansenin cointegraatio –testillä.

Tulokset osoittavat, että REIT ja S&P 500:n tuottojen välillä on vain lyhyen aikavälin suhde, ja se on erittäin riippuvainen ajasta. Ennen finanssikriisiä S&P 500:n tuotot Granger-vaikuttivat REIT –yritysten tuottoihin ja S&P 500:n yhden kuukauden viivästetyt tuotot olivat kaikista merkittävin parametri REIT tuottojen selittämisessä. Myös finanssikriisin aikana S&P 500 vaikutti merkittävästi REIT –yritysten tuottoihin, mutta finanssikriisin jälkeen vaikutus väheni merkittävästi. Finanssikriisin jälkeen S&P 500:n tuotot eivät enää Granger-vaikuttaneet REIT:ien tuottoihin. Nyt REIT:ien ja S&P 500:n välisten tuottojen suhde on heikompi kuin koskaan ennen 2000-luvulla, ja tästä syystä REIT –kiinteistösijoitusyhtiöt tulisi nähdä lyhyen aikavälin tarkastelussa omana omaisuuslajikkeena, eikä tavallisina pörssinoteerattuina osakkeina.

Acknowledgements

I would like to thank Postdoctoral Researcher Jan Stoklasa for his competent and helpful guidance throughout the Master's Thesis process and Associate Professor Sheraz Ahmed for his valuable feedback. I also want to thank my family and friends who kept supporting me and continuously asking how my thesis was progressing. Finally, I wish to thank Nuppu for keeping me company by meowing for additional food, scratching my couch and sleeping on my keyboard during the whole writing process. Thanks!

In Helsinki, February 19, 2017.

Hannu Rauhamaa

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1. Introduction

Real Estate Investment Trusts have been growing rapidly and gaining ascending attention since the early 90s. The recent financial crisis and the following sequel of economic downturn hit the financial markets hard. Real Estate Investment Trusts were not an exception, suffering major losses in the US stock markets alongside with the common stocks. The All Equity REIT Index by National Association of Real Estate Investment Trusts (NAREIT) fell from 10,256 points in January 2007 to 3,337 points in February 2009, suffering a cumulative loss of 67% (Sun et al, 2015). In the short term, REITs were acting similarly to common stocks when a huge external shock caused panic all over the Western world. Since financial crisis the stock markets in the US have been increasing exceedingly, REITs included. In August 2016, REITs were declared to have their own industry classification in the major market indices, as they were separated from the "financials" classification, which underlines the fact that REIT industry has become a remarkable factor in the US economy.

Direct real estate investments have always played a significant role in investment markets and it is proven that they provide notable diversification benefits (see e.g. Seiler et al., 1999; Feldman, 2003; Hoesli et al., 2004; Clayton, 2007; MacKinnon & Al Zaman, 2009). However, unlike REITs, direct real estate investments suffer from various disadvantages such as high transaction costs, information asymmetry and relatively low liquidity (Georgiev et al., 2003; Sirmans & Worzala, 2003; Knight et al., 2005). The debate on whether REITs should be seen more like a real estate investment or more like common stock has always been a controversial topic in existing literature (see e.g. Giliberto, 1990; Myer & Webb, 1993; Clayton & MacKinnon, 2003; Hoesli & Oikarinen, 2012). This thesis contributes to the existing literature by investigating the REIT's short-term relationship with common stocks during the 21st century and the effects of financial crisis that occurred in 2007.

1.1. Objectives and research questions

The objective of this thesis is to examine the short-term dynamic relationship between REIT and S&P 500 returns from 01/2000 to 12/2015 in U.S. The main goal is to understand how REIT returns are affected by S&P 500 returns and to provide valuable information about Real Estate Investment Trusts in general. The term "dynamic relationship" in the before mentioned goal signifies that the similarities or dissimilarities between REIT and S&P 500 returns are expected to vary in time, and that even the form of the relationship might change. However, the results of this thesis show that the short-term relationships holding for specific time-periods can be found between these two variables. It is the description of these short-term relationships and their development in time that is the main outcome of this thesis. Furthermore, understanding the dynamics between REIT and S&P 500 will help investors in decision-making and thus allow better portfolio diversification possibilities. The point of this thesis is not to calculate optimal portfolio allocations using historical data but to show the extraordinary and challenging nature of REITs as an asset class.

The dynamic relationship between REIT and S&P 500 stock returns is studied through various different analyses in this thesis. Firstly, the time series of monthly REIT and S&P 500 returns are overviewed in order to grasp the time-varying changes of correlation between the assets during the recent years. Then the data is divided into three sub-periods: before finance crisis, finance crisis and after finance crisis periods. The sub-periods are tested individually by using vector autoregression (VAR) model, impulse response, variance decomposition and the Granger causality test to analyse how the returns of REIT and S&P 500 are acting during different economic market cycles and to see the possible influence of the past values of one time series to the other.

Lastly, the rolling window VAR of 36 months is deployed for the whole data set for the sake of confirming the results from sub-periods, and to mitigate possible unequal sub-sample size bias that may occur. Especially the finance crisis sub-period is rather problematic with the relatively low amount of observations, but rolling window VAR will eliminate the issue of significantly different sub-sample sizes. The advantages of rolling window VAR are that it is not relying on the results that are received from unequally divided and static sub-samples, but dynamic and diverse moving results throughout the full data sample of 16 years. Rolling window VAR generates a fresh approach for the thesis and thus allows understanding the continuously changing dynamic relationship between the REIT and S&P 500 returns more competently. This is something that, to my knowledge, has not been previously done in the field of research focused on the challenging nature between the Real Estate Investment Trusts and S&P 500 returns, or in LUT School of Business and Management in any field whatsoever. There are two master's theses done in LUT regarding to REITs, but the first one is focusing on diversification benefits in forest investing and the second one on dynamic linkages of real estate and stock markets in Finland. This thesis will focus only on U.S. markets and the REIT industry as a whole and therefore differs from the previous theses.

The possible long-term relationship between REIT and S&P 500 was also taken into account. The level data was tested for its stationarity with the Augmented Dickey-Fuller (ADF) test. ADF test suggested that both time series were non-stationary (p=0.882 for the REIT and p=0.994 for the S&P 500), and therefore they could be tested for possible long-term cointegrations. However, Johansen (1991) cointegration test suggested that even though both variables, REIT and S&P 500 total return indices, were integrated, they were not cointegrated at the 5% significance level (unrestricted cointegration rank test with trace p=0.091) and thus there is not any long-run link present between REIT and S&P 500 total returns. These results are consistent with the Lee and Chiang (2010) findings that after the REIT structural changes in the early 1990s, REITs became less like common stocks and more like direct real estates in the long-run horizon and that is the reason why only short-term relationship is examined in this thesis.

The research questions to be answered in this thesis are following:

1. Is there a correlation between the REIT and S&P 500 returns and is it static or time-varying?

2. Is there a short-run relationship between the REIT and S&P 500 returns?

3. Have the dynamics between REIT and S&P 500 returns changed during the research period and how did the financial crisis affect this?

1.2. Research limitations

This thesis examines the relationship between the REIT and S&P 500 in United States and thus results cannot be directly applied to the REIT markets over the world. Using only two variables, the study unavoidably crops out other macroeconomic variables, such as interest rates, inflation, bonds or real estate indices. By using only two variables, it is not realistic to expect that the models' goodness of fit statistic values will be extremely high, and thus the focus is on the significance of their parameters instead. This is in line with the thesis perspective to investigate the existence of relationship (explanatory power of one variable for the other) rather than finding the best fitting model with multiple variables included.

The REIT index contains 8 different REIT sectors and by using index data it is not possible to identify whether some REIT sectors respond differently to the shocks from S&P 500 than other sectors. The main reason this thesis uses REIT index data is to offer information about Real Estate Investment Trusts as an asset class.

1.3. Brief history and background of the REITs

The history of the real estate investment trusts begins in the 1880s. Back then, if the trust income was distributed to the beneficiaries, it was not taxed. In the 1930s, a Supreme Court decided that all investment vehicles that were passive, but administered and organized like corporations, should be taxed like normal corporations. This meant that tax authorities started to tax real estate investment trusts as well. After the World War II, the urgency for a vast amount of real estate equity and mortgage funds revived the interest in more comprehensive use of the real estate investment trusts and followed by that, they became known as REITs. A campaign for the REIT special tax considerations started and it aimed to get REITs treated in the same way than accorded mutual funds. Supreme Court decided in 1936 that regulated investment companies, like mutual funds, were exempted from federal taxation. That campaign succeeded, and in 1960, the U.S. Congress passed the necessary legislation in favour of REITs. (Brueggeman & Jeffrey, 2011)

A real estate investment trust can be seen as a creation of the Internal Revenue Code. It is a company or trust that, under specified tax provisions, can function as a middleman that distributes all of its taxable earnings in addition to any capital gains yielded from the sales or disposition of its properties, such as rents, to its shareholders. When following the tax provisions set by Internal Revenue Code, real estate investment trusts do not pay taxes on earnings. However, earnings that are distributed to shareholders are seen as dividend income. Thus incomes from real estate investment trusts are taxed like incomes from dividends and taxed at the shareholder’s applicable tax rate. (Brueggeman & Jeffrey, 2011)

The Internal Revenue Code (26 U.S.C. §§ 856-858) with the amendments made in January 1961 set the strict requirements for real estate investment trusts to qualify in order to achieve tax benefits. The most notable requirements are the following:

Asset requirements (26 U.S.C. § 856a) at the close of each quarter of the taxable year are the following,

- At least 75 percent of REITs total value must be cash and cash items (receivables included), real estate assets and government securities.
- Not more than 25 percent of REITs assets can consist of stocks in taxable REIT subsidiaries.
- Not more than 5 percent of the value of the assets may consist of the securities of any one issuer if the securities are not includable under the 75 percent.
- REIT cannot hold more than 10 percent of the outstanding voting securities of any one issuer if the securities are not includable under the 75 percent.

For income, the most noteworthy requirements (26 U.S.C. § 856c) are,

- At least 95 percent of the REITs gross income must be from rents, interest, dividends or gains from the sale or other disposition of securities and stocks which are not treated as inventory or dealer property.
- At least 75 percent of the REITs gross income must be derived from rents from real property, interest on obligations secured by mortgages, dividends and gains from the sale of shares in other REITs and income and gains from foreclosure property.

The most important ownership and stock requirements (26 U.S.C. § 856a) are,

- REIT is managed by one or more trustees or directors.
- REIT is taxable as a domestic corporation.
- REIT shares must be transferable and held by a minimum of 100 persons.
- Maximum of 50% shares can be held by five or fewer persons during the last half of a taxable year.

And the Internal Revenue Code (26 U.S.C. § 857a) states that *the deduction for dividends paid during the taxable year equals or exceeds the sum of 90 percent of the real estate investment trust taxable income for the taxable year.*

There are two major classes of REITs and the more common class is equity REIT (eREIT) that owns income-producing properties. The second class, mortgage REIT (mREIT), invests in mortgages on residential or commercial properties. There is also a third REIT class, hybrid REIT. Hybrid REITs invest in both income-producing properties and mortgages on residential or commercial properties, but they are a substantially less common class. There are also private and non-traded public REITs which cannot be bought and sold on major exchanges like publicly traded REITS and non-REIT public companies. (Case et al. 2012)

Equity REITs are seen as a considerably more secure business model than other REIT models and the literature around real estate investment trusts is mainly based on investigating equity REITs. While equity REITs actually invest in real estates and can increase their value by the rise in the value of the property and additional returns by selling properties, mREITs purchase mortgage obligations. So in reality, mREITs do not own any properties and their business model is highly leveraged which leads to a situation where they are more vulnerable to interest rate increases than equity REITs. Mortgage REITs might appear as tempting investments because they are characterized by the offering high of dividend yields. However, with high yield there comes a high risk and studies have shown that in the long run equity REITs clearly outperform mortgage REITs (Peterson & Hsieh, 2007; Bley & Olson, 2005).

Most of the REITs are specialized by property type. There are also REITs that specialize geographically and REITs that are specialized in both property types and locations. Some REITs diversify their business model geographically and with different property types, and do not specialize in one category. By specializing in one property type, REIT is trying to achieve comparative advantages through experience and knowledge in that business field. However, focusing on only one property type is also associated with the relative risks. REITs and analysts usually use the term specialization to include a rather wide range of concentration, and thus specialization is only a matter of degree. Hence, in order to assess relative risks, it is highly important to determine how specialized one REIT is in comparison with other REITs. The National Association of Real Estate Investment Trusts (NAREIT) has divided equity REITs into 8 different categories which are: industrial/office, retail, residential, diversified, lodging/resorts, health care, self-storage and specialty (i.e. prisons, golf courses, cellular towers and timberland). (Brueggeman & Jeffrey, 2011)

There are three different lease agreements that REITs use. In Single Net Lease model the tenant only pays rent and property taxes. The rent is usually higher than in other lease models and thus it is the least used model. In Double Net Lease model the tenant pays both rent and property taxes and, in addition, it pays the insurance of rented real estate. The Triple Net Lease model is often the best model for REIT companies, since it is the most predictable lease model in terms of additional expenditures. In Triple Net Lease model the tenant pays all the expenses above, and furthermore, the tenant pays the maintenance and repair costs of the rented real estate. This model is usually priced cheaper than previous ones mostly because REIT does not need to cover any unexpected expenditures. This makes the Triple Net Lease the most secure model for REITs in terms of its predictability.

2. Literature review

The debate whether REITs should be seen as a real estate investment or more like a stock or bond has been the subject of numerous studies. For example Giliberto (1990), Myer & Webb (1993), Ling & Naranjo (1999) and Clayton & MacKinnon (2003) have examined the relationships between REITs, real estate variables and stock markets. Their conclusion is that there can be found a link between the real estate price indices and U.S. REITs, but it is weak and not sufficient to explain REIT returns. These studies find that U.S. REITs have similar investment attributes to U.S. stocks, and they provide only a weak exposure to the underlying property markets.

Seck (1996) and Seiler et al. (2001) propose that the statistical properties of the REITs and the real estate returns are significantly different from each other and that the REITs cannot offer diversification in well-diversified investment portfolio in the field of direct real estate markets. Pavlov & Wachter (2011) utilized the Carlson et al. (2010) model that estimated the strength of the relationship between REIT returns and underlying real estate returns. They found that only in the office sector there could be found a statistically significant relationship, but the relationship between other property types was really weak and insignificant. They came into the conclusion that REITs cannot replicate direct real estate investments or investments through the property type derivates. However, Hoesli & Oikarinen (2012) found that REITs behave much like direct real estate investments in the long-run horizon and the substitutability between REIT and direct real estate appears to be rather good. They also found that in the short-term horizon, REIT’s co-movement was stronger with stocks than with direct real estates.

