Modeling REIT Returns with Macroeconomic, Monetary Policy and Financial Variables in the Frameworks of Structural Break and Regime-Switching VAR: Evidence from the USA and the UK

by

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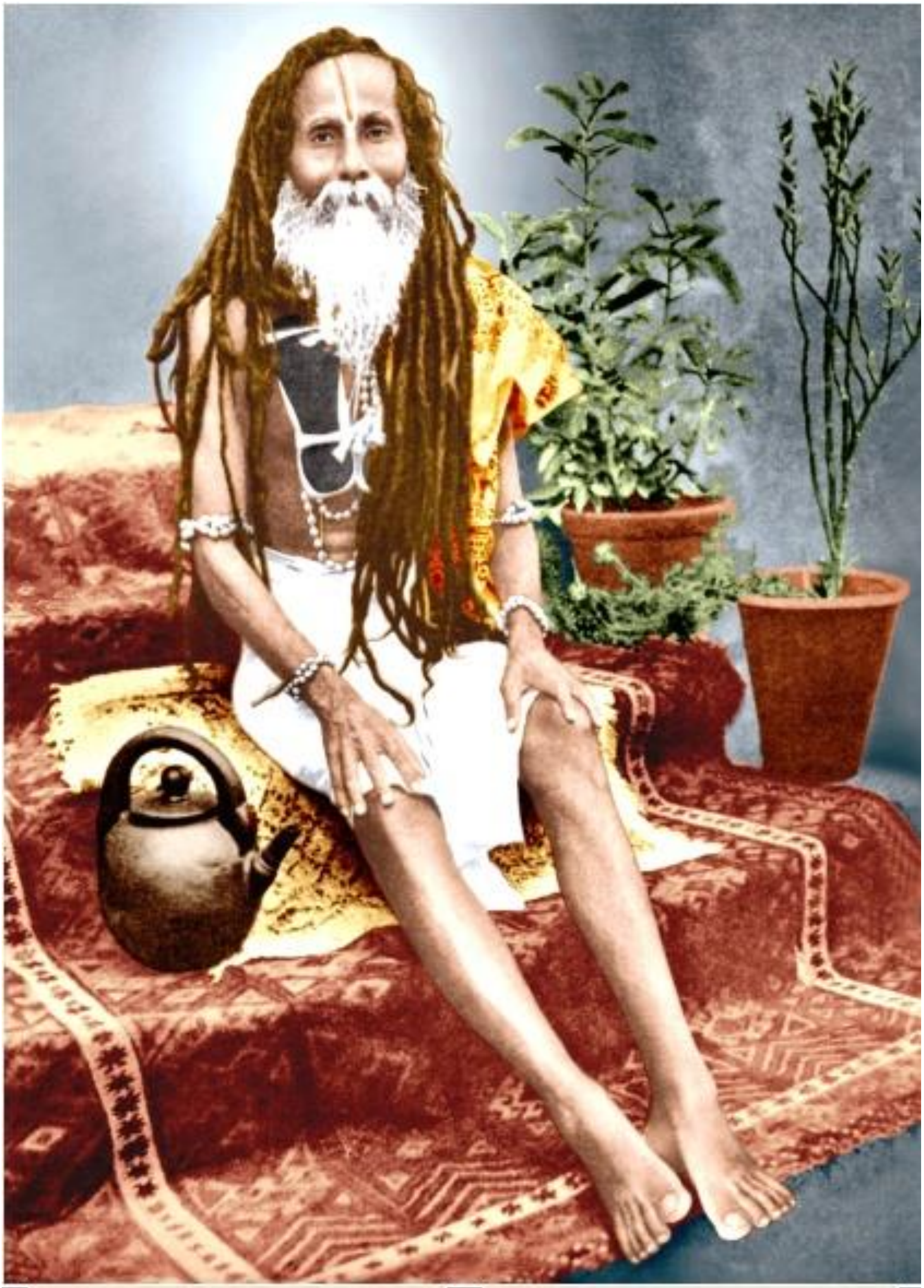
Table of Contents



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List of Tables

List of Figures

Abstract

This thesis is basically concerned with studying the various relationships involving REIT returns, inflation, monetary policy variables, and general equity market returns in the USA and the UK markets by considering modeling approaches which allow for either structural breaks or regime-switching behavior in the relationship. Although study of such relationships, especially the one involving inflation and REIT returns, have evoked significant interest amongst researchers, the number of such studies is still very few in number. Moreover, there is an element of 'puzzle' embedded in this relationship. Hence, it is imperative as well as interesting that further empirical investigations are done so as to resolve this 'puzzle' or what is often termed, in the literature, as 'anomalous' nature of this relationship. And the first two works of this thesis essentially tries to do that. The other two research works have been focused on the linkages between REIT returns and monetary policy and other financial variables, respectively.

To be more specific, the research problems posed in the first two works essentially take a relook at the anomalous relationship between inflation and REIT returns from two different modeling considerations. The idea is that the anomalous nature of this relationship is essentially due to what can be called 'misspecification' of the underlying model. The two aspects of misspecification that appears relevant here are (i) appropriate functional form of the model, and (ii) omission of relevant variables. Keeping this in mind, we have considered two modeling approaches for these studies. The first approach has been applied in Chapter 3 where structural break has been explicitly considered not only for the variables concerned but also in the relations involving these variables, along with inclusion of another variable, called relative price variability.

The same anomalous negative relationship has been examined in the second work (Chapter 4) by applying both the observed and unobserved regime switching models with two regimes only. In this study, another relevant macroeconomic variable *viz*., output growth, has been included. The

justification for inclusion of this variable is that output growth may have some direct effects on REIT returns and some indirect effects as well through the influence of relative price variability.

The next chapter i.e., Chapter 5 of the thesis examines the interdependences between REIT returns and a monetary policy variable as well as the contemporaneous effect of this monetary policy variable on REIT returns by using structural VAR model. Here interest rate spread has been taken as the monetary policy variable. Qu and Perron (2007) methodology of structural break has been applied to find if there is any structural change in the relationship among the variables involved. Keeping in mind the likely effect of business cycle on this relationship, we have also included output growth, as in the preceding chapter.

The last work is a little different from the main focus of the other works done in this thesis. Behaviors of REIT returns and stock returns are closely similar. This Chapter essentially studies their relationship at the level of volatility. More appropriately, the focus here is basically on studying the volatility spillovers as well as volatility-in-mean effect between REIT returns and stock returns by applying bivariate GARCH-M model where the conditional mean is specified by a smooth transition VAR model. Dynamic conditional correlation approach has been applied with GJR-GARCH specification so that the intrinsic nature of asymmetric volatility in case of positive and negative shocks can be duly captured.

CHAPTER 1

INTRODUCTION AND REVIEW OF LITERATURE

The central focus of this thesis is real estate investment trust (REIT) which is essentially an indirect investment property vehicle and this study is basically concerned with empirically examining the various relationships involving REIT returns, inflation, relative price variability, output growth, interest rate spread as monetary policy variable and stock returns in the USA and the UK.

