Real Estate Market and Uncertainty Shocks: A Novel Variance Causality Approach

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Abstract

This paper investigates the impact of macroeconomic effects of uncertainty on the conditional volatility of US-listed Real Estate Investment Trusts (REITs). To this end we employ three broadly known US REITs indices and two uncertainty indices. Our sample is extensive covering the period from 4th of January 1999 to 28th of June, 2013. Employing a novel variance causality test that is robust to distributional assumptions we track the response of REITs conditional volatility to various key events as marked by the evolution of the uncertainty indices. Our results provide some useful insights for the information flow between real estate and macroeconomic environment. We provide evidence in favor of a two-way transmission channel between REITs conditional volatility and macroeconomic uncertainty. Moreover, equity REITs appear rather sensitive to deteriorating investors' sentiment. Policy implications for investors, regulators and monetary authorities are also discussed.

Keywords: Real estate investment trusts; uncertainty shocks; macroeconomy; causality; volatility impulse response function
JEL Classification: C22; C32; E52; R31

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1 – Introduction

It has long been recognized that real estate prices have registered an unprecedented growth during the 2000s. The collapse of the real estate market that followed in 2006 has been irrevocably linked to the ensuing financial turmoil and severe economic recession. Thus, understanding the causality nexus between real estate markets and the macroeconomic environment carries substantial implications both for risk management strategies and for policy making. In view of the recent global economic meltdown, academics, policy makers and researchers have become rather concerned with the interaction between the housing sector and the economy. In particular, the turbulence caused by the housing sector is severe enough to induce market participants such as financial institutions, central banks to devote a lot of effort and resources in order to map the relationship between real estate and monetary policy or other structural variables of the macroeconomic environment in general. Another important role acted by housing is that of collateral that amplifies the research interest of this sector. Literature has meaningfully highlighted that when it comes to the collapse of housing prices it is common to observe a non-negligible shrinkage in the real economic activity which in turn causes anxiety to policy makers (Iacoviello and Neri, 2010; Reinhart and Rogoff, 2008). Although policy makers and central banks have managed to tame inflation over the last three decades they were not able to insulate the economy from the creation of bubbles in the real estate market and their adverse implications. Therefore, the linkages of real estate markets with the macroeconomic setting and other capital markets have been a subject of continuing empirical investigation.

Real Estate Investment Trusts (REITs hereafter) serve as a reliable proxy for investigating the functioning of real estate markets because their assets consist of investments in real estate[1]. Since their introduction in 1960 Real Estate Investment Trusts have become a rather popular investment vehicle inside and outside the USA due to their unique characteristics. A REIT can be defined as a corporate entity that gathers available funds from individual investors and invests them in real estate. Many REITs have their shares traded in major stock exchanges. In the case of REITs, it was the first time that the benefits of commercial real estate investment were accessible to all investors other than to large financial intermediaries and to wealthy individuals that have monopolized these benefits so far. Investors recognized

[1] See Zhou and Lai (2008), Lee and Chiang (2010),

the benefits of this new investment product and almost 50 years after their launch it is estimated that U.S.-listed REITs total market capitalization amounted to more than $300 billion with an average daily trading volume of about $4 billion.

Uncertainty is generally related to events that are not predictable and are associated with low confidence. Even though uncertainty is a quite vague concept in economics and finance and can be defined/measured in many different ways[2], there is a growing strand of literature that uses uncertainty shocks in order to explain business cycles (e.g. Bloom et al., 2012) and asset pricing (e.g. Pastor and Veronesi, 2012). In this paper we investigate the impact of economic policy uncertainty shocks on real estate market providing complimentary empirical evidence to the relevant literature. Baker et al. (2013) proposed an intuitive approach to capture economic policy uncertainty developing an index which aims to capture uncertainty about economic policy decisions and their impact as perceived by newspapers as well as a news-based equity market-related economic uncertainty index.

Our analysis differs from previous studies in two ways. Motivated by the financialization of the real estate markets and the subsequent increase in their variability (Wu et al., 2011) our method allows us to pick up possible linkages that are present in the second moment of the returns distribution and not in the first. Stated differently, the time varying nature of real estate variability necessitates the use of a robust framework of testing causality. On methodological grounds, to the best of our knowledge, it is the first time in the relevant literature that we propose to combine the causality in variance tests with the volatility impulse response functions (VIRFs) introduced by Hafner and Herwarz (2006). The employed VIRFs present two important differences as compared to traditional VIRFs: they allow us to examine conditional variance and to compute conditional expectations of volatility. Second, it is the first time that we employ in this context the two uncertainty indices constructed by Baker et al. (2013) in order to capture macroeconomic effects of uncertainty following the work of Bloom (2009). Next, we extend the research findings with regards to the sensitivity of REIT returns to stock-market and economic policy related shocks to a more recent time period than in earlier studies. Along the same lines our sample spans the recent global financial crisis.

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[2] For example, Orlik and Veldkamp (2014) define macroeconomic uncertainty as "the variance of next-period GDP growth conditional on all information observed through time".

Previewing our results we document a bi-directional causality in variance between All REITs index and US Economic Policy Uncertainty Index. Apart from conducting standard variance causality tests we put forward some key macroeconomic events based on the evolution of the two uncertainty indices and track their effect on REITs conditional volatility. REITs conditional volatility seems rather responsive to different historical shocks. Deteriorating investor's sentiment affects US Equity REITs while Mortgage REITs appear less sensitive to stock market developments.

The remainder of the paper is structured as follows: Section 2 outlines the relevant literature whereas section 3 describes the dataset and the employed methodology. Section 4 provides the major findings and Section 5 concludes the paper.

2 - Literature review

The significant role of real estate markets in the stability of the financial system has long been recognized by researchers and policy makers. Therefore, the linkages of real estate markets with the macroeconomy and other capital markets have been a subject of continuing empirical investigation. One strand of literature relies on theoretical models to explore the relationship between real estate market and the macroeconomy. For example, a loose monetary policy may lead to a house price boom as documented by Ahearne et al. (2005) while two other studies (Iacoviello, 2005 and Iacoviello and Neri, 2010) show that economic activity and housing market are strongly related by means of a Dynamic Stochastic General Equilibrium (DSGE) model. Numerous studies investigate the interaction between real estate markets and the macro economy in the context of factor models. The interaction of commercial real estate returns in the US and a variety of macroeconomic risk factors under a Multifactor Asset Pricing Model was the focus of Ling and Naranjo (1997). They argued that the term structure of interest rates, the unanticipated component of inflation, the growth rate in real per capita consumption and the real Treasury bill rate exhibited the strongest effect on the commercial real estate returns. Gupta and Kabundi (2010) and Gupta et al., (2010) documented a negative response of housing returns to positive monetary shocks in the nine census divisions and the aggregate US economy, and South Africa respectively, employing a factor-augmented vector autoregressive (FAVAR) model. In the same vein of large data sets used in factor models, using a large-scale Bayesian VAR, Gupta et al., (2012a) indicated that the contractionary impact of monetary policy on US house prices (for the four census regions and the aggregate US economy) has become stronger post the financial liberalization period of 1985. Using the same framework, Gupta et al., (2012b) indicated the contractionary effect of monetary policy for not only house prices, but also home sale, housing starts and housing permits authorized for both the US and its four census regions. Bredin et al. (2007, 2011) provided evidence of a strong response of REIT returns and their volatility to unexpected monetary policy shifts in the US under a GARCH framework. Bouchouicha and Ftiti (2012) employing a dynamic coherence function examined the response of direct and indirect real estate markets to macroeconomic factors in the US and in the UK. Their main finding was that factors that drive the economic growth were also responsible for real estate prices in the US. Moreover, they concluded that there was a higher dependence between the indirect real estate indices and the macroeconomic variables both in the US and UK.