There have been many studies that show that the REIT returns and risks can be explained by the same macroeconomic variables which have been found to explain stock and bond returns and risks at the significant level. Chan et al. (1990) study shows that REIT returns are associated with interest rates, inflation and risk premium. Peterson & Hsieh (1997) found that over the period of 1976 to 1992, risk premiums on equity REITs are significantly related to risk premiums on a market portfolio of stocks as well as to the return on mimicking on portfolios for size and book-to-market equity factors in common stock returns. Karolyi and Sanders (1998) used a multiple-beta asset pricing model to examine the predictability of stocks, bonds and REITs. They found that the REITs have a comparable return predictability to stock portfolios, and that REITs have a significant economic risk premium. Chan et al. (2005) claimed that REITs have behaved more like stocks than bonds after the institutional changes in the 1990s.

Ghosh et al. (1996) and Ziering et al. (1997) reported that the REIT upswing from 1993 to 1997 made REITs more like a direct real estate investment than stock due the immense growth and maturation in the REIT sector. They suggested that the REIT sector boom attracted more analysts, increased the knowledge of REITs and thus gained more attention from institutional investors which, in turn, led to a situation where REIT returns started to have stronger a relationship with the direct, unsecuritized real estate returns.

Clayton and MacKinnon (2000) showed evidence that there are structural changes in the nature of REIT returns. This was in line with the hypothesis that REITs have become more mature markets information wise. It was also consistent with the findings of Khoo et al. (1993) who found that the betas of equity REITs decreased after structural changes in 1980s, which is related to the changing information environment for REITs. Clayton & MacKinnon (2001) studied the time-varying link between REIT, real estate and financial asset returns. Their results indicated that the relationship between the returns of bonds, small cap and large cap stocks, unsecuritized real estate and the returns of REIT have changed over time. They found that in the 90s, REIT provided a direct link to the real estate returns, and REITs provided some exposure to the real estate asset class, but the link is cyclical in nature. However, the sensitivity of REIT returns to large cap stocks has declined over time. Clayton & MacKinnon (2003) also found that from 1993 to 1998 the small cap REITs acted more like real estate than larger cap REITs. They argue that this might be because of the institutionalization of the ownership of larger cap REITs which took place in the 1990s.

As one can see, the question of whether REITs can be seen as stocks or real estate investments is not easy to answer. Myer and Webb (1993) found that depending on the method and econometric techniques, there can be found evidence that supports both sides. On the one hand there can be found evidence that REITs are more related to the real estate markets, and on the other hand that REITs are more associated with the stocks. While Clayton and MacKinnon (2001) found that REITs are indeed related to both asset classes but the relationship varies over time, Stevenson (2001) has declared that there is not a positive correlation between the REIT and real estate market returns.

Case et al. (2012) investigated the dynamic correlations between the REIT and stock returns. They found out that the correlations between the REIT and stock returns form three recognizable periods. The first period was from 1972 (the earliest date that data was available) to August 1991. During the first period, correlations were high and they never dropped below 59 percent nor trended. August 1991 can be seen as the start of the modern REIT era. After that the correlation between REIT and stock returns decreased. During the second period, which ended in September 2001, the correlations declined tremendously. In the September 2001 the correlation between the REITs and stocks was only 30 percent. This allowed extensively higher portfolio allocations to both assets and thus higher portfolio returns without increasing the volatility of the portfolio. During the third period, which ended in September 2008, correlations increased steadily over time and, in the end, the correlation was 59 percent. The Case et al. (2012) paper shows that the dynamic correlation between the REIT and stock returns varies over time which makes REIT stocks an effective tool for a portfolio diversification.

Ling and Naranjo (2015) studied the returns between unlevered equity REIT returns to levered equity REIT returns over the time period 1994–2012. They also compared passive portfolios of unlevered equity REIT returns to the unlevered returns on private equity real estate portfolios. Their results suggested that during 1994–2012, levered equity REITs outperformed unlevered equity REITs by 158 basis points annually. Further, Ling and Naranjo (2015) found that during the same time period, unlevered equity REIT returns surpassed private equity real estate returns by 49 basis points annually.

Glascock, Michayluk and Neuhauser (2004) examined the reaction between the equity REITs and stock market during the market crash in October 1997. They found that after the stock market crash, non-REIT stocks decreased more than REITs. Also the bid-ask spreads of REITs decreased whereas the bid-ask spreads of stocks increased. They came into the conclusion that REITs are good defensive stocks for investors and they may be able to mitigate market cycles.

When Glascock, Michayluk and Neuhauser (2004) studied the reaction of equity REITs and stock markets during the market crash in October 1997 and suggested that REITs are good defensive stocks, the market crash was caused by an economic crisis in Asia and by automated stock market program trading. The recent financial crisis which started in December 2007 was different. It was related to the real estate markets in the U.S.

The financial crisis is a fairly fresh incident and its post-events influenced the whole world. Simon and Ng (2009) analysed the impact of the 2007 financial crisis on the dependence between the returns of REITs and common stocks. They used daily data from December 2004 to end of June, 2008 with 852 observations. Their conclusion was that investing in REITs provides greater protection against drastic downturns of the U.S. stock market than investing in a foreign common stock index, which is typically seen as a competent diversification of risks. Results implied that REITs certainly provide limited protection during stock market downturns. Sun et al. (2015) found out that during rebound period 2009–2011 larger REITs encountered higher returns than smaller REITs, suggesting that large REITs may have overreacted to the negative incidents during the crisis period 2007–2009.

Luchtenberg and Seiler (2014) found that real estate returns influenced stock market returns. This was an uncommon result because before the financial crisis this kind of relationship never existed. For example, Subrahmanyam (2007) studied the return spillovers between the stock market and equity REITs. He found that the return spillovers were unidirectional and the stock market returns influenced the REIT returns with a lag, but REIT returns did not have any effect on stock market returns.

The relationship between the REIT and S&P 500 returns is in the core of this thesis. Bley & Olson (2005) used the monthly return data of the equity REIT, mortgage REIT and S&P 500 from 1972 to 2001. They found significant calendar effects for both REIT and S&P 500 indices with positive January and negative August and October effects. They also found that the correlation coefficient relationship between equity REIT and S&P 500 has been weakened over time and equity REITs perform well compared to common stocks on a risk-return basis. Bley & Olson (2005) suggest that equity REIT can indeed enhance portfolio's risk-return spectrum and should be considered as a major asset class equal to stocks or bonds.

Fitzpatrick et al. (2014) compared the returns of S&P 500 and REIT indices using return data from 2000 through 2011. They found that average returns for the S&P 500 was 2.44% while average REIT returns was 13.73% for the time period. With risk adjusted returns using coefficient of variation, they found that the REIT composite index took only 1.6497 units of risk for each unit of return while S&P 500 took 7.9959 units of risk per return. Their findings suggest that even during crisis period REIT's risk-return relationship is favourable in comparison with common stocks and therefore should be used in portfolio diversification. Bhuyan et al. (2015) results were consistent with the Fitzpatrick et al. (2014) findings. They investigated the risk-reduction benefits of REITs and common stocks in portfolio diversification using data from 2002 to 2012. They found that investors can enhance their portfolio performance by using equity REITs in diversification while mortgage REITs were found to be the worst asset class in diversifying portfolio. Even though the financial crisis was included in data period, Bhuyan et al. (2015) results suggest that equity REITs offer diversification benefits and even small investors can use equity REITs to diversify portfolio risk.

3. Methodology and data

3.1. Methodology

3.1.1. Stationarity

In time series analysis it is essential to test whether data is stationary or not. If the data has a unit root, it means that it is non-stationary and therefore usually cannot be used as it is. If the data tested is non-stationary, it means that it will have a time-varying variance, time-varying mean or both. Especially with time series, it is highly important to use stationary data for the sake of reliable results. If a series is non-stationary, simple time-series techniques can result in misleading (or false) values of statistics (i.e., R-Square (R^2), Durbin-Watson (DW) and t-statistics) that may lead one to falsely conclude that a significant and essential relation exists between the regression variables (Ling & Naranjo, 2015).

The random walk model with drift is a frequently used model to characterize the non-stationarity,

$$y_t = \mu + y_{t-1} + u_t \tag{1}$$

where μ is a constant term, y_{t-1} is the previous value of variable y, and u_t is a white noise disturbance term. By subtracting y_{t-1} from both sides we get:

$$y_t - y_{t-1} = \mu + u_t \tag{2}$$

$$\Delta y_t = \mu + u_t \tag{3}$$

The process (3) is no longer dependent on the values of y, but just on inter-period differences of the values of y. Also now the new variable Δy_t, is stationary. By subtracting the previous value of y in equation (2) means that the series has been differenced. If a non-stationary series, y_t, must be differenced d times before it becomes stationary, then it is said to be integrated of order d. This would be written $y_t \sim I(d)$ which means that an I(1) series contains one unit root while I(0) series is a stationary. (Brooks 2014, pp.355-360)

In this thesis the unit root is tested by two different unit root tests. First one is augmented Dickey-Fuller (ADF) test which is used for large samples and the second one is Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test which can be used to validate the results from ADF test.

Early work on testing for unit root in time series was done by Dickey and Fuller (Dickey and Fuller, 1979). The main element of the test is to examine the null hypothesis that ϕ = 1 in (4), where ϕ = 1 characterizes non-stationarity of y_t. The Dickey-Fuller (DF) test can be written as

$$y_t = \phi y_{t-1} + u_t \tag{4}$$

against the alternative hypothesis ϕ < 1, therefore H_0 hypothesis is that series contains a unit root and H_1 that the series is stationary. The problem with the traditional DF test is that it assumes the error term u_t to be white noise and not autocorrelated. The solution is to use p lags of the dependent variable and thus “augment” the test. Augmented Dickey-Fuller (ADF) can be expressed as

$$\Delta y_t = \psi y_{t-1} + \sum_{i=1}^{p} \alpha_i \, \Delta y_{t-i} + u_t \tag{5}$$

where ψ = 0 (ϕ – 1 = ψ). Now the lags of Δy_t will accumulate any dynamic structures that are present in the dependent variable and thus ensure that u_t is not autocorrelated. (Brooks 2014, pp.361-363)

In autoregressive (AR) models if time series is non-stationary, ϕ = 1 in (4), shocks would have permanent effect to y_t and it would never die out. Furthermore, If ϕ > 1 in (4), the shock would have permanent effect to y_t but in addition the shock would have increasing influence in system through time. (Brooks 2014, p.356.)

Kwiatkowski et al. (1992) work was motivated by the fact that unit root tests by Dickey and Fuller (1979), Dickey and Fuller (1981), and Said and Dickey (1984) proposed that most aggregate economic series had a unit root and the null hypothesis in these tests was that the series has a unit root. Kwiatkowski et al (1992) suggested that the trend stationary should be the null hypothesis, and the unit root should be the alternative. Thus, rejection of the null hypothesis could be then seen as a reliable evidence of the unit root existence in series. (Kokoszka and Young, 2015).

3.1.2. Vector autoregressive model

Sims (1980) proposed that vector autoregressive (VAR) models should be seen as alternatives for multivariate simultaneous equations models that were widely used for macroeconomic analysis. Back then, macroeconomic time series that were larger, or in other words longer and more frequently observed, needed models that could describe the relationship and the dynamic structure of the variables. Because VAR models tend to treat all variables as endogenous, they were a good fit for this purpose. Sims' criticism is justified in the sense that, for some of the variables in simultaneous equations models, the assumptions about exogeneity are not always supported by existing theory. In addition, the assumptions are often *ad hoc* in their nature. Some of the variables may be exogenous, for instance, and there may be further restrictions when statistical procedures are applied to VAR models. (Lüetkepohl, 2011)

VAR is a regression model that has more than one dependent variable. The most basic example would be a two-dimensional VAR with only two variables, y_{1t} and y_{2t} where their current values are affected only by different combinations of the previous k values (lag) of both values and their error terms,

$$y_{1t} = \beta_{10} + \beta_{11} y_{1t-1} + \dots + \beta_{1k} y_{1t-k} + \alpha_{11} y_{2t-1} + \dots + \alpha_{1k} y_{2t-k} + u_{1t} \qquad (6)$$

$$y_{2t} = \beta_{20} + \beta_{21} y_{2t-1} + \dots + \beta_{2k} y_{2t-k} + \alpha_{21} y_{1t-1} + \dots + \alpha_{2k} y_{1t-k} + u_{2t} \qquad (7)$$

where u_{it} is a white noise disturbance term with E(u_{it}) = 0, (i = 1, 2), E($u_{1t}u_{2t}$) = 0.