The first chapter of this thesis starts with brief description of the evolution and basic structure of real estate investment trusts in the USA and the UK. The next section presents a review of the relevant literature. The motivation behind this study is discussed in Section 1.3. Finally, outline of the thesis is given in Section 1.4

1.1 The Evolution of Real Estate Investment Trusts

During the last few decades, the features of capital markets have changed significantly. At the same time, property investment has grown significantly, especially in the last three decades, and become one of the core asset classes in the investors' world. Moreover, the strong performance of real estate in the sense of higher returns being associated with lower risk as compared to other financial assets has also increased the interest in real estate as an asset class.

In comparison to traditional asset classes like bonds, equity etc., property has been found to offer an attractive risk-return relationship. This combined with its low correlation to other asset classes makes property to be an attractive selection in mix-asset diversified portfolios.

However, direct property investments suffer from a number of characteristics which limit its attractiveness. These characteristics include features such as

(i) the lack of a central market for property;

(ii) illiquidity;

(iii) high unit values of property investments; and

(iv) management requirements.

Moreover, high transaction cost or the lack of knowledge on local market may also constitute a barrier to entry in the direct property market for both domestic and foreign investors. In order to ease these drawbacks of direct property investments, various types of indirect property vehicles have been developed. The fundamental idea behind these indirect investments is to pool property assets so that by purchasing shares of these pools an investor can indirectly hold property assets. A real estate investment trust is an example of such an indirect investment vehicle. Real estate investment trust (REIT) is a useful way to channel and structure the capital flow to the real estate market (see, Glascock et al. (2000), for details). The increasing usefulness and importance of this indirect investment channel is evident by the fact that the market capitalization of the REIT industry amounted to over US $ 1 trillion at the end of 2016.

As for the historical facts, REITs were defined and authorized by the US Congress in 1960, in terms of the Real Estate Investment Trust Act of 1960. The legislation allowed individual US investors to group their investments and form special purpose companies which could invest in real estate in order to benefit from the same opportunities as direct real estate owners.

As mentioned already, real estate is associated with several characteristics which may limit the attractiveness of investments. A major issue is the illiquidity of real estate, which is a crucial stake for investors since reselling illiquid securities may result in significant losses. This obviously affects the effectiveness of the market and the risk premium. However, the liquidity and the opportunity offered by REITs mitigate some of these aspects of real estate investment. This invites the question of REIT efficiency. Another aspect of real estate investment trusts is that they offer an interesting alternative to the traditional asset classes. With stable returns along with low volatility due to transparency and low correlation with other assets, investment in REITs can enhance portfolio performances. And this makes it interesting to study the effects of including REITs into a mix-asset diversified portfolio. In what follows we present some details on the structure of REIT in the USA and the UK.

1.1.1 REIT structure in the USA

A REIT is a real estate company or trust that has been elected to qualify under certain tax provisions to become a pass-through entity that distributes to its shareholders almost all of its earnings and capital gains generated from the disposition of its properties. A REIT in the USA is not required to pay tax on its earnings if it distributes all the taxable income as dividends, but the distributed earnings obviously represent dividend income to its shareholders and these are taxed accordingly.

A REIT is overseen by financially skilled management teams that handle all types of real estate operations such as acquisitions and sales of properties, property management and leasing, property rehabilitation and repositioning, and property development. To qualify as a REIT for tax purposes in the USA, the trust must strictly satisfy certain asset, income, and distribution requirements which are stated below.

(i) A REIT must distribute at least 90 percent of its annual taxable income, excluding capital gains, as dividends to its shareholders.

(ii) A REIT must have at least 75 percent of its assets invested in real estates, mortgage loans and shares in other REITs, cash or government securities.

(iii) A REIT must derive at least 75 percent of its gross income from rents, mortgage interest, or gains from the sale of real estate property. At least 95 percent of its income must come from these sources together with dividends, interest, and gains from the sale or other disposition of stocks and securities.

(iv) A REIT must have at least 100 shareholders and must have less than 50 percent of the outstanding shares concentrated in the hands of five or fewer shareholders.

1.1.2 REIT structure in the UK

The UK-REIT regime is set out in Part 4 of the Finance Act 2006 (as updated by the Finance Act 2007) and it is supplemented by a number of regulations. It is also supported by guidance published by HM Revenue & Customs (HMRC). The regime for UK-REIT has been operational since January 2007, and 18 listed UK property companies including many of the largest property companies in the industry, have thus far converted to or listed with UK-REIT status. Entry to the regime is by notice to HMRC, and it does not necessitate a new form of corporate vehicle.

A potential UK-REIT has to carry on with a property rental business i.e., a UK property investment business or an overseas property business for UK tax purposes. It must also fulfill the qualifying conditions which are mentioned below. It may be noted that there is no need to fulfill all these qualifying conditions for entering the UK-REIT regime.

The qualifying conditions fall into three categories *viz.*, (a) the company conditions, (b) the tax-exempt business conditions, and (c) the balance of business conditions.

(a) The company conditions state that the concerned company is required

(i) to be solely resident in the UK for tax purposes;

(ii) not to be an open-ended investment company; and

(iii) to have a listing on a recognized stock exchange.

(b) The tax-exempt business conditions state that such a company must

(i) have at least three single rental properties which can be commercial or residential, and a property includes each separately-rented unit in a multi-let property;

(ii) not involve a property representing more than 40 per cent of the total value of the property rental business; and

(iii) distribute at least 90 per cent of its property rental business profits by way of dividend in each accounting period.

(c) The balance of business conditions require that the company

(i) generates at least 75 per cent of the total profits (before tax and excluding realized and unrealized gains and losses on the disposal of properties and items that are outside the ordinary course of business the UK-REIT) from the business of a UK-REIT, calculated in accordance with international accounting standards, must arise from its tax-exempt business; and

(ii) the value of assets of the UK-REIT in the tax-exempt business must be at least 75 per cent of the total value of all of its assets, as valued in accordance with international accounting standards.

1.1.3 Types of REITs

REITs are mainly of three types: equity REITs, mortgage REITs and hybrid REITs. Equity REITs are real estate companies that acquire commercial properties such as office buildings, shopping centers and apartment buildings, and lease the space in these structures to tenants. After paying the expenses associated with operating their properties, equity REITs pay out annually the bulk of the income to their shareholders as dividends. Equity REITs also include capital appreciation from the sale of properties in the dividends that they pay. The significant dividend distribution is designed to approximate the investment return that the investors would receive if they own properties directly.

Mortgage REITs invest in real estate mortgages or mortgage-backed securities, earning income from the interest on these investments as well as from the sales of mortgages. Mortgage REITs, like other businesses, earn their profits from the difference between the income they receive and their costs, including their fund costs, to purchase mortgage investments. They have the same requirement as equity REITs to distribute the bulk of their income to their shareholders annually.