McCue and Kling (1994) after controlling for the influence of stock market on REIT return series examined their response to various macroeconomic factors. Their results showed that prices, nominal rates, output and investment all explicitly interact with the real estate prices. It should be noted that the nominal short term rate was the key driving force behind real estate prices variability. Brooks and Tsolacos (2001) explore the impact of macroeconomic and financial environment on UK real estate market through a vector autoregressive model (VAR). They concluded that unexpected inflation, and the interest rate term spread account for the most part of the variability in the property market. Ewing and Payne (2005) employed the generalized impulse response analysis as a tool of analyzing the response of US equity REIT returns to unanticipated changes in the real output growth, the inflation, the default risk premium and the stance of monetary policy. Their results revealed a negative response of REIT returns to monetary policy, economic growth and inflation whereas default risk premium was positively related to future REIT returns. Chang et al. (2011) relying on a regime-switching VAR model examined the response of REITs, housing and stock market to monetary policy. They documented a non-linear and strong response of equity REIT returns to federal funds rate and the interest rate spread. Moreover, they found that the inclusion of the real GDP growth had virtually no effect on the derived results. In the context of empirical models, Bjørnland and Jacobsen (2010) employed a structural VAR in order to investigate the response of real house prices to macroeconomic variables in small open economies namely Norway, Sweden and the UK.

Their main finding pointed to the existence of a direct effect of unexpected changes in interest rates on real estate prices. Moreover, they inferred that house prices respond directly and severely to a monetary policy shock. Similar results were depicted by Demary (2010), Ndahiriwe and Gupta (2010), and Bjørnland and Jacobsen (2013) for a number of international housing markets, as well as, the US economy.

Several researchers have employed Vector Error Correction models in order to explore the relationship between real estate market and various macroeconomic factors. For instance, Schatz and Sebastian (2009) showed that consumer prices, government bonds and unemployment rate are responsible for the long-term equilibrium in the real estate markets of UK and Germany. In particular, a positive relationship between property markets and consumer prices and government bonds emerged from their results. On the contrary, the unemployment rate exhibited a negative effect on property markets.

Another strand of literature maps its way into the interaction between real estate and various capital markets. The first study on the topic dates back to Liu et al. (1990) who provided mixed evidence as regards the relationship between US securitized real estate market and stock market. Peterson and Hsieh (1997) decomposed the returns of equity and mortgage REITs employing the known Fama-French model and a model comprising two bond market factors and three stock market factors respectively. In a related study, Allen et al. (2000) employing a sample of publicly-traded REITs documented that their returns are sensitive to long or short term interest rate changes and stock market variability. REITs sensitivity however, depends on their asset structure, financial leverage, management style and level of specialization in their portfolios. Clayton and Mackinnon (2003) reported mixed evidence with respect to the factors that drive US REIT variability. Their results reveal two different phases, one through the 1970s and 80s when REIT returns were driven by the same economic factors as large cap stocks and another in the 1990s when REIT returns were related to both small cap stock and real estate-related factors. Downs and Patterson (2005) reached the conclusion that the US REIT returns during a 20-year period from 1972 to 1991 cannot be fully reproduced by a generalized asset pricing model.

Cointegration has been another useful tool for exploring the long-term interdependence between real estate markets and capital markets. By examining the existence of a long-run equilibrium between real estate and capital markets investors can benefit in terms of portfolio diversification. Glascock et al. (2000) showed that REITs resemble more to stocks and less to bonds after the structural changes in the early 1990s. Moreover, their results indicate that there are reduced benefits of diversification by including REITs in multi-asset portfolios after 1992. On the contrary, Chaudry et al. (1999) confirmed the existence of a multivariate long-run relationship between direct investment real estate indices, the stock market, the bond market and T-Bills. Okunev and Wilson (1997) reported a non-linear relationship between US REIT and stock markets employing fractional cointegraton while standard cointegration tests failed to reveal any significant long-term relationship between the variables. Wilson et al. (1998) showed that even in the presence of a possible structural break in cointegration tests there is no long-term relationship between real estate and stock markets in US, UK and Australia. Liow and Yang (2005) provided evidence of a long memory process and short-run adjustments between securitized real estate price, stock market price and key macroeconomic factors in four Asian economies employing cointegration and fractional cointegration techniques.

The dynamic nature of the relationship between real estate and financial markets has also caught the attention of researchers. Kallberg et al. (2002) reported various regimes in the first and second moment of real estate and stock markets for eight Asian markets while Kim et al. (2007) detected a structural break in October 1980 in a multivariate system of time series model of returns on US REITs, stocks and various macroeconomic factors. Cotter and Stevenson (2006) documented an upward shift in the comovement between REIT and stocks by means of a two-variable GARCH model. Huang and Zhong (2006) employing a multivariate DCC-GARCH model concluded that the conditional correlation between REITs and US equity exhibit a positive pattern while conditional correlations for bonds and REITs ranged around zero. Other studies in this area include Case at al. (2012) who examined the conditional correlations between US stock and REIT markets and Yang et al. (2012) who applied an asymmetric generalized dynamic conditional correlation GARCH model for REITs, US stocks and bonds for the period 1999-2008.