From the VAR equations (6) and (7) it is apparent that the model is noticeably adjustable and easy to generalize. Instead of just two-dimensional VAR, it could be extended to a model with g variables y_{1t}, y_{2t}, y_{3t},…., y_{gt}, where each variable has its own equation. VAR model can also be enhanced to involve moving average errors, which would make it a multivariate version of an ARMA model, VARMA. (Brooks 2014, p.327)

One essential feature of VAR models is the compactness with which the documentation can be phrased. The equation from above could be modified for example so that both variables have only one lag, $k = 1$. This means that each variable depends only on previous values of y_{1t} and y_{2t}, plus an error term. This can be written as

$$y_{1t} = \beta_{10} + \beta_{11}y_{1t-1} + \alpha_{11}\, y_{2t-1} + \mu_{1t} \tag{8}$$

$$y_{2t} = \beta_{20} + \beta_{21}y_{2t-1} + \alpha_{21}\, y_{1t-1} + \mu_{2t} \tag{9}$$

or,

$$\begin{pmatrix} y_{1t} \\ y_{2t} \end{pmatrix} = \begin{pmatrix} \beta_{10} \\ \beta_{20} \end{pmatrix} + \begin{pmatrix} \beta_{11} & \alpha_{11} \\ \alpha_{21} & \beta_{21} \end{pmatrix} \begin{pmatrix} y_{1t-1} \\ y_{2t-1} \end{pmatrix} + \begin{pmatrix} \mu_{1t} \\ \mu_{2t} \end{pmatrix} \tag{10}$$

or even

$$\underset{g\,x\,1}{y_t} = \underset{g\,x\,1}{\beta_0} + \underset{g\,x\,gg\,x\,1}{\beta_1 y_{t-1}} + \underset{g\,x\,1}{\mu_t} \tag{11}$$

In equation (11) there are $g = 2$ variables in the system. Extending this model to the form where each variable in each equation have k lags, is interpreted as

$$\underset{g\,x\,1}{y_t} = \underset{g\,x\,1}{\beta_0} + \underset{g\,x\,g\,g\,x\,1}{\beta_1 y_{t-1}} + \underset{g\,x\,g\,g\,x\,1}{\beta_2 y_{t-2}} + \cdots + \underset{g\,x\,g\,g\,x\,1}{\beta_{1k} y_{t-k}} + \underset{g\,x\,1}{\mu_t} \tag{12}$$

(Brooks 2014, p.328)

3.1.3. Impulse responses and variance decompositions

Impulse response shows how the dependent variables response to shocks from each of the variables in the VAR model over time. This is accomplished by expressing the VAR model as a vector moving average (VMA). If the system is stable, the shock should eventually die away. (Brooks 2014, p.335)

The impulse responses are calculated as follows, consider following bivariate VAR(1):

$$\gamma_t = A_1 \gamma_{t-1} + \mu_t \tag{13}$$

where $A_1 = \begin{bmatrix} 0.5 & 0.3 \\ 0.0 & 0.2 \end{bmatrix}$

Using the elements of the matrices and vectors, VAR can also be written as

$$\begin{bmatrix} \gamma_{1t} \\ \gamma_{2t} \end{bmatrix} = \begin{bmatrix} 0.5 & 0.3 \\ 0.0 & 0.2 \end{bmatrix} \begin{bmatrix} \gamma_{1t-1} \\ \gamma_{2t-1} \end{bmatrix} + \begin{bmatrix} \mu_{1t} \\ \mu_{2t} \end{bmatrix} \tag{14}$$

Consider a unit shock to γ_{1t} at t = 0

$$\gamma_0 = \begin{bmatrix} \mu_{10} \\ \mu_{20} \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix} \tag{15}$$

$$\gamma_1 = A_1 \gamma_0 = \begin{bmatrix} 0.5 & 0.3 \\ 0.0 & 0.2 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \end{bmatrix} = \begin{bmatrix} 0.5 \\ 0 \end{bmatrix} \tag{16}$$

$$\gamma_2 = A_1 \gamma_1 = \begin{bmatrix} 0.5 & 0.3 \\ 0.0 & 0.2 \end{bmatrix} \begin{bmatrix} 0.5 \\ 0 \end{bmatrix} = \begin{bmatrix} 0.25 \\ 0 \end{bmatrix} \tag{17}$$

etc. Now it would be possible to plot the impulse response functions of γ_{1t} and γ_{2t} to a unit shock in γ_{1t}. Even thought the example above is quite simple and it is easy to see the effects of shocks to the variables, the same principles are valid when VAR model is containing more equations or lags and it is harder to observe by eye the interactions between the equations. (Brooks 2014, p.336)

Variance decomposition examines the VAR equations and their dynamics from a different angle. It examines the proportion of the movements in the dependent variables that are caused by their own shocks and caused by shocks from other variables. It determines how much of the s – step-ahead forecast error variance of given variable is explained by variations to each explanatory variable for $s = 1, 2, \dots, n$. (Brooks 2014, p.337)

3.1.4. Granger causality test

In order to enhance the interpretation of a VAR model, Granger causality test (Granger, 1969) is used. Granger causality test measures if changes in the x variable can be used to predict changes in the y variable. The argument is that if x Granger-causes y, lags of x should be significant in the equation for y for predicting the future value of y variable. If the x causes y, but not vice versa, it is referred that x Granger-causes y or that there exists a unidirectional causality from x to y. However, the word causality is somewhat misleading. Granger-causality measures a correlation between the current value of one variable and the past values of others. It does not mean that the movements of one variable causes the movement in another variable but rather that the past values of one variable have explanatory power on the current value of another variable. (Brooks 2014, p.335)

3.2. Data

The empirical part is based on two time series; Standard & Poor's 500 total return index and MSCI US REIT total return index. MSCI US REIT index represents 99% of the US REIT universe with 150 constituents, and it excludes Mortgage REITs and selected Specialized REITs. The sample interval is from January 2000 to December 2015. The reasoning behind the starting date is that during the mid 90's the market capitalization of U.S. REITs increased excessively. Also, having started the data from early 90's or earlier, the results would not be as useful as later starting point is beneficial to analyse REITs behaviour in 21th century. This thesis uses monthly data and the total return indices are transferred into logarithmic returns in order to avoid problems with non-stationary data. The use of monthly data is commonly used in investigating REIT and common stock returns behavior; see e.g. Kuhle (1987), Bley & Olson (2005) and Bhuyan et al. (2015). Monthly data is gathered from the Thomson Reuters DataStream.

In this thesis the financial crisis is considered to start in February 2007 and end in June 2009, which is in line with the Basse et al. (2009) findings. Basse et al. (2009) used Quandt-Andrews test (Andrews, 1993) to estimate the beginning date of structural changes affecting the relationship between REITs and utility stocks. They used utility stocks because it has been documented that the link between U.S. REITs and house prices in the U.S. is significant. Quandt-Andrews breakpoint was used to test structural change for the stability of estimated parameters. Their test sample was monthly data from August 2000 to November 2007, which included 87 possible break points. The result suggested that there indeed existed a massive structural breakpoint in the dataset and the most likely breakpoint date is February 2007. This is interesting because, at the same time in February 2007, first obvious signs started to appear, which indicated that the house prices in the U.S. were overheating.

Table 1 shows descriptive statistics for the full sample period and sub-periods. Mean is multiplied by 12 and standard deviation is multiplied by square root of 12 in order to present the mean and volatility on annual basis. Median, maximum and minimum are presented on a monthly basis.

Table 1. Descriptive statistics

	Full sample 01/2000 –12/2015		Pre-crisis period 01/2000 –01/2007		Crisis period 02/2007 – 06/2009		Post-crisis period 07/2009 –12/2015	
	REIT	S&P 500	REIT	S&P 500	REIT	S&P 500	REIT	S&P 500
Mean	11.28 %	3.98 %	20.97 %	1.32 %	-36.33 %	-16.24 %	18.41 %	14.40 %
Median	1.93 %	0.96 %	2.29 %	0.67 %	-0.14 %	-0.43 %	1.93 %	1.74 %
Maximum	27.36 %	10.37 %	8.68 %	9.33 %	27.36 %	9.14 %	13.47 %	10.37 %
Minimum	-38.28 %	-18.39 %	-16.04 %	-11.51 %	-38.28 %	-18.39 %	-11.57 %	-8.32 %
Std. Dev.	23.02 %	15.29 %	14.31 %	14.33 %	44.13 %	21.27 %	17.30 %	12.98 %
Skewness	-1.63	-0.70	-1.21	-0.41	-0.60	-0.70	-0.10	-0.26
Kurtosis	11.93	4.32	5.84	3.34	4.48	3.47	2.78	3.01
Observations	192	192	85	85	29	29	78	78

The table above presents summary statistics on monthly total returns for the MSCI US REIT and Standard & Poor’s 500 total return indices

Table 1 shows that the REIT index has been outperforming S&P 500 on an annual basis during the full sample period. Descriptive statistics show that the before crisis period REIT index yielded almost 21% per annum while S&P 500 yielded only 1.3% whilst the volatility remained almost identical between the asset classes. During the finance crisis period, REIT index suffered massive losses compared to S&P 500, and the volatility of REIT index was also two times higher than S&P 500’s volatility. After the finance crisis period it seems that the annual returns of asset classes have mostly equalized. During the post-crisis period, REIT index has been yielding slightly higher returns than S&P 500 but it has also suffered higher volatilities in comparison with S&P 500.

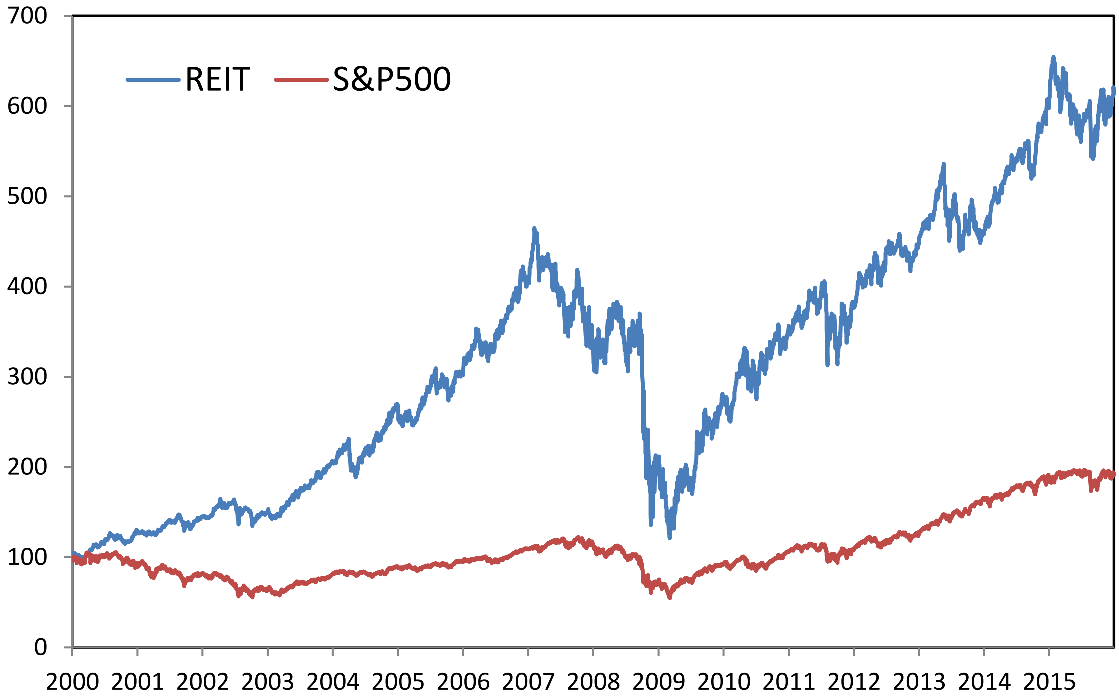

Figure 1. Development of the REIT and S&P 500 total return indices from 01/2000 to 12/2015. Index value = 100, January 2000

When comparing total returns from 01/2000 to 12/2015 in the Figure 1, REIT index has drastically outperformed S&P 500. Early 2000s REIT total return index was performing remarkably well compared to decreasing S&P 500 total return index, but during the finance crisis, REIT index was hit more violently. Since 2009 both total return indices have fattened the investors' portfolios steadily. The volatility of these two asset classes is seemingly different. S&P 500 has had a relatively low volatility whilst REIT index has not.

4. Results

This thesis uses a vector autoregression model for examining the dynamic linear relationship between REIT and S&P 500 returns because it is a powerful tool for describing data. With VAR, it is possible to get information about the dynamics between the variables and, provided that there is predictive causality between variables as tested by Granger causality, assess the predictive value of one variable for the other variable.

VAR is a linear model in which each variable is in turn explained by its own lagged values as well as the lags of other variables. While it is a simple framework, it provides a reliable model to capture rich dynamics in multiple time series. (Stock and Watson, 2001) VAR also ignores the problem with exogenous variables by treating all variables as endogenous. Furthermore, VAR provides impulse response graphs and forecast error variance decompositions which can be used for further analysis of interpreting the linear dependencies among variables used in VAR. VAR has been widely used to study the relationship between REIT and other macroeconomic variables (see e.g. McCue & Kling, 1994; Payne, 2003; Kim et al., 2007), and it has proven to be an effective tool for capturing these dynamics.

The next chapter for the empirical results will proceed in the following order. Firstly, ADF and KPSS tests will be used for the whole data in order to test for series unit roots and stationarity. After ADF and KPSS tests, a 36-month rolling correlation graph is presented to help illustrate the dynamic correlation between the REIT and S&P500 returns. Then VAR(6) model is implemented for the whole dataset alongside with the impulse response graphs, variance decomposition table and the Granger causality test. The lag length of 6 is selected by using Akaike information criterion (AIC) for the full sample period from 1/2000 to 12/2015. Furthermore, the same analyses will be employed to three sub-categories, pre-crisis period, crisis period and post-crisis period, respectively. Ultimately, the rolling window VAR will be deployed in furtherance of understanding the relationship between REIT and S&P500 returns. The rolling window VAR is done in order to avoid the problems with the relatively short crisis period with 23 monthly observations, which may cause problems with the stationarity, and therefore it can make the comparison of the three sub-periods' results difficult or even directly impossible. Furthermore, the rolling window VAR will give much better understanding of the relationship between the variables during and around the finance crisis without relying too much on the VAR results given by three unequally divided periods.

4.1. Full sample period 1/2000 – 12/2015

4.1.1. Stationary and unit root tests

The full data sample period of 01/2000 to 12/2015 will be tested for its stationarity. Especially with time-series it is important to test whether data is stationary or not for the sake of reliable results. Firstly, both variables are tested by Augmented Dickey-Fuller test which is used for testing large samples.

Table 2. Augmented Dickey-Fuller test for REIT and S&P 500 monthly total return data

REIT		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.197718	0.0000
Test critical values:	1% level	-3.465202	
	5% level	-2.876759	
	10% level	-2.574962	
SP500		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-12.29851	0.0000
Test critical values:	1% level	-3.464643	
	5% level	-2.876515	
	10% level	-2.574831	

The null hypothesis for augmented Dickey-Fuller test is that the unit root is present in a time series sample. In both cases the null hypothesis is rejected at 1% significance level indicating that the time series do not contain unit roots and therefore are stationary.

Table 3. Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test for REIT and S&P 500 monthly total return data

REIT		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.076839
Asymptotic critical values:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000
SP500		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.260704
Asymptotic critical values:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

Kwiatkowski-Phillips-Schmidt-Shin test can be used to validate the results from ADF test and rule out the possibility that the data sample is non-stationary. Its null hypothesis is that the series is stationary. As Table 3 shows, null hypotheses are rejected at 1% significance levels suggesting that the both time series are stationary.

4.1.2. 36-month rolling correlation between REIT and S&P 500 returns

The 36-month rolling correlation between REIT and S&P 500 returns from 01/2000 to 12/2015 is presented in Figure 2. The rolling correlation shows how the correlation between REIT and S&P 500 returns is time-varying and that during different economic times the correlation may fluctuate remarkably.