A hybrid REIT is a real estate investment trust that is effectively a combination of equity REITs, which own properties, and mortgage REITs, which invest in mortgage loans or mortgage-backed securities. By diversifying across both the types of investments, hybrid REITs intend to get the benefits of both with less risk than if it invested in one or the other.

1.1.4 Distribution and the resulting tax treatment

A REIT is obligated to distribute a significant amount of income to shareholders. This makes REITs attractive for those seeking investments that actively pay dividends. In general, a REIT is required to distribute at least 90 percent of its otherwise taxable income. However, to reduce its taxable income to zero, a REIT will typically distribute all of its otherwise taxable income in the form of a shareholder dividend.

While the other real estate investment forms avoid the payment of corporate taxes by using debt to finance the acquisition of property and taking interest and depreciation deductions, the REIT structure provides an advantage for entities that wish to eliminate the risk of debt-financed property acquisition. The flip side is that REITs, by distributing their income annually, do not retain earnings like most corporations and therefore must often depend on frequent equity infusions in order to grow.

But REITs have the ability to avoid corporate-level taxes, which is one of its most attractive features. Paying just one level of tax provides a significant savings to the entity and generally makes the investment more appealing to the investors. Industry insiders estimate that the stocks of corporations that convert to REITs are worth from 15 percent to 20 percent more based merely on the tax arbitrage opportunities available by converting.

1.2 Review of Theoretical and Empirical Studies on REITs Relationship with Some Variables

This thesis is basically concerned with studying the various relationship involving REITs returns, inflation, monetary policy variables, and general equity market returns and hence we present a brief review of REITs relationship with inflation as well as some other variables. Before actually doing this review, we first present a brief summary of the studies on the relationship between general equity returns and inflation since the REITs generally tends to behave like stock.

In this section we begin with the review of the theoretical and empirical studies involving general equity markets and inflation. Thereafter we move on to citing those works which discuss the relationship unsecuritized as well as securitized real estate market returns with inflation. Then we have reviewed the literature concerning the relationship between monetary policy variables and REIT returns. Finally, a review of literature on the relationship between REITs returns and other financial asset returns is done.

1.2.1 Literature on the relationship between equity market returns and inflation

There is a general belief that real estate and common stock are hedges against inflation unanticipated as well as anticipated. According to the Fisherian theory of interest, stock returns should be positively related to both expected and unexpected inflation (see, for details, Fisher (1930)). The idea behind this is that equities are hedges against inflation because they represent claims on real assets, and hence stock returns should be positively related to inflation. But empirical studies have contradicted theory often and showed that the relationship is mostly negative for both expected and unexpected inflation. In few cases, the relationship has been found to be statistically insignificant. The negative relationship between returns to common stocks and expected inflation rate has been found by Linter (1975), Body (1976), Jaffe and Mandelker (1976), Nelson (1976), and Fama and Schwert (1977), to cite a few. Various theoretical frameworks and empirical approaches have been developed by researchers to explain this anomalous negative relationship between stock returns and inflation (see, for example, Fama (1981) and Geske and Roll (1983)).

Very few studies have tried to explain this perverse inflation hedging in case of common stock market. It was Fama (1981) who first suggested that for a given monetary policy, real output increase will lead to decrease in inflation. Therefore, the real activities should be able to forecast asset returns, and it would be negatively correlated with inflation. Hence, the relationship between asset returns and inflation should become either weaker or insignificant when real economic activity is taken into account. Geske and Roll (1983) proposed that economic shocks influence stock returns, which, in turn, affect real economic variables such as unemployment rate or corporate earnings. Consequently, tax income, budget deficit, monetary base, and inflation will be affected. Kaul (1990) has argued that the relationship between inflation and stock returns is merely a proxy when relative price variability measure is taken into account.

1.2.2 A review of studies on unsecuritized real estate returns as well as REIT returns with inflation

In the context of real estate market literature, there has been a consensus that unsecuritized real estate can serve as an inflation hedge. Fama and Schwert (1977) found residential real estate to be an excellent hedge against both expected and unexpected inflation. Brueggeman et al. (1984) have shown the existence of large positive correlation between returns on real estate and consumer price index. They mentioned further that given this positive correlation, the potential for inflation protection also exists in a portfolio containing real estate investments. The findings in Hartzell et al., (1986) lend support to the fact that real estate offers attractive diversification opportunities for stock and bond investors as well as substantial inflation protection. Gyourko and Linneman (1988) studied the hedging ability of both unsecuritized and securitized real estate returns. They found that the appreciation in property returns and owner occupied homes are positively associated with inflation while REIT returns tend to be strongly negatively related with unexpected inflation. Further, Miles and Mahoney (1997) found evidence that commercial real estate can hedge against inflation. Bond and Seiler (1998) empirically analyzed the inflation hedging effectiveness of residential real estate over the period 1969 to 1994, and showed that residential real estate is a significant hedge against both expected and unexpected inflation.

The empirical results on REIT's ability to hedge inflation are mixed. Only a few studies, such as those by Chen and Tzang (1988), and Liang et al. (1998) indicate that REIT possesses some inflation hedging properties. Chen and Tzang (1988) documented that REIT has some ability to hedge the expected component of inflation. As regards Liang et al. (1998), they ruled out the possibility that a stock market-induced proxy effect is the cause for the apparent lack of relationship between REIT and inflation. In fact, they found that REIT returns are positively related to temporary as well as permanent components of inflation measures.

However, extant evidence tends to suggest that securitized real estate tends to behave like share of common stock. Specifically, these studies have documented either a negative or an insignificant relationship between the returns on REIT and inflation for various sample periods. For instance, Gyourko and Linneman (1988) found that REIT returns tend to be strongly negatively related with unexpected inflation. Murphy and Kleiman (1989), in their study, incorporated stock market returns and found that this makes the correlation between REIT returns and expected inflation covering the period 1972-1985 from being significantly negative to insignificant. Goebel and Kim (1989), and Park et al. (1990) also had similar conclusion *viz*., existence of negative relationship between REIT returns and inflation. Chan et al. (1990) analyzed monthly returns on equity REITs that were traded on major stock exchanges over the period 1973-87, and concluded that returns from REIT is not a hedge against unexpected inflation. Nevertheless, according to Yobaccio et al. (1995), REIT returns are still significantly and negatively correlated with expected inflation. The same is the finding of the study by Chatrath and Liang (1998), based on analysis of data covering the period 1972-1995.