3 - Data and Methodology

3.1 - Data

We employ daily returns for the US REITS from 4th of January, 1999 up to 28th of June, 2013 using the official All REITs index. REITs are grouped in two categories namely equity and mortgage trusts. The most common type is equity REITs whose main purpose is the ownership and operation of income-generating real estate. On the other hand mortgage REITs mostly earn their revenues through real estate financing. Equity REITs comprise those firms that own, manage and lease investment-grade commercial real estate. In order to qualify as a REIT a company must keep 75 percent or more of its gross invested book assets in real property and pay out at least 90 percent of its taxable income to its shareholders at an annual basis. Due to their differences in asset structure we choose to examine equity as well as mortgage REITS separately and for this reason we employ the Equity REITs index and the Mortgage REITs index respectively. Data were retrieved from the official site of the National Association of Real Estate Investment Trusts (NAREIT).[3]

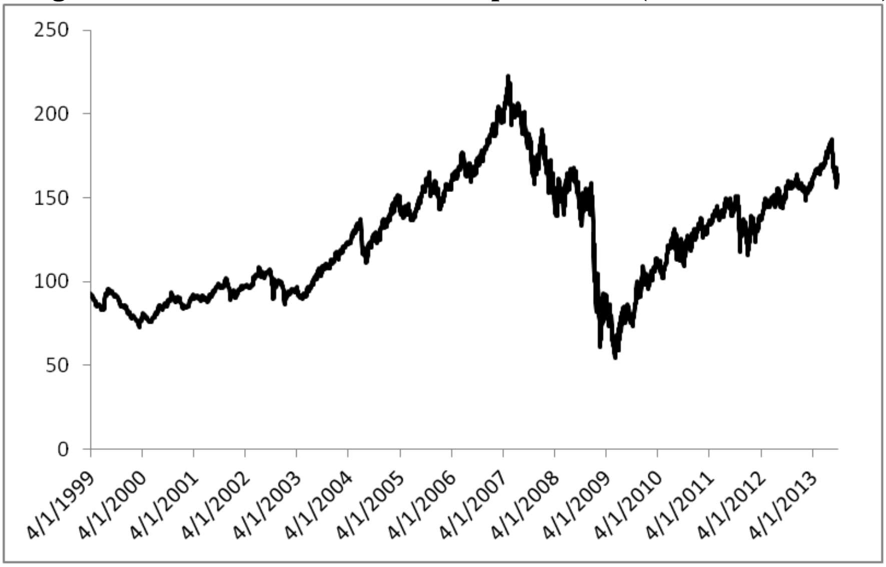
Two indices are also employed in order to capture information that is conveyed in the economic policy uncertainty in the US market. The US Policy Uncertainty index is constructed by Baker et al. (2013) and measures the US policy-related economic uncertainty having three components based on the economic uncertainty newspaper coverage that is related to policy, the federal tax code provisions that are about to expire in the future years and finally the disagreement that exists among economic forecasters. Moreover, the Equity Market Uncertainty Index is used in order to capture the US equity market economic uncertainty based on news articles with uncertainty related terms. It has to be mentioned that the Equity Market Uncertainty Index correlation with the US Implied Volatility Index (VIX index), a widely used uncertainty/fear indicator, exceeds 0.5 using monthly data.[4] The uncertainty indices' data were derived from the Economic Policy Uncertainty website.[5] Finally, it should be noted that the logarithmic values of the two uncertainty indices were employed.

Figure 1 plots the evolution of the All REITs price index for the period of analysis. The evolution of the All REITs index could be arbitrarily divided into three distinct phases, two upward and one downward. The index reached its highest levels in July of 2007 before the first signs of the imminent crisis became evident. The index saw its lowest value in March 2009 following the repercussions of the subprime mortgage crisis. However, as it can be seen from Figure 1, by the mid of 2013 the index has gradually

[3] Data available at http://www.reit.com/.
[4] See http://www.policyuncertainty.com/equity_uncert.html.
[5] Data available at http://www.policyuncertainty.com/.

regained part of investors' confidence as US economy strives to turn to positive growth rates.

Figure 1: Evolution of the All REITs price index (4/1/1999-28/6/2013)



Source: National Association of Real Estate Investment Trusts (NAREIT)

3.2 – Methodology

Understanding the causal nexus in second-order moment guides us into the joint dynamics of the variables under consideration especially during turbulent periods when volatility increases. Hafner and Herwartz (2006) have developed a variance causality test that is superior to earlier tests introduced by Cheung & Ng (1996) and Hong (2001) and were based on cross correlation functions (CCF) of GARCH standardized residuals. Conducting a battery of tests Hafner and Herwartz (2006b) have showed that their method alleviates inherent problems of Portmanteau type tests especially in cases of leptokurtic distributions. Moreover, as Hafner and Herwartz (2006b) convincingly point out the accuracy of the CCF test is strongly dependent on the lead-lag choice. Therefore, in this section, we start with the Lagrange Multiplier (LM) test for non causality in variance of Hafner and Herwartz (2006a). Then, we provide a brief description of the volatility impulse response method of Hafner and Herwartz (2006b) to analyze the persistence of the volatility shocks.

3.2.1 - Causality in variance test

Recently, Hafner and Herwartz (2006a) introduced a Lagrange Multiplier (LM) test for causality in variance. This test constitutes an adaptation of the misspecification testing framework in univariate GARCH models, introduced by Lundbergh and Terasvirta (2002).

To test the null hypothesis y_{it} does not cause in variance y_{jt} for $i, j = 1,2$ and $i \neq j$, Hafner and Herwartz (2006a) consider the model:

$$h_{it} = c_i + a_i \varepsilon_{it-1}^2 + b_i h_{it-1} \tag{1}$$

Where ε_{it} is the residuals from GARCH model with $\varepsilon_{it} = \xi_{it}(h_{it} g_t)^{1/2}$, $g_t = 1 + s_{jt}^{'}\theta$, $s_{jt} = (\varepsilon_{jt-1}^2, h_{jt-1})^{'}$, $\theta \geq 0$ and ξ_{it} is a sequence of *iid* random variables with zero mean and unit variance.

The null hypothesis of the LM test to ensure the non causality in variance is $H_0 \colon \theta = 0$.

Hafner and Herwartz (2006a) propose the following LM test statistic to determine the causality in variance:

$$LM = \frac{1}{4T} \left(\sum_{t=1}^{T} \left(\xi_{it}^2 - 1\right) s_{jt}^{'}\right) V^{-1}(\beta_i) \left(\sum_{t=1}^{T} \left(\xi_{it}^2 - 1\right) s_{jt}\right) \tag{2}$$

Where

$$V(\beta_i) = \frac{l}{4T} \left(\sum_{t=1}^{T} s_{jt} s_{jt}^{'} - \sum_{t=1}^{T} s_{jt}\, z_{jt}^{'} \left(\sum_{t=1}^{T} z_{jt}\, z_{jt}^{'}\right)^{-1} \sum_{t=1}^{T} z_{jt} s_{jt}^{'}\right),$$

$l = \frac{1}{T} \sum_{t=1}^{T} (\xi_{it}^2 - 1)^2$, $z_{it} = \frac{1}{h_{it}} \left(\frac{\partial h_{it}}{\partial \beta_i}\right)$ and $\beta_i = (c_i, a_i, b_i)^{'}$.

The LM statistic follows asymptotically a chi-square distribution with two degree of freedom.