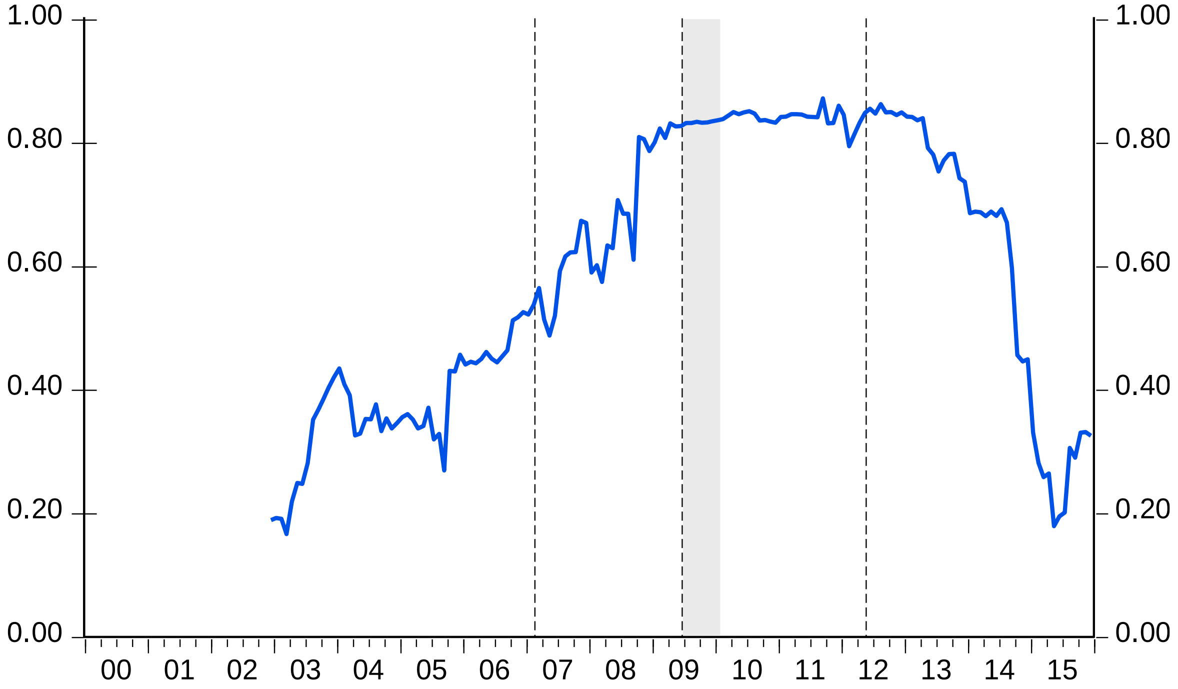

Figure 2. The 36-month rolling correlation between REIT and S&P 500 returns. Y-axis denotes the correlation and x-axis denotes the ending month of 36-month rolling windows. First dashed line in 02/2007 denotes the first month of the crisis in the rolling window and grey area from 06/2009 to 01/2010 denotes the period when all of the crisis months were calculated in rolling window. Second dashed line in 05/2012 denotes the last crisis month (06/2009) that is used in the rolling window correlation.

The Figure 2 shows the 36-month rolling correlation between the REIT and S&P 500 returns where y-axis denotes the correlation and x-axis denotes the last month used of each 36-month rolling window correlations. During the pre-crisis period the correlation has been relatively low, but there seems to be apparent increase in correlation towards the finance crisis. A high increase in correlation occurred in the beginning of 2009, suggesting that from early 2007 to early 2009 the relationship between REIT and S&P 500 returns started to be more correlated. The highest correlation point, 0.87, was in September 2011, which means that the REIT and S&P 500 returns were most correlated during the window of October 2008 to September 2011.

The correlation has been pretty high throughout the whole finance crisis and it has been decreasing significantly during the post-crisis period. One notable result is that right after the crisis the correlation between REIT and S&P 500 returns remained relatively high for a short period of time. The second dotted line in Figure 2 represents the last crisis month that is used in the window for the computation of correlation, i.e. after 05/2012 the correlation remained strong even though the crisis period was not included in correlation calculations. This indicates that after the crisis the REIT and S&P 500 returns acted rather similarly for a short period of time. The last observation is from December 2015 with the correlation of 0.32, whilst the correlation for the whole sample is 0.61.

It seems that during the recent years the correlation between the REIT and S&P 500 returns has changed drastically. Results imply that the stock market does not treat these indexes in a similar way especially after the finance crisis. This is consistent with the previous work of Case et al. (2012) who found that dynamic correlation between the REIT and stock returns varies over time and it makes REIT stocks an effective tool for a portfolio diversification. The results are also in line with the Fei et. al (2010) findings that the correlation between REIT and stock returns are time-dependent and volatile, and they can be explained by other macroeconomic variables, such as inflation and unemployment rate. They also found that during the 1987–2008 period, when the correlation between REIT and S&P 500 was at its lowest, the future performance of REITs was the highest. Implementing these findings of Fei et. al (2010) to the current situation, one might expect that REITs’ future performance should be good, since the correlation between REIT and S&P 500 is currently relatively low. Nonetheless, during the crisis period it seems that REIT and S&P 500 returns are highly correlated, so the benefits of portfolio hedging using REIT stocks during financial crises may not be justified or at least the benefits are limited.

2.1.3. VAR

The results of VAR model for the full sample are presented in Table 4. The number of lags was selected based on the Akaike information criterion (AIC) which suggested that VAR with 6 lags should be used for the best model and the output for VAR lag order selection criteria can be found in appendices section.

Table 4. VAR for full sample period 01/2000 - 12/2015

	REIT	S&P500		REIT	S&P500
REIT(-1)	-0.117765	0.019039	**SP500(-1)**	0.485581	0.112257
	(0.09148)	(0.06441)		(0.13189)	(0.09286)
	[-1.28730]	[0.29559]		[3.68182]***	[1.20892]
REIT(-2)	-0.081237	-0.070299	**SP500(-2)**	-0.084572	0.005105
	(0.09206)	(0.06482)		(0.13651)	(0.09612)
	[-0.88243]	[-1.08458]		[-0.61951]	[0.05311]
REIT(-3)	0.190840	0.089931	**SP500(-3)**	-0.002385	0.082703
	(0.09040)	(0.06365)		(0.13604)	(0.09578)
	[2.11112]**	[1.41297]		[-0.01753]	[0.86347]
REIT(-4)	0.019260	-0.014814	**SP500(-4)**	0.184977	0.019489
	(0.09044)	(0.06368)		(0.13503)	(0.09507)
	[0.21295]	[-0.23264]		[1.36988]	[0.20499]
REIT(-5)	-0.070683	-0.119571	**SP500(-5)**	0.246919	0.167709
	(0.08989)	(0.06329)		(0.13663)	(0.09619)
	[-0.78637]	[-1.88937]		[1.80726]	[1.74343]
REIT(-6)	-0.151102	-0.146627	**SP500(-6)**	-0.186766	0.075635
	(0.08749)	(0.06160)		(0.13566)	(0.09552)
	[-1.72712]	[-2.38040]**		[-1.37671]	[0.79187]
			R-squared	0.241327	0.119417
Coefficient	0.008535	0.004075	Adj. R-squared	0.188703	0.058336
	(0.00469)	(0.00330)	Sum sq. resids	0.636393	0.315472
	[1.81876]	[1.23342]	S.E. equation	0.060651	0.042703
			F-statistic	4.585820	1.955056
Determinant resid covariance (dof adj.)		4.40E-06	Log likelihood	264.1023	329.3647
Determinant resid covariance		3.80E-06	Akaike AIC	-2.700024	-3.401771
Log likelihood		632.7363	Schwarz SC	-2.474569	-3.176315
Akaike information criterion		-6.524046	Mean dependent	0.009028	0.003447
Schwarz criterion		-6.073135	S.D. dependent	0.067336	0.044006

***, **, denotes significance levels at 1% and 5%, respectively. Standard errors in ( ) and t-statistics in [ ]

When implementing the VAR(6) model for the full period, it seems that one-month lagged S&P 500 returns have the highest impact on today's REIT returns with t-value of 3.68. It also seems that the 3rd lag REIT returns are affecting on current REIT returns at a 5% significance level and parameter REIT(-6) is statistically significant in S&P 500 equation. The coefficient of determination, R^2, is around 24 percent and 12 percent for REIT and S&P 500 equations, respectively. It seems that over the whole period, the effect of S&P 500(-1) is the most statistically significant parameter in REIT returns and it definitely needs to be studied in more detail.

2.1.4. Impulse response, variance decomposition and Granger causality

In the Figure 3 the impulse responses are presented. The first graph shows the response of REIT to the impulses of REIT and S&P 500 and the second one S&P 500 response to the REIT and S&P 500 impulses. The blue line denotes the REIT response and the red line S&P 500 response. REIT's response to REIT and S&P 500 impulses seems to be quite similar with the S&P 500 response to both impulses. It seems, however, that the REIT response to impulses is stronger than S&P 500 response and eventually the effect will fade out after 8 months in both graphs.

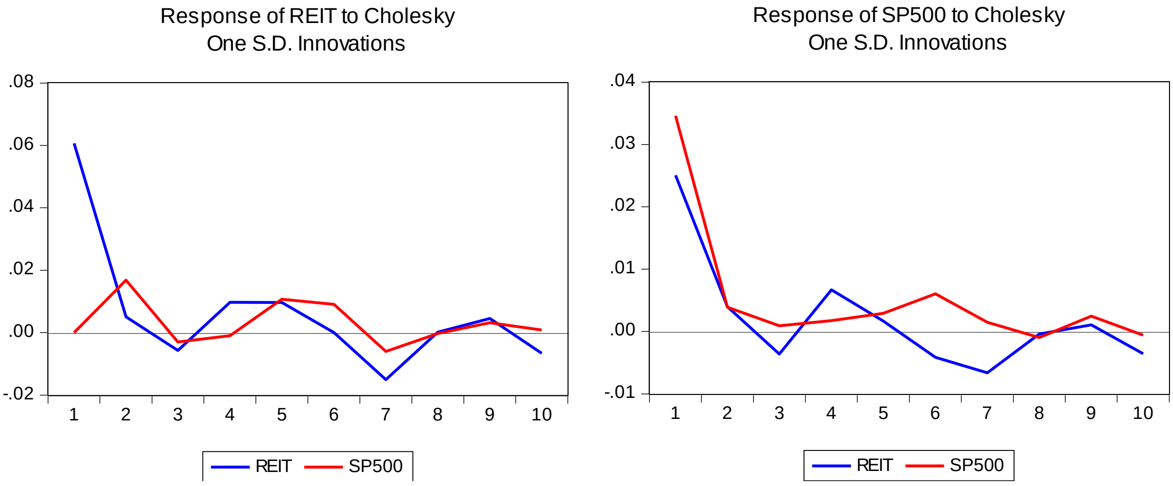

Figure 3. Impulse responses of REIT and S&P 500. Period 01/2000 – 12/2015

The variance decomposition table below shows how much of the forecast error variance of each variable can be explained by shocks in the other variable in the VAR model. It seems that in the REIT equation, a shock from S&P 500 can cause around 7 percent fluctuation in REIT returns in the second period. In the 5^{th} period a shock from S&P 500 can cause around 9.4 percent fluctuation in REIT returns and in the following period the influence increases to around 11.1 percent. After 6 months it seems that the effect from the S&P 500 shock no longer increases the fluctuations in future REIT returns.

Table 5. Variance decomposition of REIT and S&P 500. Period 01/2000 – 12/2015

Variance Decomposition of REIT:				Variance Decomposition of SP500:			
Period	S.E.	REIT	SP500	Period	S.E.	REIT	SP500
1	0.060651	100.0000	0.000000	1	0.060651	0.000000	100.0000
2	0.063133	92.92788	7.072125	2	0.063133	0.047141	99.95286
3	0.063462	92.77520	7.224801	3	0.063462	0.686652	99.31335
4	0.064206	92.91899	7.081007	4	0.064206	1.673277	98.32672
5	0.065802	90.60506	9.394940	5	0.065802	1.669317	98.33068
6	0.066425	88.91315	11.08685	6	0.066425	4.020401	95.97960
7	0.068383	88.76547	11.23453	7	0.068383	5.849959	94.15004
8	0.068384	88.76394	11.23606	8	0.068384	5.849280	94.15072
9	0.068609	88.62354	11.37646	9	0.068609	5.845486	94.15451
10	0.068932	88.71497	11.28503	10	0.068932	6.123623	93.87638
Cholesky Ordering: REIT SP500							Cholesky Ordering: SP500 REIT

In S&P 500 equation it seems that shocks from REIT have only little effect on S&P 500 returns. In the second period, REIT shocks can cause only 0.05 percent fluctuation in S&P 500 returns. Nevertheless, it seems that the impact from REIT shocks increases in the 4th, 6th and 7th period.

In the following table, the Granger causality test is presented for the whole period with 2 and 6 lags included. Despite the Akaike Information Criterion suggesting the use of 6 lags in VAR model, Granger causality tests with 2 lags are also included. This is done in order to examine the even shorter-term dynamics, since the F-statistics seem to increase when lesser lag lengths are selected, indicating that the Granger causality may be more significant during immediate future.

Table 6. Granger causality tests for the full sample period 01/2000 – 12/2015

	Null Hypothesis:	Obs	F-Statistic	Prob.
Lags: 2	SP500 does not Granger Cause REIT	190	7.85568	0.0005***
	REIT does not Granger Cause SP500		0.83034	0.4375
Lags: 6	SP500 does not Granger Cause REIT	186	3.45450	0.0030***
	REIT does not Granger Cause SP500		2.08921	0.0568

***, **, denotes significance levels at 1% and 5%, respectively

The null hypothesis for Granger causality test is that the x-variable does not Granger cause y-variable. The results suggest that the both S&P 500 null hypotheses, that the S&P 500 does not Granger Cause REIT, can be rejected with 1% significance level. This means that the S&P 500 provides statistically significant information about future REIT returns when analysing the whole period from 1/2000 to 12/2015. Either of the REIT hypotheses cannot be rejected at 1% or 5% significance level, and it seems than during the whole period REIT returns did not have any explanatory power in S&P 500 returns. However, in the latter Granger causality test the p-value for REIT is 0.0568, which can almost be seen as significant at the 5% significance level.