With a different focus, Liu et al. (1997) examined whether real estate securities continue to act as perverse inflation hedges from a global perspective in countries like Australia, France, South Africa, Switzerland, the UK and the USA. With few exceptions, the results were found to be consistent with negative inflation hedging ability of REIT returns. Ewing and Payne (2005) have shown that inflation news results in lower REIT returns. Interestingly, in the study by Simpson et al. (2007), asymmetric response of equity REIT returns to inflation has been documented. Equity REIT returns are shown to rise irrespective of whether inflation increases or decreases. Hoesli et al. (2008) has investigated the long-run relationship between REITs and both expected and unexpected inflation. According to their results, US REITs provide significant hedges against anticipated inflation whereas the hedging is perverse against unanticipated inflation.

In the context of this perverse inflation hedging in case of REITs returns, it may be noted that there are very few works that have attempted at explaining this negative relationship between REIT returns and inflation. Glascock et al. (2000) have shown that the negative relationship between REIT returns and inflation is merely a manifestation of the effects of changes in real economic activities and monetary policies. They have argued that real activities reflect future economic prospects, and hence changes in industrial production have impacts on the real estate sector as well. When real output increases and business expands, vacancy rates of real estate are expected to decrease. Hence, both prices and rental incomes are pushed higher. Consequently, returns on REIT also increase. However, this increased real output may lower the inflation. Thus the observed negative relationship between REIT returns and inflation is spurious.

However, the number of studies relating to REIT returns and inflation as well as fundamental economic activities such as real output growth and monetary policy variables are very limited till date. Hekman (1985) examined the office market construction in different local markets, and found that office construction is related to rent levels and growth in service-related employment. Kling and McCue (1987) investigated the impact of the macroeconomic variables on both office and industrial construction cycles, and found that shocks to output, nominal interest rate and money supply have strong effects on office construction, and also that employment accounts for most of the variations in industrial property construction. Chen and Tzang (1988) also found that REIT returns are closely related to interest rates. Further, in their study, Darat and Glascock (1989) argued that federal deficits have important wealth effects on REIT returns. Finally, McCue and Kling (1994) found significant impact of output, investment and nominal interest rate on real estate returns using data covering the period 1972 to1991.

1.2.3 Review of studies on relationship between REIT returns and monetary policy variables

In this sub-section, we discuss briefly the literature on the relationship between monetary policy variables and REIT returns. The first such study is due to Ceceheti et al. (2000) who pointed out, based on their analysis, that monetary policy makers should react to perceived misalignments in asset prices to reduce the likelihood of formation of price bubbles. In their study Rigobon and Sack (2003) have found that short-term interest rates react significantly to movements in broad equity price index, reflecting the expected endogenous response of monetary policy on the impact of stock price movements. Filardo (2000) also carried out a similar study on the role of asset prices in monetary policies. In another study in 2004, Rigobon and Sack observed the reverse relationship where asset prices react to changes in monetary policies. According to Bernanke and Gertler (2000), asset prices can be important sources of macroeconomic fluctuations. They have argued that asset prices become relevant only to the extent that they may signal potential inflationary or deflationary forces. Goodhart and Hofmann (2000) also carried out a study to find whether monetary policies react to asset price movements or not.

It may be mentioned that very few studies have been carried out where the relationship between monetary policy and REIT returs has been examined. The first such work is due to Chen and Tzang (1988) who examined the effect of changes in short-term and long-term interest rates on the equity and mortgage REITs. Murphy and Kleiman (1989) showed that expected inflation is negatively related to EREIT returns. Since expected inflation is part of interest rate, this could imply interest rate affects EREIT returns. McCue and Kling (1994) have also noted that nominal interest rate is an important macroeconomic variable which influences REIT returns. Further, Liang et al. (1995) compared equity REIT and mortgage REIT and found that equity REIT is less sensitive to interest rate change than mortgage REIT. Sanders (1997), He et al. (2003), and Bredin et al. (2007) have also confirmed that REIT returns could be affected by interest rate. However, they have also concluded that in order to fully understand the projection of REIT prices over longer horizon, knowledge of the “forward looking variables” is the key. Mei and Saunders (1995) and Chang et al. (2011) have used term structure or interest rate spread as a partly forward looking variable and shown that the effect of term spread on REIT returns is negative.

1.2.4 Literature on the relationship between REIT returns and other financial asset returns

The relationship between real estate securities and general financial markets has been extensively explored. Empirical studies on the performance of REITs in the US generally have suggested that REITs have similar risk and return characteristics to those of stocks over the period prior to the 1990s. Smith and Shulman (1976) in his paper covering the period 1963-1974, have found that REITs provide returns that are comparable to those of diversified portfolios of common stocks. Han and Liang (1995), and Liang et al. (1995) also have reported that REIT returns behave far closer to those of stock returns than those of returns on direct properties. For the period 1978-1994, Brueggeman and Fisher (1997) have reported correlation coefficient of 0.69 between equity REITs and shares, and 0.41 between REITs and bonds. Mull and Soenen (1997) analyzed the correlation between US REITs, domestic stock and domestic bonds for the time period 1985-94. They found that REITs have moderate positive correlation coefficient (0.61) with stocks and low correlation coefficient (0.28) with bonds.

The determinants of REIT returns have also been analyzed by using asset pricing model. Chen et al., (1990) employed the capital asset pricing model (CAPM) and arbitrage pricing theory (APT) to examine equity REIT returns. Asset pricing models have been applied to investigate integration *versus* segmentation between real estate market and general financial markets. Liu et al. (1990) who were the first to do so, used a single factor model and reported that the US private securitized real estate market is integrated with the stock market, while the US private commercial real estate market is segmented from the stock market. Peterson and Hsieh (1997) showed that risk premiums on equity REITs are significantly related to common stock returns. Using a series of commonly used multi-factor asset pricing models, Ling and Naranjo (1999) found that US REITs are integrated with the stock markets and the degree of such integration had significantly increased during the 1990s, while there is little evidence of integration between real estate and stock markets when appraisal based real estate returns are used. However, while this evidence is supportive of strong relationship between REITs and general stock markets, a number of studies have found contrasting evidence as well. For instance, Wilson and Okunev (1996) in their examination of not only REITs but also the indirect traded real estate markets in Australia and the UK, found an absence of any cointegrating relationship in all these three markets. In addition, Clayton and MacKinnon (2001) found that the sensitivity of REIT returns to stock market in the USA declined significantly in the 1990s.

As regards studies on this relationship between REIT returns and stock returns with consideration to volatility in the modeling framework, there are only very few. Using a bivariate generalized autoregressive conditional heteroscadastic (GARCH) model, Cotter and Stevenson (2006) found that correlation between returns on daily REIT and stock indices generally increased during the period from 1990 to 2005. Applying a multivariate dynamic conditional correlation (DCC)-GARCH model to a group of seven assets, Huang and Zhong (2006) argued that during the period from 1999 to 2005 in the USA, conditional correlation between REITs and US equity using daily – level data was always positive, but the same with US bond fluctuated around zero. Feng et al. (2006) and Ambrose et al. (2007) found that, starting in October 2001, the coefficient attached to REIT betas relative to that of stocks increased following the inclusion of REITs in S&P 500 and other broad stock market indices. Using a DCC-GARCH model, Case et al. (2014) examined the monthly conditional correlations between returns from the US stock market and REIT market over the period 1972 to 2008, and explored the implications of these correlations in portfolio allocation.