3.2.2 - Volatility impulse response function

The Volatility Impulse Response Function (VIRF), introduced by Hafner and Herwartz (2006b), was based on an alternative multivariate GARCH representation. The VECH-representation of multivariate GARCH (p,q) introduced by Engle and Kroner (1995), is given by:

$$vech(\Sigma_t) = c + \sum_{i=1}^{q} A_i vech(\varepsilon_{t-i} \varepsilon_{t-i}^{'}) + \sum_{j=1}^{p} B_i vech(\Sigma_{t-j}) \tag{3}$$

Where $vech(.)$ is an operator that stacks the lower triangle of an $N \times N$ matrix to a $N(N+1)/2\ \times 1$ vector. Σ_t is the conditional covariance matrix at time t, A_i and B_i are $N(N+1)/2 \times N(N+1)/2$ parameters matrices and c is a $N(N+1)/2$ vector.

After estimating the multivariate GARCH model in equation (3), the Volatility Impulse Response Function (VIRF) of Hafner and Herwartz (2006b) can be computed. In fact, the Generalized Impulse Response Functions (GIRFs) introduced by Koop et al. (1996) trace the effects of independent shocks on conditional mean. However, the VIRFs of Hafner and Herwartz (2006b) trace the effects of independent shocks on conditional variance.

The VIRF of Hafner and Herwartz (2006b) is defined as follows:

$$V_h(\xi_t, I_{t-1}) = E[vech(\Sigma_{t+h})|\xi_t, I_{t-1}] - E[vech(\Sigma_{t+h})|I_{t-1}] \qquad (4)$$

Where ξ_t is a specific shock hitting the system at date t, I_{t-1} is the observed history up to *t-1* and h is the forecast horizon. Hence, The VIRF is conditional on the initial shock and history (ξ_t and I_{t-1}), and constructs the response by averaging out future innovations given the past and present.

The VIRF can easily be computed recursively based on the following relations:

$$V_1(\xi_t, I_{t-1}) = A_1\{vech\left(\Sigma_t^{\frac{1}{2}}\xi_t\xi_t'\Sigma_t^{\frac{1}{2}}\right) - vech(\Sigma_t)\} \qquad (5)$$

$$V_h(\xi_t, I_{t-1}) = (A_1 + B_1)V_{h-1}(\xi_t,) \qquad (6)$$

The VIRF has two main properties compared to the traditional Impulse Response Function (IRF). First, the VIRF is an even function of the initial shock, that is $V_h(\xi_t, I_{t-1}) = V_h(-\xi_t, I_{t-1})$, contrary to impulse response that are odd functions of the initial shock. Second, the IRF is homogenous of any degree whereas which is not the case for the VIRF.

4 - Empirical results

4.1 - Descriptive statistics and unit root tests

In this section we provide some descriptive statistics of the employed variables. In particular we present information on the mean, the maximum and minimum, the skewness coefficient, the kurtosis coefficient and the Jarque-Bera (J.B.) normality test. From a quick glimpse of Table 1 we can infer that Mortgage REITs had a negative, though small in magnitude, average return during the analyzed period whereas Equity REITs exhibited a weak positive return. It is worth mentioning that Mortgage REITs experienced larger variability compared to Equity REITs as it is revealed from Maximum and Minimum values. As for the normality hypothesis it is clear that none of the employed variables satisfies the conditions for a bell-shaped distribution. This finding clearly justifies the use of the robust variance causality test.

Table 1: Summary of basic descriptive statistics for REITs returns

	Mean	Max.	Min.	Skew.	Kurt.	JB
All REITS	0.0001	0.1623	-0.2054	-0.1692	20.9055	*0.0000*
All equity REITs	0.0002	0.1687	-0.2153	-0.1841	21.2357	*0.0000*
Mortgage REITs	-0.0003	0.3859	-0.3869	-0.0221	80.5831	*0.0000*

Notes: Notes: This table report descriptive statistics of the employed variables namely the mean, the maximum and minimum, the skewness coefficient, the kurtosis coefficient and the Jarque-Bera (J.B.) normality test. Italic values in the table are the p-values for the Jarque-Bera test that examines the null hypothesis of normal distribution.
*, ** and *** indicates significance at the 10%, 5% and 1% level of significance, respectively.

Before we proceed with the causality analysis and in order to avoid spurious results we conduct unit root tests using daily prices of all variables for the time period from February 1990 to September 2013. Table 2 reports statistics for the Augmented Dickey Fuller (ADF) and Phillips-Perron (1988, PP) unit root tests. Estimation results suggest that, as expected, the first differences of the REITs variables, namely All REITs, Equity and Mortgage category are stationary (integrated of order 0) at 1% significance level. The stationarity hypothesis is robust across ADF and PP tests and for the cases with a constant and with both a constant and a trend. As for the two uncertainty indices (Economic Policy Uncertainty-EPU and Equity Market Uncertainty-EMU) the tests indicate the absence of a unit root in the levels of the indices.

Table 2: Unit root tests

		Trend and Intercept		Intercept		Conclusion
		Level	1st Difference	Level	1st Difference	
All REITS Index	ADF	0.6760	0.0000***	0.5063	0.0000***	
	PP	0.6360	0.0001***	0.4895	0.0001***	**I(1)**
All equity	ADF	0.6409	0.0000***	0.5621	0.0000***	
	PP	0.5967	0.0001***	0.5409	0.0001***	**I(1)**
Mortgage	ADF	0.8578	0.0001***	0.8147	0.0001***	
	PP	0.7409	0.0001***	0.7789	0.0001***	**I(1)**
Equity index	ADF	0.0000***	---------	0.0000***	----------	
	PP	0.0000***	--------	0.0001***	---------	**I(0)**
Policy index	ADF	0.0000***	-------	0.0000***	--------	
	PP	0.0000***	------	0.0001***	-------	**I(0)**

Notes: This table reports the results for the augmented Dickey Fuller (ADF) and Phillips-Perron (PP) (1988) unit root tests. *, ** and *** indicates significance at the 10%, 5% and 1% level of significance, respectively.

4.2 - Causality analysis

As already stated, in the context of the present study we adopt the Hafner and Herwartz (2006a) Lagrange Multiplier (LM) test of causality in variance. The empirical results are presented in Table 3. The null hypothesis that one variable does not cause in variance another (Column 1) is evaluated against the alternative using the Lagrange Multiplier test (LM,- Column 2) and the relevant probability (p-value-Column 3) computed as explained in earlier section. In general our results are in favor of a strong interdependence between the returns of indirect real estate investment and the developments pertaining to economic policy decisions and overall stock market situation. The null hypothesis that Economic Policy Uncertainty Index (EPU) does not cause in variance REITs returns (All REITs index) is rejected at 5% significance level. Moreover, investors’ sentiment as proxied by the Equity Market Uncertainty Index (EMU) appears to play a pivotal role for indirect real estate investment returns since again we cannot reject the null hypothesis that Equity Market Uncertainty Index does not cause in variance All REITs index. In particular if we turn our attention to fourth line column 1 of Table 3 we note that the null hypothesis that All Equity REITs does not granger cause in variance the Equity Market Uncertainty Index is rejected with a very low probability ($3.95x10^{-8}$) and the same holds for the other way around since the null hypothesis that Equity Market Uncertainty Index does not granger cause in variance All Equity REITs is rejected at 5% significance level (p value equals 0.0373).