2.2. Before crisis period 01/2000 – 01/2007

2.2.1. VAR

Table 7. VAR for pre-crisis period 01/2000 – 01/2007

	REIT	SP500		REIT	SP500
REIT(-1)	-0.438633	0.013134	**SP500(-1)**	0.367996	0.054270
	(0.13170)	(0.14284)		(0.12021)	(0.13037)
	[-3.33056]***	[0.09195]		[3.06126]***	[0.41626]
REIT(-2)	-0.107991	-0.111535	**SP500(-2)**	0.089056	0.000251
	(0.13857)	(0.15028)		(0.12611)	(0.13677)
	[-0.77934]	[-0.74217]		[0.70620]	[0.00184]
REIT(-3)	-0.122681	-0.055399	**SP500(-3)**	0.055702	0.093435
	(0.13019)	(0.14120)		(0.12300)	(0.13340)
	[-0.94232]	[-0.39235]		[0.45286]	[0.70042]
REIT(-4)	-0.343167	-0.039742	**SP500(-4)**	0.213070	-0.057095
	(0.13135)	(0.14246)		(0.12129)	(0.13155)
	[-2.61262]***	[-0.27898]		[1.75665]	[-0.43402]
REIT(-5)	-0.287567	-0.030281	**SP500(-5)**	0.226314	0.159532
	(0.13777)	(0.14941)		(0.12433)	(0.13484)
	[-2.08737]**	[-0.20266]		[1.82028]	[1.18311]
REIT(-6)	-0.149112	-0.124064	**SP500(-6)**	0.104557	0.140365
	(0.12638)	(0.13706)		(0.12389)	(0.13436)
	[-1.17992]	[-0.90518]		[0.84396]	[1.04467]
			R-squared	0.256601	0.063594
Coefficient	0.040283	0.006917	Adj. R-squared	0.121437	-0.106661
	(0.00876)	(0.00950)	Sum sq. resids	0.103543	0.121793
	[4.59663]***	[0.72780]	S.E. equation	0.039608	0.042958
			F-statistic	1.898448	0.373522
Determinant resid covariance (dof adj.)		2.55E-06	Log likelihood	150.0739	143.6616
Determinant resid covariance		1.78E-06	Akaike AIC	-3.470225	-3.307889
Log likelihood		298.7713	Schwarz SC	-3.080316	-2.917980
Akaike information criterion		-6.905602	Mean dependent	0.017225	0.001235
Schwarz criterion		-6.125784	S.D. dependent	0.042257	0.040835

***, **, denotes significance levels at 1% and 5%, respectively. Standard errors in ( ) and t-statistics in [ ]

In the pre-crisis VAR analysis there is a evidence that the REIT(-1), REIT(-4) and REIT(-5) parameters are significantly affecting the REIT returns. This means that before crisis, REIT returns were negatively affected by the previous month, 4th month and 5th month of REIT returns. There is also evidence that the S&P 500(-1) significantly effects on the REIT returns. It is interesting to notice that while parameters of lagged REIT returns had negative values, S&P 500(-1) does have a notably high positive value to REIT returns with t-value being over 3. This result suggests that before crisis, the REIT returns were positively affected by last month S&P 500 returns but negatively affected by its own short time historical returns. These are unexpected results because REITs were blooming before crisis and REIT returns were clearly outperforming S&P 500 returns. Still the parameters of lagged REIT returns are negative, which may imply that there can be found evidence of the lead-lag effect from S&P 500 to REIT. Also the U.S. housing price bubble peaked in 2004 which likely caused negative directional and unidirectional changes in REIT returns.

S&P 500 returns were not influenced either by lagged REIT or S&P 500 returns. Even S&P 500(-1) did not have any statistical significance and the r-square for S&P 500 is really weak, around 6 percent with really low F-statistics. This is consistent with the full period results, except now the REIT(-6) is no longer statistically significant in S&P 500 equation.

2.2.2. Impulse response, variance decomposition and Granger causality

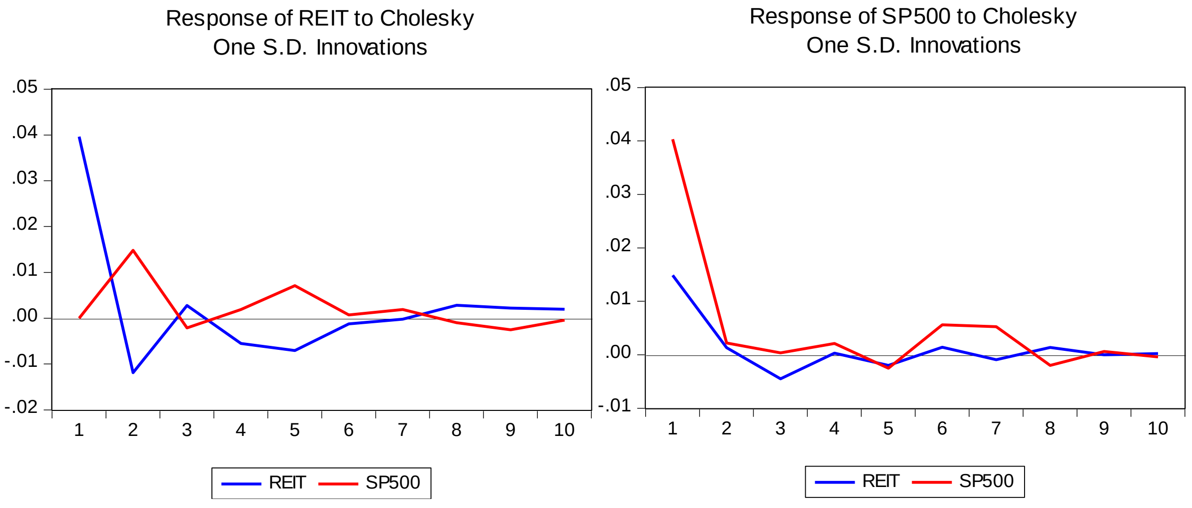

Figure 4. Impulse responses of REIT and S&P 500. Pre-crisis period 01/2000 – 01/2007

The impulse response graph of REIT seems to have inverse correlation between the REIT and S&P 500 impulses. Both responses to impulses shrink at 3rd period, but increase during 4th and 5th periods.

Table 8. Variance decomposition of REIT and S&P 500. Pre-crisis period 01/2000 – 01/2007

Variance Decomposition of REIT:				Variance Decomposition of SP500:			
Period	S.E.	REIT	SP500	Period	S.E.	REIT	SP500
1	0.039608	100.0000	0.000000	1	0.039608	0.000000	100.0000
2	0.043938	88.60489	11.39511	2	0.043938	0.012864	99.98714
3	0.044075	88.44610	11.55390	3	0.044075	1.015311	98.98469
4	0.044456	88.46368	11.53632	4	0.044456	1.022816	98.97718
5	0.045569	86.59692	13.40308	5	0.045569	1.070010	98.92999
6	0.045592	86.58619	13.41381	6	0.045592	1.071405	98.92859
7	0.045631	86.43897	13.56103	7	0.045631	1.424925	98.57508
8	0.045729	86.44978	13.55022	8	0.045729	1.618688	98.38131
9	0.045851	86.22156	13.77844	9	0.045851	1.621238	98.37876
10	0.045895	86.24006	13.75994	10	0.045895	1.627550	98.37245
Cholesky Ordering: REIT SP500							Cholesky Ordering: SP500 REIT

In variance decomposition Table 8, the fluctuation of REIT returns seems to be explained by its own shocks in the second period at the rate of 88.6%, while shocks from S&P 500 seems to cause 11.4% variation. The effect of S&P 500 shocks stays around at the same rate up until the 5th month where it can influence 13.4% variation in the REIT returns and after that the relation does not change significantly. It seems that during the pre-crisis time, the fluctuations of REIT returns were slightly more influenced by S&P 500 shocks than in the full period time. The variations in S&P 500 returns are almost entirely explained by its own shocks during the pre-crisis time which is mostly in line with the whole period sample.

Table 9. Granger causality tests for pre-crisis period 01/2000 – 01/2007

	Null Hypothesis:	Obs	F-Statistic	Prob.
Lags: 2	SP500 does not Granger Cause REIT	83	5.04926	0.0087***
	REIT does not Granger Cause SP500		0.11107	0.8950
Lags: 6	SP500 does not Granger Cause REIT	79	2.51201	0.0299**
	REIT does not Granger Cause SP500		0.23785	0.9625

***, **, denotes significance levels at 1% and 5%, respectively

It seems that in Table 9, the H_0 which denotes that S&P 500 does not Granger Cause REIT returns can be rejected at the significance level of 1% when using 2 lags and at the 5 % significance level when using 6 lags. This means that before the finance crisis, S&P 500 did have explanatory power in predicting the returns of REIT. The results for REIT are much more different than what they were in full sample period. In full sample period, REIT with 6 lags had almost significant explanatory power in S&P 500 returns, but during the pre-crisis period such relationship cannot be found.

2.3. Finance crisis period 02/2007 – 06/2009

2.3.1. VAR

Table 10. VAR for finance crisis period 02/2007 – 06/2009

	REIT	SP500		REIT	SP500
REIT(-1)	-0.154553	0.216028	**SP500(-1)**	1.187114	0.058719
	(0.35661)	(0.21976)		(0.68010)	(0.41912)
	[-0.43340]	[0.98300]		[1.74549]	[0.14010]
REIT(-2)	0.253435	0.094058	**SP500(-2)**	-0.787415	-0.426590
	(0.36673)	(0.22600)		(0.75346)	(0.46433)
	[0.69106]	[0.41618]		[-1.04506]	[-0.91872]
REIT(-3)	0.004655	-0.083980	**SP500(-3)**	-0.021226	0.241806
	(0.29454)	(0.18151)		(0.69957)	(0.43112)
	[0.01581]	[-0.46266]		[-0.03034]	[0.56088]
REIT(-4)	-0.680829	-0.434326	**SP500(-4)**	1.807020	0.990739
	(0.29308)	(0.18061)		(0.75784)	(0.46703)
	[-2.32301]**	[-2.40471]**		[2.38443]**	[2.12136]**
REIT(-5)	-0.241301	-0.221883	**SP500(-5)**	0.875543	0.029248
	(0.30883)	(0.19032)		(0.90041)	(0.55489)
	[-0.78133]	[-1.16582]		[0.97238]	[0.05271]
REIT(-6)	0.220073	-0.113549	**SP500(-6)**	-1.949930	-0.466556
	(0.30062)	(0.18526)		(0.78616)	(0.48448)
	[0.73206]	[-0.61291]		[-2.48032]**	[-0.96300]
			R-squared	0.842352	0.729913
Coefficient	-0.023405	-0.029778	Adj. R-squared	0.653175	0.405808
	(0.02566)	(0.01581)	Sum sq. resids	0.070148	0.026641
	[-0.91220]	[-1.88325]	S.E. equation	0.083754	0.051615
			F-statistic	4.452711	2.252087
Determinant resid covariance (dof adj.)		8.31E-06	Log likelihood	33.97981	45.11365
Determinant resid covariance		1.57E-06	Akaike AIC	-1.824331	-2.792491
Log likelihood		88.41420	Schwarz SC	-1.182530	-2.150690
Akaike information criterion		-5.427322	Mean dependent	-0.028045	-0.017963
Schwarz criterion		-4.143720	S.D. dependent	0.142217	0.066959

***, **, denotes significance levels at 1% and 5%, respectively. Standard errors in ( ) & t-statistics in [ ].

During the crisis period there are some radical changes in the significance levels of the parameters. There is not any statistically significant evidence that the 1-month lagged values of REIT and S&P 500 returns are affecting the current period REIT returns anymore. However, the results are suggesting that during the crisis the REIT(-4), S&P 500(-4) and S&P 500(-6) parameters were statistically significant in REIT equation with the confidence level of 95%. Parameters REIT(-4) and S&P 500(-4) were also statistically significant in the S&P 500 equation. Again it seems that the REIT(-4) is negative in both equations whilst S&P 500(-4) is positively affecting current returns. It is also noteworthy that the S&P 500(-6) parameter in the REIT equation is highly negative during the crisis period.

It seems that during the crisis the fit of the model was relatively high for both variables. The coefficient of determination, R^2, was over 84% for REIT and almost 73% for S&P 500 and the F-statistics for both variables were on a good level. Crisis period has only 23 observations in VAR equation after 6 lags so the problem of non-stationarity in the data may be present. However, the possible problem with non-stationary data is taken into account in the next step of the analysis and thus the rolling window VAR will be done and its results will be interpreted after the sub-period analysis.

2.3.2. Impulse response, variance decomposition and Granger causality

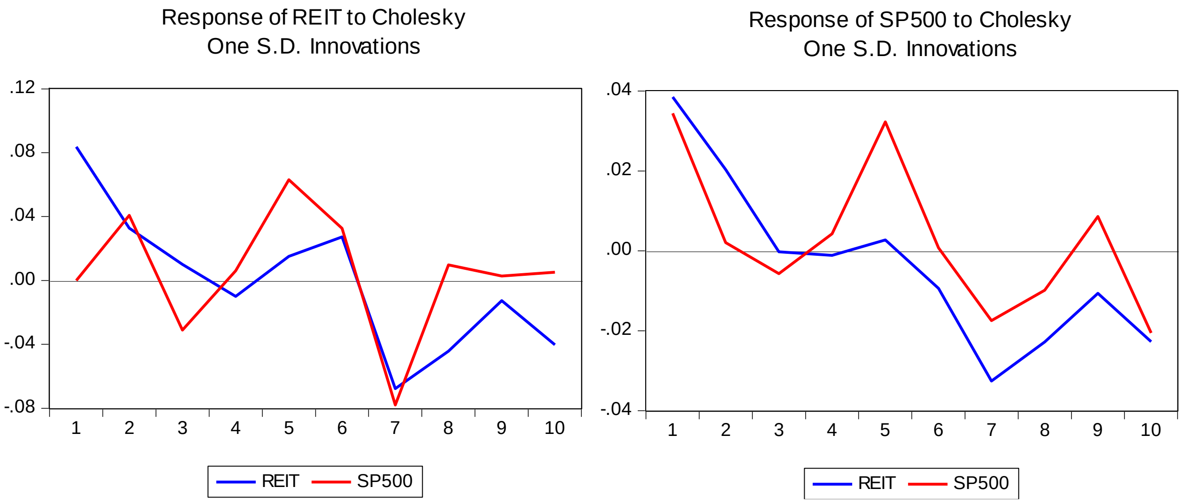

Figure 5. Impulse responses of REIT and S&P 500. Finance crisis period 02/2007 – 06/2009

The impulse response graphs in Figure 5 look quite different than before finance crisis. Remarkably high positive and negative reaction to impulses can be seen and they do not seem to fade out, except the S&P 500's response to REIT impulse onwards from 7th period. It seems that there cannot be found any consistent movement in the variable's responses to either REIT or S&P 500 impulses. However, the response of REIT was more positive to S&P 500 impulses than REIT impulses, suggesting that during the crisis REIT was the leading cause of the losses in the REIT index.