1.3 Motivation

It is evident from the presentation in the preceding section that relationship between real estate returns and inflation has been the subject of some empirical studies. However, despite significant interests – theoretical as well as empirical – studies on the relationship between inflation and REIT returns are still very few in number although there is an element of “puzzle” embedded in this relationship. By “puzzle”, we mean, as already mentioned in the preceding section, that the empirical finding is that of either a negative relationship or no significant relationship between inflation and REIT returns, whereas the theory suggests that the relationship is positive since the underlying assets of REITs investment i.e., the unsecuritized real estate market has inflation hedging ability. It is, therefore, imperative as well as interesting that further empirical investigations are done so as to resolve this ‘puzzle’ or what is often termed, in the literature, as ‘anomalous’ nature of this relationship, . This topic in the field of property market is quite interesting because of the fact that the perceived inflation-hedging ability of real estate is often used to justify its inclusion in efficient mixed-asset investment portfolios.

It is worth noting that evidence of a positive relationship between inflation and ‘unsecuritized’ real estate has been found in some of the studies mentioned earlier (see, for example, Brueggeman et al., 1984; Miles and Mahoney, 1997). In general these studies have reported that real estate holdings represent, at least, a partial hedge against expected and unexpected components of inflation. As regards the ‘securitized’ real estate, researchers have concluded that REITs tend to behave, like shares of common stock, as perverse inflation hedges (see, Gyourko and Linneman (1988), Goebel and Kim (1989), Park et al. (1990) Chen et al. (1990), and Liu et al. (1997), for details). Specifically, most of these studies have documented either a negative or an insignificant relationship between the returns on REITs and inflation using US data (see, for instances, Murphy and Kleiman (1989); Chan et al. (1990); Chatrath and Liang (1998); and Ewing and Payne (2005) etc.). A plausible explanation for this puzzling or anomalous relationship in case of securitized real estate returns, may be attributed to the manifestation of the effect of change in real economic activity through the effect of relative price variability.

One of the basic aims of the thesis is to take a relook at this important relationship from two different modeling considerations. The idea is that the anomalous nature of this relation is essentially due to what, in general econometrics terminology, can be called 'misspecification' of the underlying model. The two aspects of misspecification that appears relevant here are appropriate functional form of the model and omission of relevant variables. Keeping this in mind we have considered two modeling approaches. The first one considered a model where structural break is explicitly considered not only for the variables concerned but also in the relations involving the variables along with inclusion of another variable other than REIT returns and inflation.

The other modeling approach incorporates regime switching behavior – both observed and unobserved – for REIT returns. In this approach, in addition to relative price variability, another variable which represents real economic activity *viz*., output growth, is included. It may be pointed out that consideration of regimes in the study of such relationships. Lizieri et al. (1998) first used a threshold autoregressive (TAR) model and found that two distinct regimes exist in case of REIT. Liow et al. (2011) have identified regime switching behavior in international REIT markets. Further, Chang et al. (2011) have shown that the effect of monetary policy variables on REIT returns is not symmetric across different regimes. Our understanding in using this approach is that like stock returns, REIT returns are likely to have regime switching behavior and that the overall model in this approach is non-linear although regime – wise it is linear, and their lies the issue of proper specification of the model.

The motivation behind the next work in this thesis is now discussed. The importance of monetary policy changes and the transmission of information contained therein for asset market has been a subject of interest in a number of papers in recent years. Moreover, the recent US subprime crisis and the subsequent Global Financial Crisis have increased the focus on asset price developments, especially among central bankers. This is primarily due to collateral role of asset prices. Since this crisis was triggered by the busting of asset prices and which had negative effect on real economic activity, asset prices can be important sources of macroeconomic fluctuations that the central bank may want to respond to (see for example, Bernanke and Gertler, 2000; Goodhart, 2000). The effect of monetary policy changes on financial assets, in particular on REIT returns, has been analyzed in the literature. Among these, Chen and Tzang (1988), Liang et al. (1995), Sanders (1997) He et al. (2003), and Bredin et al. (1007) Chang et al. (2011) are the most important ones. Most of these studies have used the conventional VAR structure. This conventional VAR structure does not allow for the contemporaneous interactions between monetary policy and REIT returns. It is therefore, an interesting and important to capture the two-way interaction between monetary policy and REIT returns. It is very realistic to have an impact of REIT returns changes to monetary policy. REITs being a high-yield investment, its may have greater sensitivity to interest rate change. Also the REIT price spike, in particular, and consequent unstable housing prices, in general, can push Federal Reserve Bank to respond to such price movements with accommodating monetary policy. Thus, it would be more appropriate to capture the two-way interaction between monetary policy and REIT returns. Furthermore, it might not be possible for the short-term rate to fully reflect information on asset returns. Thus, using term-structure or interest rate spread as a monetary policy variable might be helpful as it is a partly forward looking variable.

Finally we spell out the idea behind the last work in this thesis. Recent years have seen growth in the investors' incentive and substantial development of the REIT market in the USA as well as in some other developed economies. Much of this increased interest of the investors has taken place due to some factors, which include the improved liquidity, strong performance of this asset relative to other assets like stocks, bonds and also imperfect covariance of REIT with other assets. Further, inclusion of REITs into the S&P's mainstream benchmark indices also has influenced investors' willingness to include REITs in their multi-asset portfolio. According to Markowitch (1952), investors have to understand that a successful portfolio investment depends crucially on understanding the correlation values of returns between pairs of assets contained therein in the portfolio. Subsequent studies have extensively documented that diversifying across different asset markets, given the low correlation of returns between them, would enable investors to reduce their total portfolio risk without lowering returns. Hence, REITs have become a popular investment vehicle to be included in a well-diversified portfolio.

In the last work, we primarily focus on the issue of volatility and its spillovers and the impact of these on returns on REITs and another important financial variable. Given empirical evidence and also theoretical explanations to the effect that there are some strong similarities in features of stock market and REIT market and that in portfolio choice REIT is gradually becoming a strong competitor. Hence, we have chosen stock returns to be the other financial variable in our work. Studies on this aspect involving these two variables are indeed very limited. We can cite of only Cotter and Stevension (2005), Michayluk et al. (2006), Fei et al. (2010), and Case et al. (2012) who have considered MGARCH model with DCC representation. There are various direction and consideration in which this work can be carried out. We have considered two well-known market conditions *viz*., bull and bear, asymmetry in volatility, explicit effect of volatility on conditional mean i.e., 'in-mean' model and interdependences in the conditional mean through smooth transition VAR.