However, when we examine the effect of investors' sentiment separately on equity and mortgage REITs the picture is not the same. Our point is that mortgage REITs due to their unique asset structure and characteristics are not affected by overall stock market conditions. Related to the above, there are studies (see inter alia Liang et al., 1995; Allen and Madura, 2000) suggesting that mortgage values are considered to be less vulnerable to stock-market movements than equity investments in real estate. At this point it is worth mentioning that our findings indicate that, as expected, there is a bi-directional causality in variance between the All Equity REITs category and the Equity Market Uncertainty Index. This finding confirms the view that the developments in the real estate sector track the behavior and expectations of stock market participants and vice versa. Consistent with the findings of Ewing and Payne (2005) and Bredin et al. (2007) we also document a sensitivity of the returns of Real Estate Investment Trusts (All REITs Index) to the US Policy Uncertainty index. It has long been recognized that economic policy issues may affect the real estate sector through various channels. For example monetary policy and changes in monetary policy (see inter alia Ewing and Payne, 2005; Simo-Kengne et al., 2013) have been responsible for lower than expected returns for the real estate investment trusts.

Table 3: Causality in variance results

Null hypothesis	LM	p-value	Null hypothesis	LM	p-value
All REIT ↛EMU	33.9193	4.31×10^{-8} ***	EMU ↛ All REIT	7.0618	0.0293 **
All REIT ↛EPU	5.6637	0.0589 *	EPU ↛ All REIT	8.4314	0.0148 **
All Equity ↛EMU	34.0945	3.95×10^{-8} ***	EMU ↛ All Equity	6.5755	0.0373 **
All Equity ↛EPU	5.4938	0.0641 *	EPU ↛ All Equity	8.0179	0.0181 **
Mortgage ↛EMU	23.8892	6.49×10^{-6} ***	EMU ↛ Mortgage	0.3388	0.8442
Mortgage ↛EPU	0.7549	0.6856	EPU ↛ Mortgage	4.0398	0.1227

Notes: This table reports the results of the Hafner and Herwartz (2006a) Lagrange Multiplier (LM) test of causality in variance. EPU stands for Economic Policy Uncertainty Index and EMU stands for Equity Market Uncertainty. Null hypothesis is that the one variable does not cause in variance another. Column 2 reports the value of the Lagrange Multiplier (LM) test statistic and Column 3 the relevant p-value.
*, ** and *** indicates significance at the 10%, 5% and 1% level of significance, respectively.

4.3 - Volatility Impulse Response Analysis

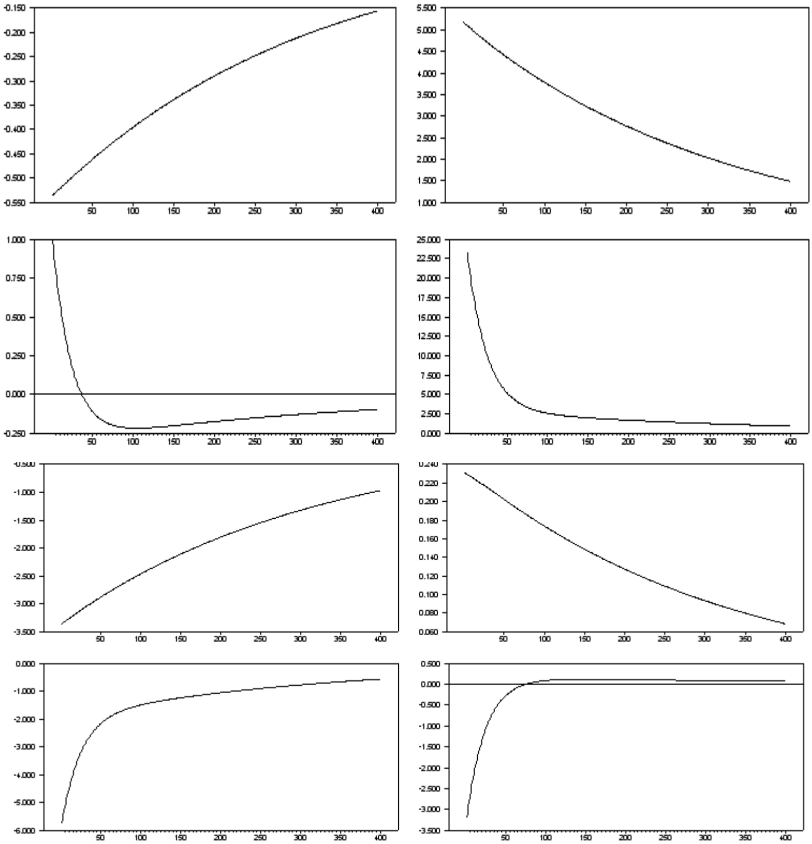
Having established some causality patterns between the variables in what follows we illustrate the Volatility Impulse Response Functions (VIRFs) introduced by Hafner and Herwartz (2006b) that uncover the effects of independent shocks on the conditional variance of the employed variables. To this end we have identified specific dates that are linked to times of turbulence in the US based on the recorded values of the US Economic Policy Uncertainty Index and Equity Market Uncertainty Index. It is evident that the higher the values for the index the greater the uncertainty for the future economic prospects. For example, the US Economic Policy Uncertainty Index registered its highest value at July of 2007 whereas for the Equity Market Uncertainty Index the peak values are registered at September of 2001 and at September of 2008, respectively. Moreover, we examine the response of REITs' conditional variance to three important shocks namely a large interest rate cut stimulus that occurred at December of 2007, the collapse of Lehman Brothers and the launching of Trouble Asset Relief Program (TARP) at September of 2008 and the recent banking crisis and US President Obama's election at January of 2009. Figures 2 to 5 plot the Volatility Impulse

Response Functions that have been computed for the returns of the three REIT categories namely All REITs, Equity and Mortgage after specific economic and stock market-related shocks.

From the first row of Figure 2, left hand panel we observe that the shock of the large interest rates cut stimulus is negative with a declining rate. Turning to the right hand panel of Figure 2 it is clear that the shock from the collapse of Lehman Brothers to REITs market is strongly positive dampening slowly to zero. As the shock is strongly positive the effect emerges not only in the variances but also in the covariance. Again in Figure 3 we observe that the deterioration of investor’s sentiment especially after the collapse of Lehman (September of 2008) causes a positive shock to REITs volatility that is highly persistent.