In the following table, the results from the variance decomposition test are presented for the crisis period.

Table 11. Variance decompositions of REIT and S&P 500. Finance crisis period 02/2007 – 06/2009

Variance Decomposition of REIT:				Variance Decomposition of SP500:			
Period	S.E.	REIT	SP500	Period	S.E.	REIT	SP500
1	0.083754	100.0000	0.000000	1	0.083754	0.000000	100.0000
2	0.098765	82.88683	17.11317	2	0.098765	4.722297	95.27770
3	0.104007	75.67513	24.32487	3	0.104007	5.211028	94.78897
4	0.104662	75.64853	24.35147	4	0.104662	5.680768	94.31923
5	0.123158	56.13729	43.86271	5	0.123158	16.04943	83.95057
6	0.130301	54.54598	45.45402	6	0.130301	16.81247	83.18753
7	0.166298	50.07247	49.92753	7	0.166298	14.08076	85.91924
8	0.172374	53.21227	46.78773	8	0.172374	13.67044	86.32956
9	0.172861	53.44959	46.55041	9	0.172861	16.09788	83.90212
10	0.177582	55.80650	44.19350	10	0.177582	14.04473	85.95527
Cholesky Ordering: REIT SP500				Cholesky Ordering: SP500 REIT			

The variance decomposition results in Table 11 from the crisis period seem to be highly different in comparison with either pre-crisis period or full period sample. It can be clearly seen that the variation in REIT returns are increasingly affected by S&P 500 shocks. In the second period, almost 83% of the fluctuation in REIT returns are caused by its own shock, but in the 5th period the own shocks accounts merely 56% of the REIT movement. The shocks from S&P 500 are playing a significant role in the REIT equation during the finance crisis, and at the 7th period the impact is almost 50%. There seem to be some changes in S&P 500 equation as well, and in the 5th period, the shocks from REIT equation account for 16% of the fluctuation in S&P 500 returns.

The Granger causality test in Table 12 stays quite consistent even during the crisis period.

Table 12. Granger causality tests for finance crisis period 02/2007 – 06/2009

	Null Hypothesis:	Obs	F-Statistic	Prob.
Lags: 2	SP500 does not Granger Cause REIT	27	8.24142	0.0021***
	REIT does not Granger Cause SP500		1.04956	0.3670
Lags: 6	SP500 does not Granger Cause REIT	23	4.61643	0.0168**
	REIT does not Granger Cause SP500		1.10638	0.4221

***, **, denotes significance levels at 1% and 5%, respectively

Even during the crisis there seems to be a similar Granger cause relation between the variables. S&P 500 has statistically significant explanatory power in REIT returns. With 2 lags included, S&P 500 H_0 is rejected at the significance level of 1% and, with 6 lags included, at the significance level of 5%. The H_0 for REIT cannot be rejected and thus REIT does not Granger cause S&P 500 returns during the crisis time.

2.4. After crisis period 07/2009 – 12/2015

2.4.1. VAR

Table 13. VAR for post-crisis period 07/2009 – 12/2015

	REIT	SP500		REIT	SP500
REIT(-1)	-0.237062	-0.045647	**SP500(-1)**	0.052308	-0.118895
	(0.16640)	(0.14000)		(0.20151)	(0.16954)
	[-1.42469]	[-0.32605]		[0.25958]	[-0.70127]
REIT(-2)	0.008571	-0.090756	**SP500(-2)**	-0.130117	-0.056981
	(0.16648)	(0.14007)		(0.20053)	(0.16872)
	[0.05149]	[-0.64793]		[-0.64886]	[-0.33773]
REIT(-3)	0.200701	0.024057	**SP500(-3)**	-0.094548	0.001663
	(0.16591)	(0.13959)		(0.20294)	(0.17075)
	[1.20968]	[0.17234]		[-0.46590]	[0.00974]
REIT(-4)	-0.153332	-0.047724	**SP500(-4)**	0.008157	-0.081854
	(0.16701)	(0.14052)		(0.20659)	(0.17382)
	[-0.91808]	[-0.33963]		[0.03948]	[-0.47092]
REIT(-5)	-0.269117	-0.147373	**SP500(-5)**	0.325487	0.077502
	(0.15585)	(0.13113)		(0.20769)	(0.17475)
	[-1.72672]	[-1.12386]		[1.56717]	[0.44352]
REIT(-6)	0.037436	-0.044943	**SP500(-6)**	-0.202960	-0.092175
	(0.15427)	(0.12980)		(0.21179)	(0.17819)
	[0.24266]	[-0.34624]		[-0.95833]	[-0.51729]
			R-squared	0.198615	0.101413
Coefficient	0.017360	0.018095	Adj. R-squared	0.035621	-0.081351
	(0.00767)	(0.00645)	Sum sq. resids	0.126813	0.089771
	[2.26295]**	[2.80349]**	S.E. equation	0.046361	0.039007
			F-statistic	1.218545	0.554884
Determinant resid covariance (dof adj.)		1.93E-06	Log likelihood	126.1380	138.5741
Determinant resid covariance		1.29E-06	Akaike AIC	-3.142722	-3.488168
Log likelihood		283.7644	Schwarz SC	-2.731657	-3.077103
Akaike information criterion		-7.160122	Mean dependent	0.011279	0.010170
Schwarz criterion		-6.337993	S.D. dependent	0.047210	0.037511

***, **, denotes significance levels at 1% and 5%, respectively. Standard errors in ( ) & t-statistics in [ ]

After the huge market crash in 2009, stock prices started to increase, and companies started to regain their previous market values. From 2010 to 2015, REIT and S&P 500 indices yielded on average 14.5% and 12.9% per annum, respectively. When estimating the VAR model with 6 lags, one can see that there is not any statistically significance relationship present in either of REIT or S&P 500 parameters. This means that during the upswing of the stock market after the finance crisis, there was not any statistically significant explanatory power in forecasting either the REIT or S&P 500 returns using the previous month returns. These results suggest that after the finance crisis, the relationship between REIT and S&P 500 returns was drastically changed. First time since 2000 it seems that the S&P 500 returns did not have any explanatory power in REIT returns. T-value for S&P 500(-1) parameter is around 0.26 which can be seen as highly non-significant and in comparison, for the whole sample t-value of 3.68 it is evident that the dynamics have changed.

2.4.2. Impulse response, variance decomposition and Granger causality

The impulse response graphs in Figure 6 below show that there are some minor impulse effects present in both variable responses. Even though the VAR results in Table 13 show that there is no statistically significant explanatory power between the variables' parameters and thus it is not justified to draw any significant conclusion based on impulse response graphs in Figure 6, examining these impulse responses can still offer information about the dynamics of REIT and S&P 500 returns after the crisis period. After the 1st month it seems that the responses of both variables shrink close to zero. The response of REIT to impulses seems to be similar than before crisis, where there seems to be an inverse correlation between the response to the impulses of REIT and S&P 500. When REIT has a positive reaction, S&P 500's reaction is negative and the same effect seems to apply the other way around. However, it looks like that at this time the reaction is slightly lagged. In the 3rd period S&P 500's response is negative, and at the same time, REIT's response is around zero. REIT's response is trending positively, reaching its peak in the 4th period. When REIT's impulse response is at the lowest during 5th period, S&P 500 is trending upwards reaching its highest point during the 6th period.

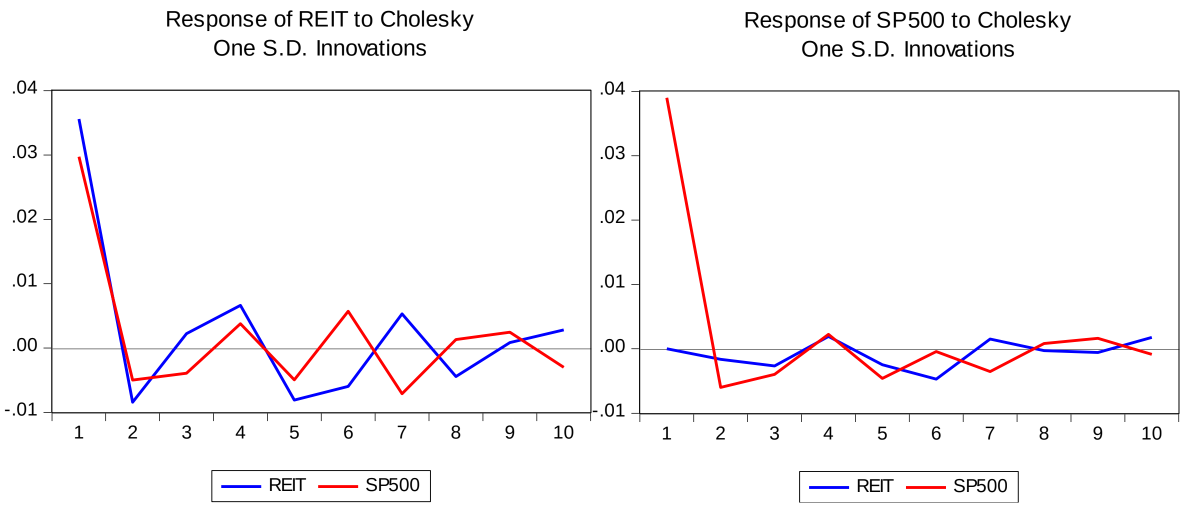

Figure 6. Response impulses of REIT and S&P 500. Post-crisis period 07/2009 – 12/2015

The variance decomposition for pre-crisis time is presented in Table 14

Table 14. Variance decompositions of REIT and S&P 500. Post-crisis period 07/2009 – 12/2015

Variance Decomposition of REIT:				Variance Decomposition of SP500:			
Period	S.E.	REIT	SP500	Period	S.E.	REIT	SP500
1	0.046361	100.0000	0.000000	1	0.046361	0.000000	100.0000
2	0.047387	99.89079	0.109206	2	0.047387	0.169096	99.83090
3	0.047603	99.01680	0.983200	3	0.047603	0.610669	99.38933
4	0.048206	98.96056	1.039438	4	0.048206	0.840879	99.15912
5	0.049133	98.92024	1.079765	5	0.049133	1.208270	98.79173
6	0.049823	96.23639	3.763610	6	0.049823	2.540319	97.45968
7	0.050605	93.29615	6.703847	7	0.050605	2.653699	97.34630
8	0.050816	92.78171	7.218294	8	0.050816	2.657342	97.34266
9	0.050881	92.73133	7.268671	9	0.050881	2.672397	97.32760
10	0.051047	92.12844	7.871555	10	0.051047	2.856058	97.14394
Cholesky Ordering: REIT SP500				Cholesky Ordering: SP500 REIT			

After the finance crisis, both REIT and especially S&P 500 movements are mainly caused by their own shocks. In REIT returns the S&P 500 shocks are accounting for 1% of the movements in the 3rd period and the rate of influence is slowly increasing up until the 8th period. The results suggest that after the finance crisis the S&P 500 shocks are contributing less information to the REIT returns than before. In period 2, S&P 500 shock is providing only 0.1% of the fluctuation of REIT returns. Comparing this to the period 2 in the whole sample (7.1%), before crisis period (11.4%) and crisis period (17%) it is apparent that after the finance crisis the shocks in S&P 500 do not explain the variation in REIT returns anymore.

This change can also be seen from the Granger causality test results below in table 15.

Table 15. Granger causality tests for post-crisis period 07/2009 – 12/2015

	Null Hypothesis:	Obs	F-Statistic	Prob.
Lags: 2	SP500 does not Granger Cause REIT	76	0.00943	0.9906
	REIT does not Granger Cause SP500		0.41450	0.6623
Lags: 6	SP500 does not Granger Cause REIT	72	0.73445	0.6239
	REIT does not Granger Cause SP500		0.36355	0.8990

***, **, denotes significance levels at 1% and 5%, respectively

The H_0 that the S&P 500 does not Granger cause REIT has been rejected throughout the whole study, but now the relationship has changed. For the first time the null hypothesis for S&P 500 remains and therefore during the post-crisis period the S&P 500 did not have any statistically significant explanatory power in REIT returns. This is a radical change in the dynamics of these two variables. H_0 cannot be rejected for the REIT variable either, but this has been a consistent outcome through the previous periods.

4.5. Rolling window VAR

The rolling window VAR is a different angle for approaching the main objectives of this thesis. Rolling window means that the data used for each VAR estimate is moving forwards. With the rolling window of 36 months it means that there are 157 different VAR estimates and their absolute t-values have been plotted in the graphs below. The orange and the yellow line in graphs represent the absolute t-values of 2 and 3, respectively. The rolling window VAR uses 6 lags as well.

The idea of rolling window VAR is to capture and understand the dynamic relationship between the REIT and S&P 500 more competently. Since all of the VAR equations are equally long, they can be easily compared and therefore it is not dependent on the authors' (sometimes) arbitrarily chosen starting and ending points for VAR equation. In Figure 7 REIT total return index is the explained variable and S&P 500 total return index is the explanatory variable.