1.4 Thesis Outline

The thesis is organized into seven chapters with the Introduction having Chapter 1. Beginning with the evolution of REIT, the first chapter presents a brief review of the literature on the relationship involving REIT returns, inflation, monetary policy variables and stock returns. The motivation behind this study is then discussed. This chapter ends with a brief outline of the thesis. The outlines of the remaining chapters of this thesis are summarized as follows:

Chapter 2 discusses about all the data sets used in this work *viz.,* REITs returns, inflation, relative price variability, output growth, stock returns, and interest rate spread for the USA and the UK. In this chapter, description of the variables, plots of some time series, and the usual summary statistics on the variables are presented in Section 2.2. Important characteristics of time series like stationarity, and structural breaks are then studied applying standard statistical tests and the findings are reported in Section 2.3. Results conclude that all the time series except interest rate spread is stationary in both the countries and there is structural break in all the series except output growth in the USA. The chapter ends with a very brief summary of these findings in Section 2.4.

In the next chapter i.e., in Chapter 3, the anomalous relationship between inflation and REIT returns is studied by allowing for the possibility of structural breaks in the relationship and also considering a third variable, called relative price variability. The results indicate that the negative effect of inflation on REIT returns is insignificant in presence of relative price variability, and thus the anomalous nature of this relationship is explained to some extent by this approach. Further, it is found that there are significant changes in the relationship involving these three variables over different sub-periods. The format of this chapter is as follows. In the first section we present brief introduction. Section 3.2 discusses the model and methodology applied for this study. The estimation results are presented in the next section. The chapter ends with some concluding remarks in Section 3.4.

Chapter 4 analyses the same anomalous negative relationship between inflation and REIT returns by applying both the observed and unobserved regime switching models with two regimes only. In this study another relevant macroeconomic variable *viz.*, output growth is included. The justification of the inclusion of this variable is that output growth may have some direct effect on REIT returns and some indirect effect through the effect of relative price variability as output growth is negatively related to relative price variability. It is evident from this study that this negative relationship is merely a proxy for the effectiveness of relative price variability and output growth on REIT returns. Further, results indicate that the causal relationship involving these variables is not symmetric across the two regimes, and hence the findings provide justification for regime-switching models rather than a single-regime VAR model for this relationship. This chapter has arranged in the following manner. After the introduction of this chapter in Section 4.1, Section 4.2 provides details about the methodology. The estimation results are presented and discussed in Section 4.3. The paper ends with some concluding remarks in Section 4.4.

Chapter 5 examines the interdependences between REIT returns and monetary policy variable as also the contemporaneous effect of monetary policy on REIT returns by using structural VAR model. Here interest rate spread has been taken as the monetary policy variable. Qu and Perron (2007) methodology of structural break has once again been applied to find if there is any structural change in the relationship among the variables involved. Keeping in mind, the likely effect of business cycle on this relationship we have also included output growth as in the preceding chapter. In this chapter we have found that there is a structural break in the relationship in case of the USA while there is no evidence of structural break. Our results suggests that the contemporaneous effect of interest rate spread on REIT returns as well as contemporaneous effect of REIT returns on interest rate spread is significant. However, the impact of contemporaneous effect is different sub-period wise in case of the USA.

This chapter has been organized as follows. The first section i.e., Section 5.1 presents the introduction of this chapter. The next section discusses about the methodology. Section 5.3 presents the empirical results on the models and analysis from impulse response function. The chapter closes with some concluding remarks in Section 5.4.

Chapter 6 essentially studies the volatility spillovers as well as volatility-in-mean effect between REIT returns and stock returns by applying bivariate GARCH-M model where the conditional mean is specified by a smooth transition VAR model. Dynamic conditional correlation approach has been applied with GJR-GARCH specification so that the intrinsic nature of asymmetric volatility in case of positive and negative shock can be duly captured. The major findings that we have empirically found in this chapter is that the mean spillover effect from stock returns to REIT returns is significant for both the countries while the same from REIT returns to stock returns is significant only in the UK. It is evident from the result in both the countries own risk-return relationship of REIT market is positive and significant only in the bear market situation while for the stock market own risk-return relationship is insignificant for both the bull and bear markets in the USA but it is negative in the bear market condition and positive in the bull market situation for the UK. We have also found the asymmetric nature in the conditional variance and dynamic behavior in the conditional correlation as well. Finally, several tests of hypotheses regarding equality of various kinds of spillover effects in the bull and bear market situations shown that these spillover effects are not the same in the two market conditions in most of the aspects considered in this study.

This chapter is laid out as follows. In Section 6.1 we present introduction of this chapter. The model and methodology used in this chapter is discussed in the Section 6.2 and 6.3 outline several tests of hypotheses of interests. The empirical results are presented and discussed in Section 6.4. The chapter ends with concluding observations in Section 6.5.

Finally, the last chapter of this thesis presents a summary of the major findings of the entire work. A brief introduction is presented in Section 7.1. Then in Section 7.2, we discuss about the major findings of this study. It includes with an idea on future work in the last section.

CHAPTER 2

DATA AND SOME IMPORTANT CHARACTERISTICS

2.1 Introduction

In the second chapter of this thesis, the description of all the variables used in this study, the sources of the time series data are given. Thereafter, along with plots and descriptive statistics of the data sets, some important properties of these time series like stationarity and structural breaks which are important for subsequent studies are reported.

In this thesis, altogether six variables *viz*., (i) Equity real estate investment trust (REIT) returns, (ii) inflation, (iii) relative price variability, (iv) output growth, (v) interest rate spread or term structure, and (vi) stock returns are involved. This study has been carried out for two most developed countries only *viz*., the USA and the UK since equity REITs data are not readily available for other countries. Time series observations at monthly level have been used covering the period January 1990 to December 2014. This range of data sets covers both the boom and recession periods for these two economies. A plausible justification for choosing the sample period starting in 1990s is that there was a structural change in the market capitalization of the REITs around 1990s in the USA and this period is known as "REITs Boom" age because of dramatic growth and maturation of REITs sector (see, for details, Clayton and Mackinnon (2003)). In case of the UK, the same sample period for the time series has been taken since the movements of REITs in UK is somewhat similar to that of REITs in the USA.

This chapter has been arranged as follows. The data sets are described in Section 2.2. Graphical plots of these series and the usual summary statistics on these variables are presented in Section 2.3.

Thereafter some important characteristics of these time series like stationarity and structural breaks are examined and reported in Section 2.4. This chapter ends with some concluding remarks in Section 2.5.