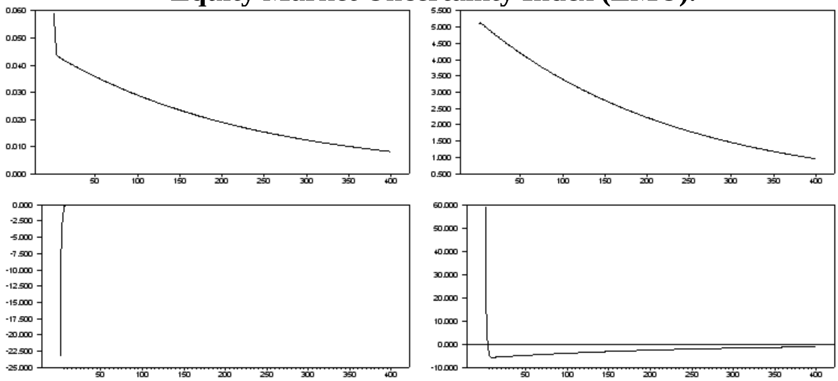
Next, Figures 4 and 5 track the response of REITs individual categories namely Equity and Mortgage to shocks identified by the behavior of US Economic Policy Uncertainty Index and US Equity Market Uncertainty Index respectively. From the first row of the left hand panel of Figure 5 we observe that the shock of the announcement of large interest rate cuts to Mortgage REITs conditional variance is negative but quickly converges to equilibrium. On the other hand Figure 4 confirms the sensitivity of Equity REITs returns to the stock market developments that has been widely documented in the literature (see inter alia Allen and Madura, 2000). In fact, the volatility impulse responses begin from a high positive level, slowly abating to lower levels.

Figure 2: Volatility impulse response functions of All REITs Index returns for four historical shocks marked by the evolution of the US Economic Policy Uncertainty Index (EPU).



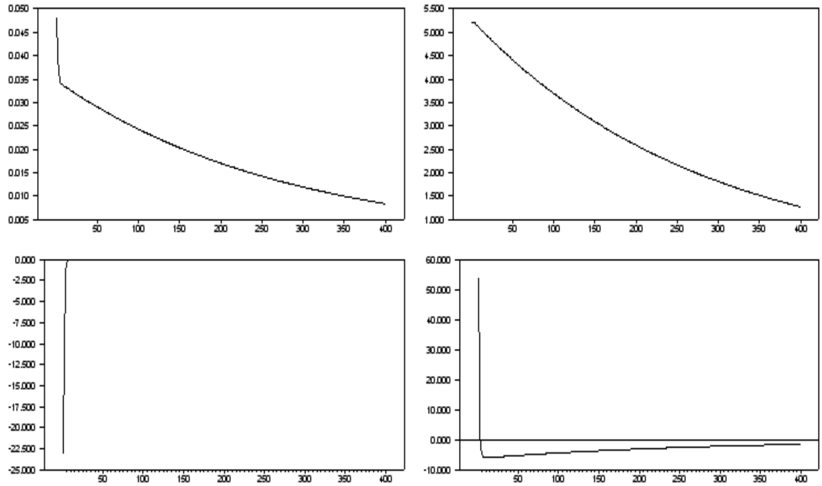
Notes: Upper left panel: shock on December 31, 2007. Upper right panel: Shock on September 30, 2008. Lower left panel: January 20, 2009. Lower right panel: July, 25 2011. The first row indicates the All REITs Index returns variance while the second row indicates the covariance between All REITs Index returns and the US Economic Policy Uncertainty Index (EPU).

Figure 3: Volatility impulse response functions of All REITs Index returns for two historical shocks marked by the evolution of the US Equity Market Uncertainty Index (EMU).



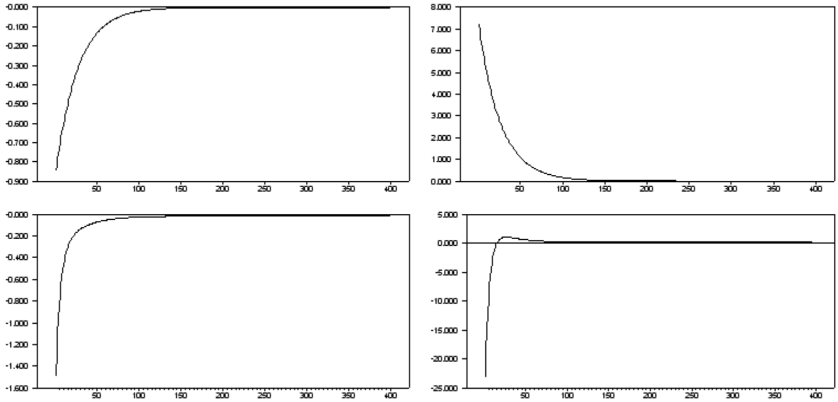
Notes: Left panel: shock on September 21, 2001. Right panel: Shock on September 30, 2008. The first row indicates the All REITs Index returns variance while the second row indicates the covariance between All REITs Index returns and the US Equity Market Uncertainty Index (EMU).

Figure 4: Volatility impulse response functions of Equity REITs Index returns for two historical shocks marked by the evolution of the US Equity Market Uncertainty Index (EMU).



Notes: Left panel: shock on September 21, 2001. Right panel: Shock on September 28, 2008. The first row indicates the Equity REITs Index returns variance while the second row indicates the covariance between Equity REITs Index returns and the US Equity Market Uncertainty Index (EMU).

Figure 5: Volatility impulse response functions of Mortgage REITs Index returns for two historical shocks marked by the evolution of the US Economic Policy Uncertainty Index (EPU).



Notes: Left panel: shock on December 31, 2007. Right panel: Shock on September 30, 2008. The first row indicates the Mortgage REITs Index returns variance while the second row indicates the covariance between Mortgage REITs Index returns and the US Economic Policy Uncertainty Index (EPU).

4.4 - Multivariate volatility analysis through a BEKK GARCH Model

The model which is in effect restricted version of the VEC model has been introduced in order to ensure that the variance covariance matrix H_t is positive definite. Engle and Kroner (1995) have proposed the basic representation of the BEKK model:

$$H_t = \Omega\Omega' + \sum_{j=1}^{q} A_j \varepsilon_{t-j}\varepsilon'_{t-j} A'_j + \sum_{i=1}^{p} B_i H_{t-1} B'_i \qquad (7)$$

where Aj,Bi and Ω are all NxN parameter matrices and Ω is a lower triangular matrix. Positive definiteness of variance covariance matrix Ht is ensured by decomposing the constant term into the product of two triangular matrices.

Due to the large number of parameters that need to be estimated we restrict our attention to the first order model BEKK(1,1) which takes the following form:

$$H_t = \Omega\Omega' + \mathrm{A}\ \varepsilon_{t-1}\varepsilon'_{t-1}\mathrm{A}'_j + \mathrm{B}\ H_{t-1}\mathrm{B}' \qquad (8)$$

A more simplified model that does not require the estimation of too many parameters is derived if we assume in the above equation that both A and B are diagonal matrices. The resulted model is called diagonal BEKK and has been proposed by Bollerslev, Engle, and Wooldridge (1988). The main advantage is that the number of parameters decreases to N(N+1)/2+2N without questioning the positive definiteness of Ht.