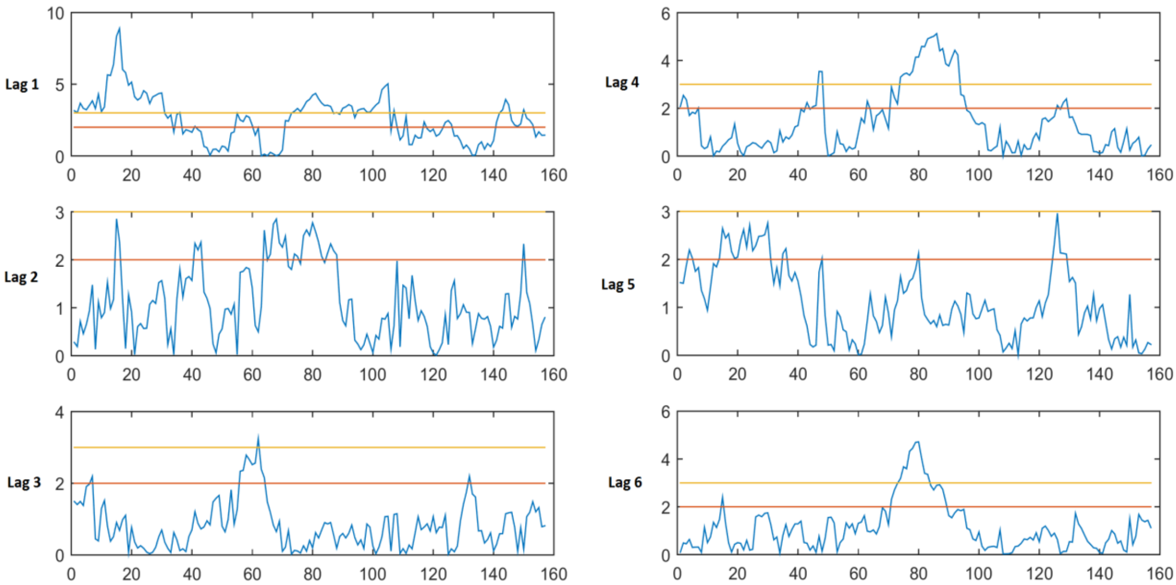

Figure 7. Rolling window VAR of 36 months. Lags of S&P 500 returns in REIT equation

Table 16. Corresponding VAR periods to x-axis values in Figure 7

X-axis	VAR period	X-axis	VAR period
10	10/2000 - 09/2003	90	06/2007 - 05/2010
20	08/2001 - 07/2004	100	04/2008 - 03/2011
30	06/2002 - 05/2005	110	02/2009 - 01/2012
40	04/2003 - 03/2006	120	12/2009 - 11/2012
50	02/2004 - 01/2007	130	10/2010 - 09/2013
60	12/2004 - 11/2007	140	08/2011 - 07/2014
70	10/2005 - 09/2008	150	06/2012 - 05/2015
80	08/2006 - 07/2009	157	01/2013 - 12/2016

The graphs are presented so that the x-axis denotes the last month used in each VAR estimation. Table 16 represents the corresponding VAR periods to x-axis values in Figure 7 for the sake of more comprehensive and clear interpretations. In Figure 7, the "Lag 1" represents the t-value movement of S&P 500(-1) parameter in REIT equation, "Lag 2" represents the t-value movement of S&P 500(-2) parameter and so forth. The beauty of rolling window VAR is that the significance of S&P 500 returns in REIT equation throughout whole data sample can be graphically plotted and thus its time-varying nature can be observed during different economic cycles.

Before crisis the results seem to be rather consistent with the pre-crisis VAR from 01/2000 to 01/2007 period and the S&P 500(-1) is still clearly the most significant parameter explaining REIT returns. Also, it seems that S&P 500(-4) and S&P 500(-5) parameters have been borderline significant during some of the periods, which is also in line with the previous VAR result.

At the end of 2005, the S&P 500(-1) parameter turned into non-significant. This was something that was not captured in the pre-crisis VAR. Rolling window VAR shows that during 2006 (corresponding x-axis values of 38–49) something happened. Before the year 2006, the 1-month lagged returns of S&P 500 were statistically significant, whereas the 4-month lagged returns of S&P 500 were not, but during 2006, the sequence turned the other way round. In 2006, the significance of S&P 500(-4) parameter increased whereas S&P 500(-1) became non-significant, indicating that just before the crisis the 4-month lagged S&P 500 returns were yielding information that had a big impact on REIT returns. Also since the t-values in figures are in absolute values, it cannot be detected that it was the first time that the statistically significant S&P 500 parameter was negative.

The same negative phenomenon happened to S&P 500(-1) parameter in 2007 (corresponding x-axis values of 50–61), around a year after an S&P 500(-4) parameter incident. At the same time while S&P 500(-1) started to have explanatory power in REIT returns, S&P 500(-4) parameter turned into non-significant. The S&P 500(-1) parameter remained negative but statistically significant from June 2007 to November 2007 (x-axis values of 55–60). One of the possible reasons for this negative effect is examined by Sun et al. (2015) who found that the REITs with higher debt to asset ratios and shorter maturity structure of the debt fell more during the 2007 to early 2009 crisis period than underlying commercial real estate prices. They found that even though the prices rebounded back rather quickly, the cost of financial distress had a permanent effect on REIT values. Although Sun et al. (2015) were interested in leverage effects in REITs during the crisis period, it seems that the REITs are more vulnerable to leverage effects than S&P 500.

In Figure 7 the x-axis values from 79 to 86 denotes VARs which includes all of the financial crisis period months. The x-axis value of 51 denotes the first VAR that contains one month from financial crisis (VAR period of 03/2014 – 02/2007) and the x-axis value of 114 denotes the last VAR that contains a month from financial crisis (VAR period of 06/2009 – 05/2012).

The rolling window VAR results of S&P 500 returns explaining the REIT returns around financial crisis period are mostly in line with the crisis period VAR from 08/2007 to 06/2009 represented in Table 10, which suffered its relatively low amount of observations and thus encountered comparison challenges against other sub-period VARs. S&P 500(-4) and S&P 500(-6) parameters peaked around 80th observation, which denotes VARs that includes all of the financial crisis months, suggesting that the information from S&P 500 returns had statistically highly significant explanatory power in REIT returns but it took from 4 to 6 months for the effect to occur.

One additional finding that crisis period VAR did not expose is that the S&P 500(-1) parameter was non-significant for rather a short period of time. After the 70th observation, which denotes a VAR window from 10/2005 to 09/2009, the S&P 500(-1) parameter turned statistically significant, and even VARs that included all of the finance crisis months (x-axis values from 79 to 86) the S&P 500(-1) remained statistically significant and did so up until the 105th observation, stating that even under the financial distresses, 1-month lagged S&P 500 returns have explanatory power in REIT returns. These findings suggest that it is not possible to hedge against market downturns in the short-term by investing in REITs because S&P 500 plays a significant role in influencing REIT returns.

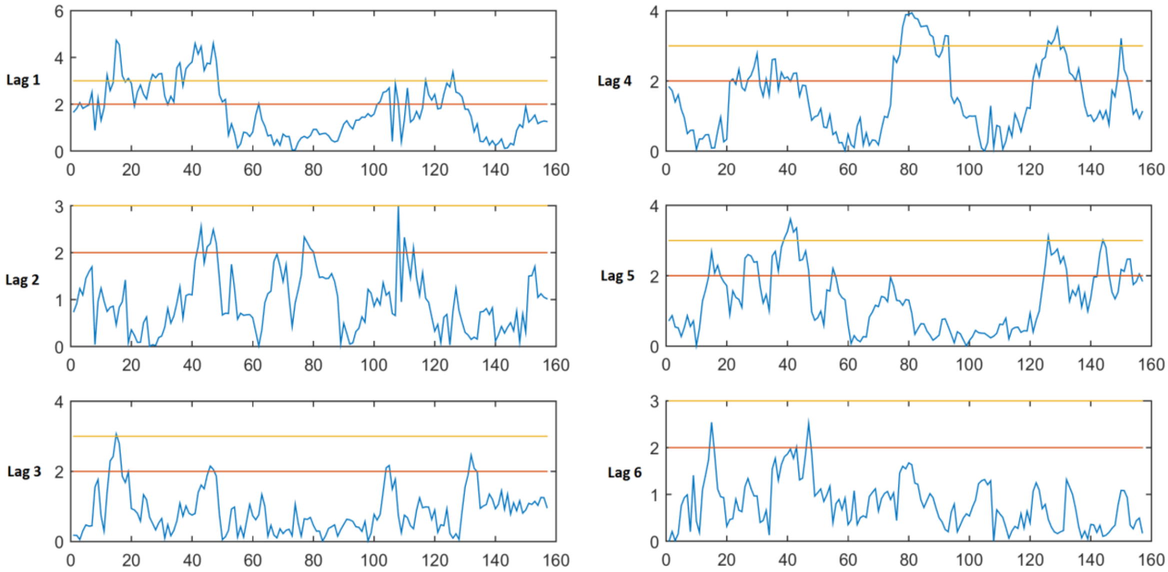

Figure 8. Rolling window VAR of 36 months. Lags of REIT returns in REIT equation

Table 17. Corresponding VAR periods to x-axis values in Figure 8

X-axis	VAR period	X-axis	VAR period
10	10/2000 - 09/2003	90	06/2007 - 05/2010
20	08/2001 - 07/2004	100	04/2008 - 03/2011
30	06/2002 - 05/2005	110	02/2009 - 01/2012
40	04/2003 - 03/2006	120	12/2009 - 11/2012
50	02/2004 - 01/2007	130	10/2010 - 09/2013
60	12/2004 - 11/2007	140	08/2011 - 07/2014
70	10/2005 - 09/2008	150	06/2012 - 05/2015
80	08/2006 - 07/2009	157	01/2013 - 12/2016

Figure 8 represents the lags of REIT returns in the REIT equation and Table 17 the corresponding VAR periods to x-axis values. It seems that before the finance crisis, REIT(-1) did have explanatory power in REIT returns, but half of the time it was only borderline significant. During the last quarter of 2011 up until the third quarter of 2013, there seem to be short periods of statistically significant relations, but, besides that, the parameter REIT(-1) does not have statistically significant explanatory power in REIT returns. There can be found cycles of significance explanatory power in REIT(-4) parameter before and during the crisis and REIT(-5) parameter before crisis, which are in line with the previous VAR estimates.

The rolling window VAR for S&P 500 equation is not displayed in the results section because it is not essential for the main purpose of this thesis, but it can be found in the appendices section. However, it seems that S&P 500(-1) did have explanatory power in S&P 500 returns during the finance crisis. Also S&P 500(-4) and REIT(-4) were statistically significant during and shortly after the crisis. In addition, the variance decomposition and Granger causality test results state clearly that the REIT returns do not explain S&P 500 returns and therefore it is not justified to make conclusions based on these statistically significant values from VAR equations.

5. Summary

In summary, there seems to be statistically significant evidence that from 2000 to 2015, the S&P500 total return index does have significant explanatory power in the REIT returns. The significance seems to be time-varying, meaning that the explanatory power has been varying during the research period. These results are consistent with the Clayton & MacKinnon (2001) and Clayton & MacKinnon (2003) findings that there exists a link between REIT and common stocks but the relationship is time-varying.

Before the finance crisis VAR results were suggesting that current REIT returns were affected by S&P 500(-1), REIT(-1), REIT(-4) and REIT(-5) parameters. The REIT parameters were negative but the S&P 500(-1) was positive. During the finance crisis, S&P 500(-1) was still positive but not statistically significant at 5% significance level. However during the crisis period the parameters REIT(-4), S&P 500(-4) and S&P 500(-6) were statistically significant in REIT equation. The REIT(-4) and S&P 500(-6) parameters were negative whilst S&P 500(-4) was positive. In the after crisis VAR, all of the lagged parameters were statistically non-significant and especially S&P 500(-1) t-value in REIT equation was extraordinarily low.

Rolling window VAR of 36 months showed that S&P 500 clearly has some explanatory power in REIT returns. This is consistent with the previous VAR results, but the rolling window exposed how time-varying these dynamics are. Before the crisis, there was evidence that the 1-month lagged returns of S&P 500 were influencing the REIT returns significantly, but during the finance crisis, this relationship was not steady. Also the 4- and 6-month lagged returns of S&P 500 had their highly significant explanatory power in REIT returns during crisis but vanished quickly after.

The reason why S&P 500 parameters were mostly positively affecting REIT returns and most of the REIT parameters were negatively affecting REIT returns might be the lead-lag effect. Lo and MacKinlay (1990) showed that stock returns are often positively crossautocorrelated and specifically almost always the returns of large-cap stocks lead to returns for smaller-cap stocks. Badrinath et al. (1995) also found that returns on the stock portfolios with the highest level of institutional ownership led to returns on stocks with lower levels of institutional ownership. Real Estate Investment Trusts have undergone major structural ownership changes after the tax legislation in 1993, which encouraged more institutional investors to make large investments in REIT industry, hence increasing the market capitalization of REIT stocks. However, REIT industry market cap and the ratio of institutional ownerships is lower compared to S&P 500 market cap and level of institutional ownership, and thus this may explain why the 1-month lagged S&P 500 returns had such high explanatory power in REIT returns. Devos et al. (2013) also found that the institutional ownership in REITs increased gradually after 2004 until peaking in the first quarter of 2008. After the peak, the institutional ownership in REITs notably decreased but shortly after rebounded back to pre-crisis levels.

The negative effect from lagged REIT returns might be explained by intra-industry lead-lag effect. Mori (2015) found that there exists a significant lead-lag relationship between the lagged returns of big REITs and the current returns of small REITs, and it has been slightly decreasing during the study period from 1986 to 2012 because of the policy and environment changes in U.S. REIT market. He also discovered that the lead-lag effect is largely caused by slow adjustment to negative information. This would explain why the lagged REIT returns are negatively affecting the current REIT returns even though the relationship is not always statistically significant. This is a logical outcome because, as Mori (2015) suggested, the negative information flows from big REITs to small REITs. Since this study uses REIT index, both big and small cap REITs are included and therefore changes in small cap REITs have less significance in the whole index.

The reason for REIT(-4) parameter being statistically significant before and during the finance crisis and REIT(-6) during the crisis can be caused by slow diffusion of value-relevant information. This is in line with Hou's (2007) findings that the lead-lag effect caused by slow information diffusion between big and small firms is mainly an intra-industry phenomenon, and the effect can be found within industries that are smaller, less competitive and less monitored, such as the REIT industry in early 2000s. Also Bley & Olson (2005) found that after a high monthly gain, REITs should be avoided for about 4 months due to their mean reversion tendencies which would expect why the REIT(-4) and REIT(-5) parameters had negative values.

Granger causality tests suggest that the S&P 500 had a significant explanatory power in REIT returns before crisis and during finance crisis, but after the finance crisis was over the Granger Cause disappeared. This is an interesting result, considering that after crisis to the end of 2015 both indices yielded relatively high returns. When the S&P 500 index was stagnating in the early 2000s because of the IT bubble and its repercussions to stock market, the REIT index was performing overwhelmingly well. This supports the notion that investors seek alternative investments when there are uncertainties in stock market, gold being typically considered a safe haven during the market turmoil. REITs started to attract investors because most of them offer a steady income by monthly or quarterly dividends and they are also more liquid than direct real estate investments. These notions are in line with the findings of Bhasin, Cole and Kiely (1997) and Ling and Naranjo (2003) that during the market downturns, such as the mild recession in the 90s and the technology stock decline in the early 2000s, investors started to desire liquid access to the real estate markets.

After the finance crisis, both indices have been performing well but the linear causality from S&P 500 returns to REIT returns is no longer present. One of the explanations might be that after the finance crisis, the U.S. government responded to the Great Recession by an economic stimulus package, and the interest rates have been historically low. There have been no good alternative investments like stocks, and the idle money needs to be invested somewhere. Now, after the crisis, there is no causal relationship between S&P 500 and REIT returns because they both are driven by other exogenous variables.