2.2 Description of Data

As stated in Chapter 1, the focus of this thesis in on equity real estate investment trusts (REIT). Accordingly, the first time series considered is the monthly equity REIT price index (RPI). The returns on equity REITs have been calculated by taking the first difference of the logarithm values of RPI in percentage i.e., $REIT_t = \log(RPI_t/RPI_{t-1}) * 100$. The equity REIT data for the USA have been taken from the National Association of Real Estate Investment Trusts (NAREIT) handbook, while for the UK, the FTSE/EPRA NAREIT data from Datastream which is available with the Reserve Bank of India been obtained, upon request, from the latter. Inflation (INF), and output growth ($IIPG$) and stock returns have been calculated, in a similar way as in REIT, from consumer price index (CPI) and industrial production index (IIP) and stock price index (SPI), respectively. Time series for CPI and IIP index for both the USA and the UK have been taken from Federal Reserve Bank (FRB) at St. Louis. The stock index considered for the USA and UK are S&P 500 and FTSE ALL, respectively, and these have been taken from CEIC data source.

The price series used to construct a relative price variability measure, called RPV, involves the seasonally adjusted price indices of the components of the consumer price index (CPI) at the item/product level. As summarized in Table 2.1, the resulting series for both the USA and the UK are available for 38 and 40 product categories, respectively. All these CPI indices at the item level for both the countries have been taken from CEIC data source. For the UK, these price indices at the item level are available from January 1996.[1] Hence, the relative price variability series is constructed from

[1] Because of non-availability of data on the price series of the items which are required for calculating RPV from January 1990 to December 1995, in Chapters 3 and 4 where the variable RPV is used, the sample period for all other variables has also been taken as February 1996 to December 2014 in case of the UK.

February 1996 onwards. Relative price variability at time t (RPV_t) is most often constructed as the weighted standard deviation of the weighted average of sub-aggregate inflation series. The primary measure of inflation used here is the monthly log-difference of the seasonally adjusted CPI.

$$\text{RPV}_t = \sqrt{\sum_{i=1}^{N} \omega_i (\pi_{it} - \bar{\pi}_t)^2} \ ,$$

where π_{it} stands for inflation if i^{th} item at time t, and is defined as $\pi_{it} = \ln P_{it} - lnP_{i,t-1}$, $\bar{\pi}_t = \sum_{i=1}^{N} \omega_i \pi_{it}$, P_{it} is the price index of i^{th} good at time *t* and ω_i denotes the fixed expenditure weight of the i^{th} product that sums to unity over all the items.

Finally, for the interest rate spread measure, we have followed Estrella and Trubin (2006) by choosing the difference between 10-year Treasury bond yield and 3-month Treasury bill rate. This data set for the USA as well as for the UK has been collected from Federal Reserve Bank (FRB) at St. Louis.

2.3 Plots and Summary Statistics

The plots of all the six variables *viz*., REIT returns, inflation, relative price variability, output growth, interest rate spread, and stock returns against time – both for the USA and the UK – are given in Figures 2.1 and 2.2, respectively. It appears from these plots that all the series except IRS is stationary since each of the five plots fluctuate around some mean value. And this is so for both the USA and the UK. It is worth noting that there are some spikes in all these data sets around 2008, which indicate the effect of the recent Global Financial Crisis on these variables.

Table 2.1 Weights of individual price indices used for the calculation of relative price variability

The U.S.			The UK	
Sample period (1990:M1-2014:M12)			Sample period (1996:M1-2014:M12)	
Item	Weight		Item	Weight
All items	100		All items	100
Cereals and bakery products	1.10		Bread and cereals	1.7
Beef and veal	0.63		Meat	2.2
Pork	0.41		Fish	0.4
Fish and seafood	0.34		Milk, cheese and eggs	1.4
Eggs	0.10		Fruits	0.9
Milk	0.29		Vegetables including potatoes tubers	1.5
Cheese and related products	0.25		Sugar, jam, syrup, chocolate and conf.	1.2
Fresh fruits	0.49		Nonalcoholic beverages	1.4
Fresh vegetables	0.47		Alcoholic beverages	1.8
Non-alcoholic beverages	0.91		Tobacco	2.4
Other food at home	1.74		Clothing	5.6
Food away from home	5.99		Footwear including repairs	0.9
Alcoholic beverages	1.11		Rental for housing	6.4
Shelter	32.78		Regular maintenance & repair dwellin.	1.4
Fuel oil and other fuels	0.34		Other service relating to dwelling	1
Electricity	2.75		Furniture, furnishings, & decorations	2
Utility gas service	1.28		Household textiles	0.7
Household furnishings and operations	4.65		Household appliances	0.9
Men's apparel	0.70		Household utensils	0.5
Boys' apparel	0.19		Tools & equipment for house & garde.	0.5
Women's apparel	1.35		Goods & services for routine mainten.	1.5
Girls' apparel	0.24		Medical products, appliances and equi.	1
Men's footwear	0.23		Other recreational item, garden & pets	3.5
Women's footwear	0.36		Purchase of vehicles	4.3
New vehicles	4.98		Operation of personal transport equip.	8.9
Used cars and trucks	1.72		Transport service	3
Motor fuel	4.35		Telephone and tele-fax equip. & serv.	2.6
Motor vehicle parts and equipment	0.37		Audio visual equipment & products	2.3
Medical care commodities	1.45		Electricity, gas & other fuel	5.6
Medical care services	4.83		Recreational & cultural service	2.9
Sporting goods	0.67		Accommodation service	1.7
Photographic equipment and supplies	0.08		Personal care	2.8
Toys	0.25		Personal effects	1.3
Admissions	0.71		Catering	9.7
Educational books and supplies	0.20		Insurance	0.8
College tuition and fees	1.52		Financial services	2.3
School tuition and fees	0.41		Education	1.9
Other goods and services	3.48		Books, news papers & stationary	1.3
			Holiday package	2.4
			Other services	1.1