The parameter estimates of the diagonal BEKK (1,1) GARCH model under a multivariate Student's t distribution reported in Table 46. Significant time–varying conditional volatility is observed for all the cases under examination Moreover strong own–volatility spillovers are present in all the bivariate settings while cross-volatility spillovers are obvious for the cases of All REITs EMU, Equity REITs EMU and Mortgage REITs EMU. These findings are in line with the causality analysis conducted in the previous section.

The conditional correlation plots drawn from the Diagonal BEKK are plotted in Figures 6-11.

[6] The recovered conditional variances come from stable GARCH (1,1) models and details of these results are available upon request from the authors.

Table 4: Parameter estimates of Diagonal BEKK(1,1) under Multivariate Student's t Distribution

All REITs vs. EMU			**All REITs vs. EPU**		
Parameter	**Coefficient**	**t-stat**	**Parameter**	**Coefficient**	**t-stat**
α_1	0.359***	16.80	α_1	0.362***	16.70
α_2	0.258***	4.26	α_2	0.090***	13.40
β_1	0.932***	123.20	β_1	0.931***	119.80
β_2	0.264**	1.96	β_2	0.996***	1682.00
ω_1	0.001***	8.10	ω_1	0.001***	8.22
ω_2	-0.212**	-2.27	ω_2	-0.002	-0.59
ω_3	0.779***	22.98	ω_3	0.011**	2.38
Equity REITs vs. EMU			**Equity REITs vs. EPU**		
Parameter	**Coefficient**	**t-stat**	**Parameter**	**Coefficient**	**t-stat**
α_1	0.361***	16.78	α_1	0.364***	16.61
α_2	0.257***	4.25	α_2	0.09***	13.36
β_1	0.931***	121.80	β_1	0.931***	118.00
β_2	0.239*	1.68	β_2	0.996***	1675.00
ω_1	0.001***	7.99	ω_1	0.001***	8.06
ω_2	-0.221**	-2.25	ω_2	-0.003	-0.65
ω_3	0.784***	23.19	ω_3	0.011**	2.37
Mortgage REITs vs. EMU			**Mortgage REITs vs. EPU**		
Parameter	**Coefficient**	**t-stat**	**Parameter**	**Coefficient**	**t-stat**
α_1	0.425***	13.53	α_1	0.441***	14.14
α_2	-0.256***	-3.93	α_2	0.098***	12.97
β_1	0.884***	55.39	β_1	0.879***	52.79
β_2	-0.228	-0.78	β_2	0.995***	1464.00
ω_1	0.003***	9.22	ω_1	0.003***	8.84
ω_2	-0.245***	-2.92	ω_2	0.001	0.38
ω_3	0.8 24***	1 0.04	ω_3	0.0 14***	3 .18

Notes: This table reports the parameter estimates of Diagonal BEKK(1,1) under Multivariate Student's t Distribution Where $\Omega=\begin{bmatrix}\omega_1 & \\ \omega_2 & \omega_3\end{bmatrix}$, $A=diag(\alpha_1,\alpha_2)$ and $B=diag(\beta_1,\beta_2)$. EPU stands for Economic Policy Uncertainty Index and EMU stands for Equity Market Uncertainty. *, ** and *** indicates significance at the 10%, 5% and 1% level of significance, respectively.

Figure 6: Correlation of All REITs and EMU of Diagonal BEKK model under Multivariate Student's t Distribution

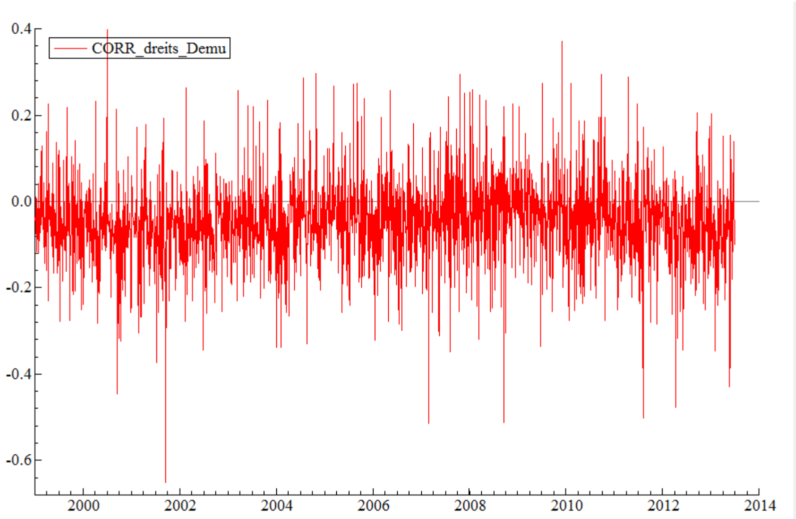


Figure 7: Correlation of All REITs and EPU of Diagonal BEKK model under Multivariate Student's t Distribution

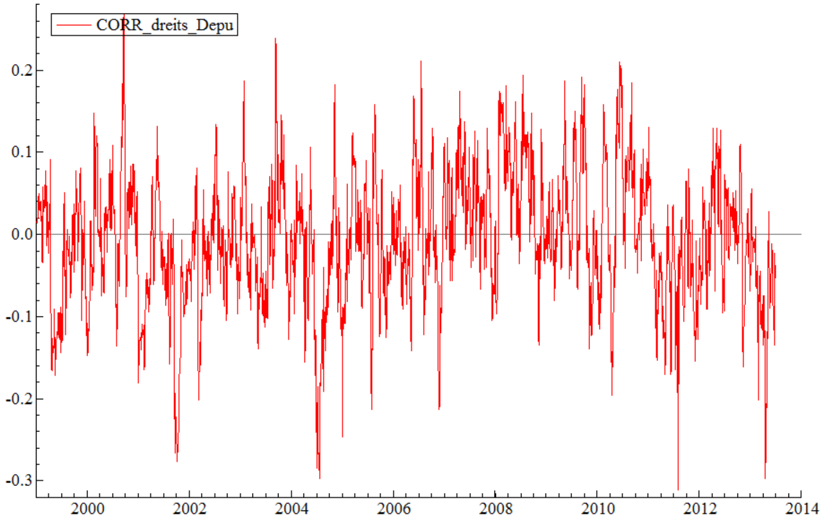


Figure 8: Correlation of Equity REITs and EMU of Diagonal BEKK model under Multivariate Student's t Distribution