Variance decomposition results and impulse response graphs were in line with the rest of the results, suggesting that the shocks from S&P 500 caused a higher fluctuation in REIT returns before the crisis than after the finance crisis. However, during the crisis S&P 500 shocks had a huge impact and they played a significant role on REIT returns, accounting for over 45% of the REIT return fluctuation after 4 months from the S&P 500 shock. The variance decomposition results are proposing that after finance crisis, most of the fluctuations in REIT returns are caused by its own shocks and not by shocks from S&P 500.

6. Conclusions

This thesis examined the short-term dynamic relationship between REIT and S&P 500 returns from 01/2000 to 12/2015 in U.S. The main goal was to understand how REIT returns are affected by S&P 500 returns. This was achieved by using monthly total return data from January 2000 to December 2015. Firstly, the whole data sample was tested by Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests in order to test the stationarity of the data. Then the whole data was analysed by using 36-month moving correlation between the REIT and S&P 500 returns. Then in furtherance of examining the dynamic relationships, vector autoregression (VAR) model was implemented for the whole data, followed by impulse response graphs and variance decomposition in order to aid in the interpretation of a fitted VAR model. In addition, the Granger causality test was performed to test the linear predictive causality between REIT and S&P 500 returns. The effects of the finance crisis were investigated by dividing the full period data into three sub categories; before crisis, crisis and after crisis and each sub-period was analysed by VAR, impulse response graphs, variance decomposition and Granger causality tests. Finally, to support the results from VAR estimates and to avoid problems with comparing three different length sub-periods, a VAR model of 36-month rolling window was implemented. Rolling window VAR(6) model calculated 157 different VAR estimations and the parameters' absolute t-values were plotted in order to understand the short-term dynamics between the REIT and S&P500 returns more in depth.

The possible long-term relationship was also taken into account by testing the level data with Johansen (1991) cointegration test. The test suggested that even though both variables were integrated, they were not cointegrated and therefore there is not any long-term relationship between the REIT and S&P 500 returns.

The first research question to be answered was:

1. Is there a correlation between the REIT and S&P 500 returns and is it static or time-varying?

The correlation between the REIT and S&P 500 returns was tested by using a 36-month rolling window correlation throughout the whole data sample. The results showed that there is a clear correlation between REIT and S&P 500 returns and the correlation fluctuates remarkably during different economic times, suggesting that the correlation is highly time-varying. Before the finance crisis, the correlation was relatively low but it increased steadily towards crisis. The correlation was high during the financial crisis period, and even after the crisis the correlation remained at the crisis period levels for a short period of time. During the recent years, the correlation has been decreasing significantly, and during 2015, the 36-month correlation was at the lowest since the early 2003. These results indicate that during the crisis period, REIT and S&P 500 returns are highly correlated and the benefits of portfolio diversification using REIT stocks in stock portfolio during economic downturns are limited. However, during more stable economic cycles it seems that REITs are offering great diversification benefits due to their distinctive nature and rather weak correlation with S&P 500. Results are also suggesting that the correlation has decreased during recent years and therefore the benefits of using REITs in portfolio diversification have increased.

The second research question to be answered was:

2. Is there a short-run relationship between the REIT and S&P 500 returns?

The results state that there exists a short-run relationship between the REIT and S&P 500 returns. The Granger causality test shows that the past values of S&P 500 returns have information about future values of REIT returns, i.e. S&P 500 historical returns have a predictive explanatory power in REIT returns. The Granger causality test also stated that the information flows unidirectionally from S&P 500 to REIT and not the other way round.

The 1-month lagged S&P 500 returns were found to be the most significant parameter in explaining the REIT returns. Also the 4-month and 6-month lagged S&P 500 returns were found to be significant at times. This indicates that in the short run, Real Estate Investment Trusts cannot be used as a substitute to direct real estate investment in a portfolio because the S&P 500 is affecting the REIT returns significantly. However, in the long-run horizon the situation may be different since there is no long-term relationship between REIT and S&P 500 returns as Johansen cointegration test stated.

It also seems that the past values of REIT returns are yielding information about future REIT returns, but the effect was milder compared to lagged S&P 500 returns. This phenomenon might be caused by the lead-lag effect in REIT industry found by Mori (2015). He found that the there exists a significant intra-industry lead-lag effect between lagged returns of big REITs and the current returns of small REITs, which is mainly caused by slow adjustment to the negative information. Bley & Olson (2005) found that REITs should be avoided after a high monthly gain for about four months due to REITs' mean reversion tendencies. This would explain why the REIT(-4) and REIT(-5) parameters were statistically significant but negative.

The third research question to be answered was:

3. Have the dynamics between REIT and S&P 500 returns changed during the research period and how did the financial crisis affect this?

The VAR results from three sub-periods and especially the 36-month rolling VAR exposed that the relationship between REIT and S&P 500 is highly time-varying. Before the finance crisis, there was evidence that the 1-month lagged S&P 500 returns were statistically significant explaining the REIT returns, but towards the crisis, this explanatory power decreased. During the crisis, the 4-month and 6-month lagged S&P 500 returns were highly significant and it was the only time during the research period that these parameters had explanatory power in REIT returns. After the beginning of the finance crisis, the 1-

month lagged S&P 500 returns turned back to having significant explanatory power in REIT returns, but during recent years the explanatory power has been decreasing.

The impulse response and variance decomposition was also used to strengthen the short-run analysis. Shocks from S&P 500 were causing more fluctuation in REIT returns before the crisis than after crisis. During the crisis, shocks from S&P 500 were accounting for almost half of the REIT return fluctuations. After the crisis REIT returns were mostly affected by their own shocks, and it seems that the influence from S&P 500 returns decreased. Also the unidirectional Granger causality from S&P 500 to REIT vanished during the post-crisis period, suggesting that the past values of S&P 500 returns did not contain any useful information about future REIT returns. Therefore, after the finance crisis S&P 500 returns cannot be used to forecast REIT returns.

The scientific contribution of this thesis is to extend the existing literature by providing new insights into the short-term behaviour of REITs and their extraordinary nature compared to common stocks. Overall, the results are consistent with the previous literature that there exists a link between REIT and common stocks but the relationship is time varying (see Clayton & MacKinnon, 2001; Clayton & MacKinnon, 2003). Also the phenomenon of 4- and 5-month lagged REIT parameters negatively affecting today's REIT returns is in line with the Bley & Olson (2005) findings that REIT markets should be avoided for about 4 months after a large monthly gain due to REITs' mean reversion propensities. However, the new evidence suggests that shortly after the financial crisis, the strength of links between the REIT and S&P 500 returns have substantially decreased and the short-term linkages between REIT and S&P 500 are weakened. It seems that the S&P 500 influence in REIT returns is partly market-cyclically dependent, but the nature still remains challenging to generalize. In spite of that, the relationship between REIT and S&P 500 returns is now weaker than ever since 2000. The results indicates that in the short term, the Real Estate Investment Trusts should be seen as an own asset class rather than a common stock asset.

These results have two possible implications. Either the short-term linkages have momentarily reduced, or the REIT asset class maturation has come to a point, where S&P 500 does not have a significant role influencing REIT returns anymore. However, as long as REITs are traded like common stocks in the stock exchange, an unexpected exogenous shock will have a similar short-term impact on REIT returns than on other common stock returns, regardless if the underlying real estate assets are suffering by it or not.

For future research, it would be interesting to see how the dynamics between different REIT sectors and S&P 500 returns differ within the same time span. Since there are many REIT sectors, it would be fascinating to examine whether some of those are more linked to the S&P 500 than others. Also, it would be useful to see similar research done in Europe where the REIT market is still emerging and investigate whether the results are similar compared to the U.S. REIT market. Furthermore, the new approach with rolling window VAR model could be extended to include other variables such as inflation, interest rates and real estate indices to investigate the possible time-varying relationship between REIT returns and other macroeconomic variables around financial crisis and its aftermath. These results could also provide information on how much REIT returns are influenced by other macroeconomic variables during different phases of market cycles, and whether the explanatory variables are affecting REIT returns in a different manner in comparison with S&P 500 returns.

This thesis is useful for both small investors and institutions by offering valuable information about the dynamic relationship between the REIT and S&P 500 returns, which in turn can help aid and forecast the future performances of the REIT market. The decreased correlation and the no longer existing explanatory power of S&P 500 offers guidance for portfolio diversification, possibly enabling higher portfolio returns without increasing the portfolio’s volatility. One can be intrigued by how REIT industry has grown in such short time, and it will be truly fascinating to see how it develops in the future.

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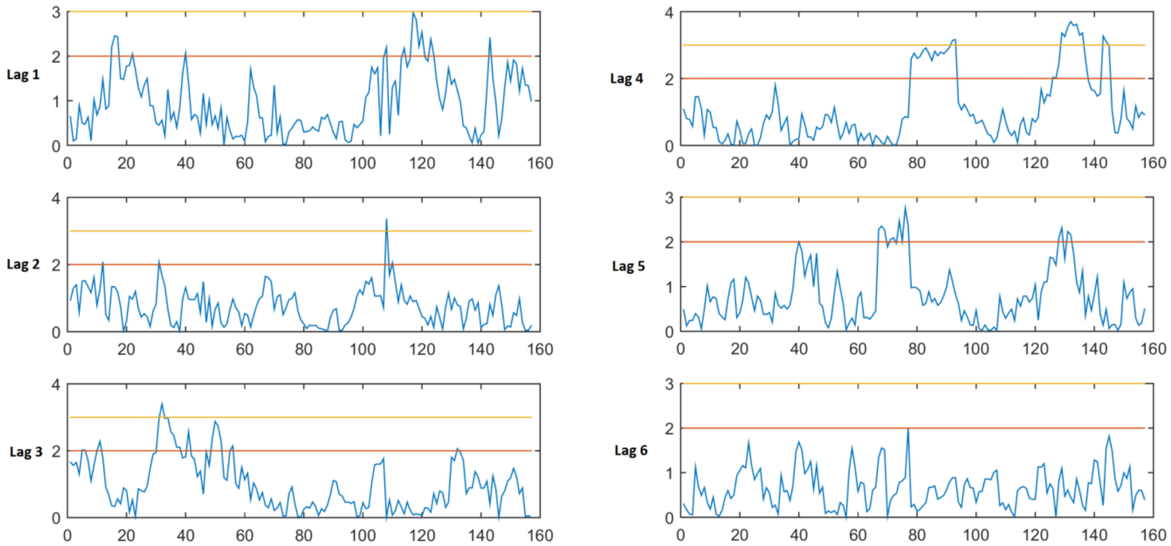
Appendices

Appendix 1. VAR lag order selection criteria for the total return data used in thesis

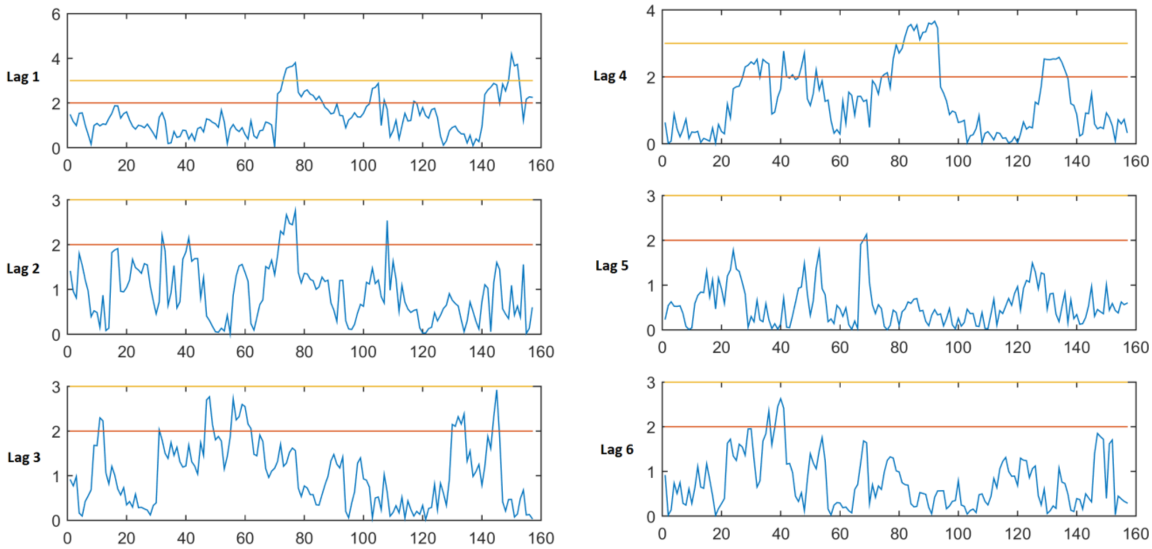
Lag	LogL	LR	FPE	AIC	SC	HQ
0	596.8914	NA	5.33e-06	-6.466211	-6.431266*	-6.452047
1	604.3398	14.65397	5.13e-06	-6.503694	-6.398859	-6.461203*
2	607.9682	7.059616	5.16e-06	-6.499655	-6.324930	-6.428837
3	613.0035	9.687448	5.10e-06	-6.510908	-6.266293	-6.411762
4	616.9221	7.453878	5.10e-06	-6.510023	-6.195518	-6.382550
5	619.3534	4.571770	5.19e-06	-6.492971	-6.108577	-6.337171
6	627.4975	15.13757*	4.96e-06*	-6.538017*	-6.083732	-6.353890
7	628.1104	1.125792	5.15e-06	-6.501200	-5.977026	-6.288746
8	628.2402	0.235671	5.37e-06	-6.459133	-5.865069	-6.218351

* Indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Appendix 2. Lags of REIT returns in S&P 500 equation



Appendix 3. Lags of S&P 500 returns in S&P 500 equation



Appendix 4. Corresponding VAR periods to x-axis values in Appendices 2 and 3.

X-axis	VAR period	X-axis	VAR period
10	10/2000 - 09/2003	90	06/2007 - 05/2010
20	08/2001 - 07/2004	100	04/2008 - 03/2011
30	06/2002 - 05/2005	110	02/2009 - 01/2012
40	04/2003 - 03/2006	120	12/2009 - 11/2012
50	02/2004 - 01/2007	130	10/2010 - 09/2013
60	12/2004 - 11/2007	140	08/2011 - 07/2014
70	10/2005 - 09/2008	150	06/2012 - 05/2015
80	08/2006 - 07/2009	157	01/2013 - 12/2016