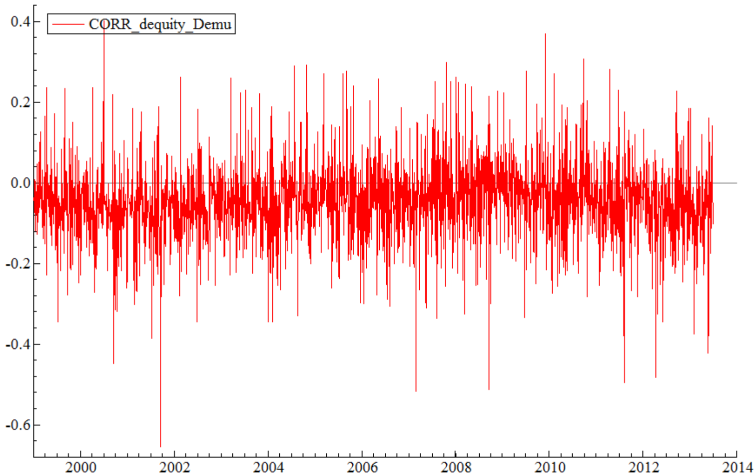


Figure 9: Correlation of Equity REITs and EPU of Diagonal BEKK model under Multivariate Student's t Distribution

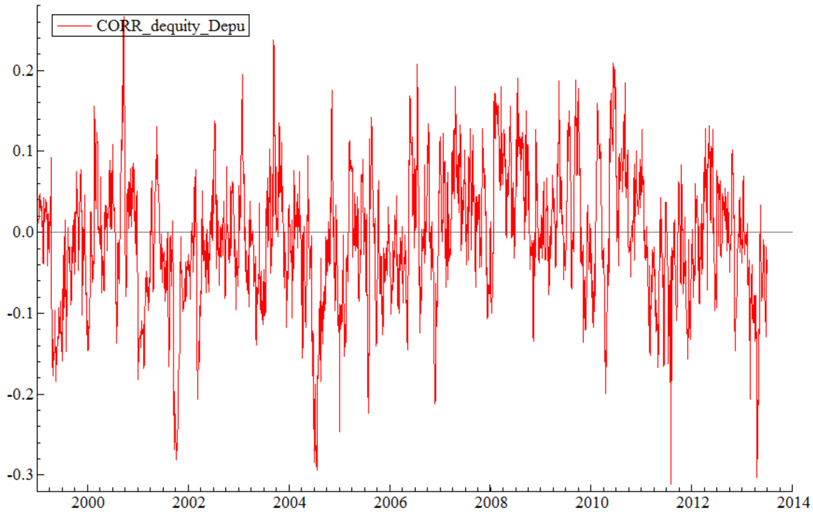


Figure 10: Correlation of Mortgage REITs and EMU of Diagonal BEKK model under Multivariate Student's t Distribution

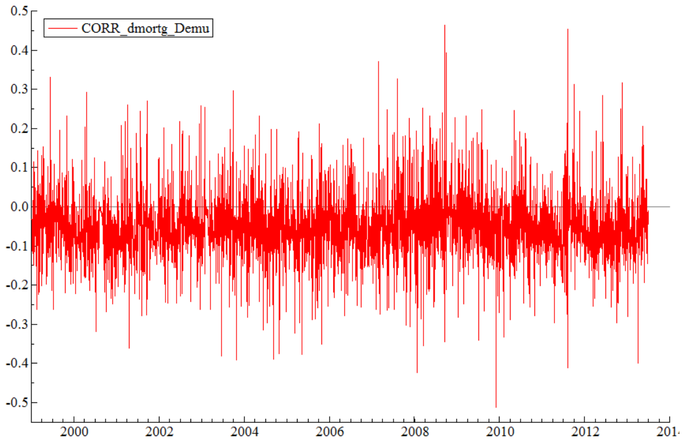
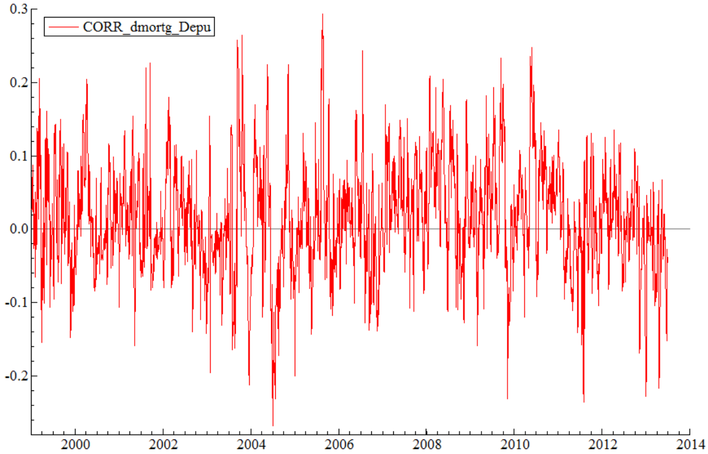


Figure 11: Correlation of Mortgage REITs and EPU of Diagonal BEKK model under Multivariate Student's t Distribution



5 – Conclusion

This paper, to the best of our knowledge, is the first one to explore the sensitivity of US-listed Real Estate Investment Trusts to stock market-related and macroeconomic shocks by employing the information conveyed in the US Equity Market Uncertainty Index and the US Economic Policy Uncertainty Index. The data employed cover an extensive period and run from the 4^{th} of January, 1999 until the 28^{th} of June, 2013. It is worth mentioning that all previous studies that examine the response of REITs to macroeconomic environment relied on specific variables such as interest rates, output, inflation, industrial production etc. (for a good review see inter alia Simo-Kengne et al.,2014).

In terms of methodology, in the context of the present study we adopt the newly developed Hafner and Herwartz (2006a) Lagrange Multiplier (LM) test of causality in variance. This test constitutes an adaptation of the misspecification testing framework in univariate GARCH models. In addition to causality tests we compute the Volatility Impulse Response Functions (VIRFs) introduced by Hafner and Herwartz (2006b) that unveil the effects of a series of predetermined independent shocks on the conditional variance of the employed variables. The VIRF is an even function of the initial shock contrary to impulse response that is an odd function of the initial shock. Also, the IRF is homogenous of any degree which is not the case for the VIRF. We have identified dates which are treated as shocks to economy-wide uncertainty as measured by the two indices. In this way, by examining how various macroeconomic and stock market shocks affect REIT returns, this paper enhances the strand of literature that has examined the importance of structural parameters. This paper has established second order causality patterns between the Real Estate Investment Trusts and the two uncertainty indices along with the persistence of shocks on REIT returns.

The key findings of the paper can be summarized as follows. We document evidence of a strong interdependence between the returns of Real Estate Investment Trusts and the developments pertaining to economic policy decisions and overall stock market situation. It seems that there is a two way causality in variance between the All Equity REITs category and the Equity Market Uncertainty Index. However, our evidence suggests that mortgage REITs due to reasons that might be related to their unique asset structure and characteristics are not affected by overall stock market conditions. REITs conditional volatility seems rather responsive to different historical shocks.

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