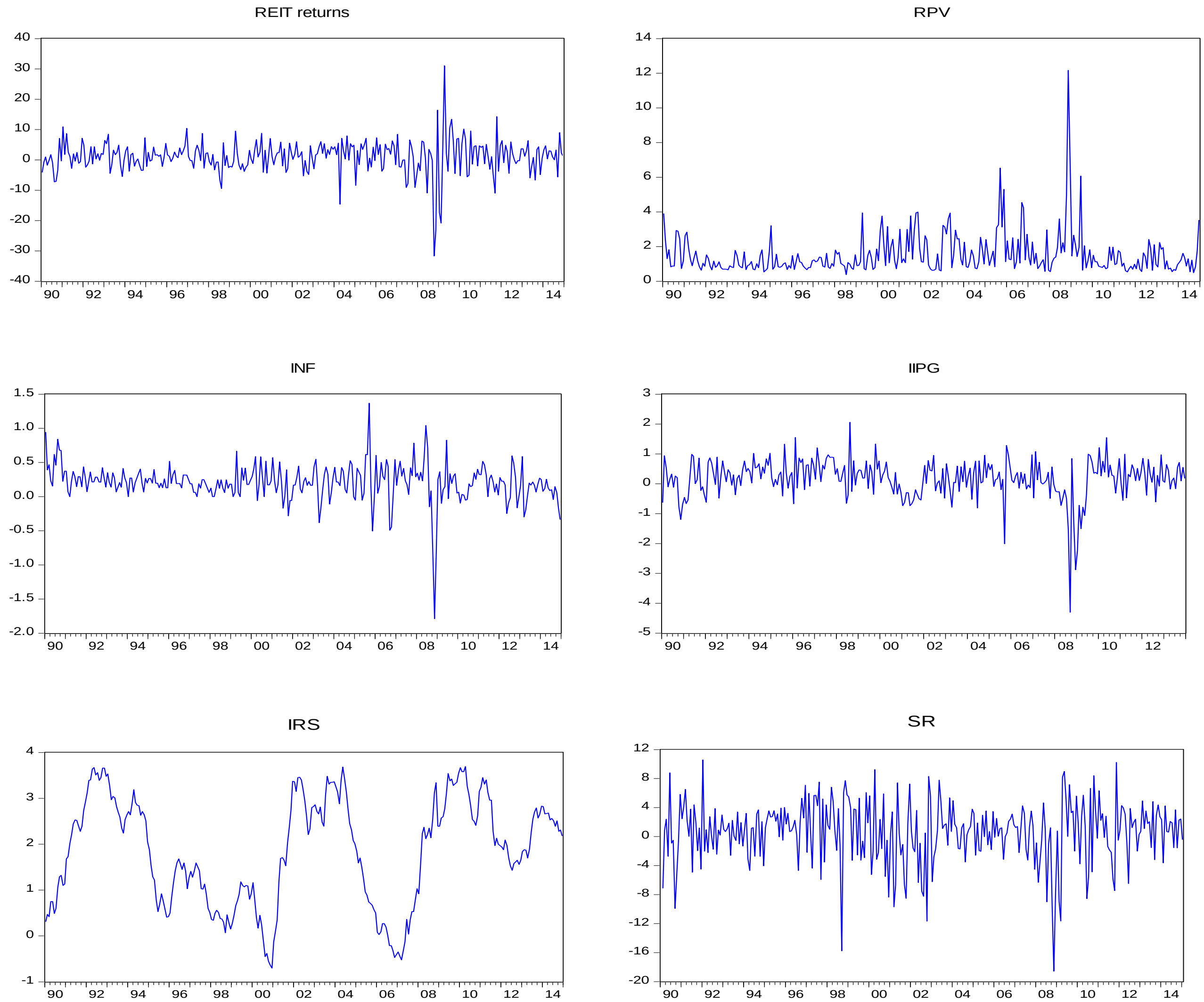

Figure 2.1 Time series plots of REIT returns, relative price variability (RPV), inflation (INF), output growth (IIPG), interest rate spread (IRS), and stock returns (SR) for the USA

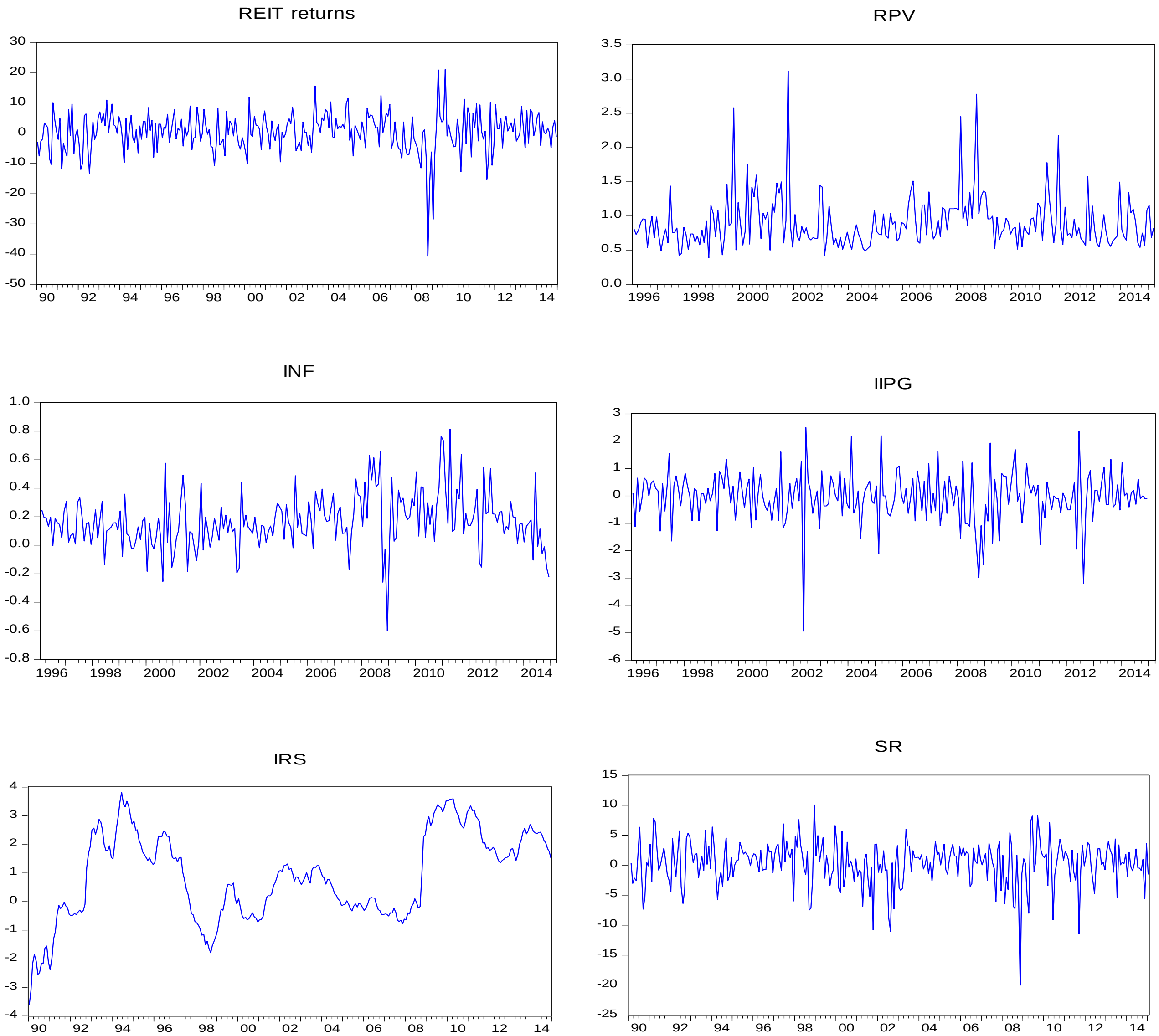

Figure 2.2 Time series plots of REIT returns, relative price variability (RPV), inflation (INF), output growth (IIPG), interest rate spread (IRS) and stock returns (SR) for the UK

The usual summary statistics on these variables are presented in Tables 2.2 and 2.3 below. It may be noted that REIT returns in both the countries have high standard deviation values. In fact, it is the highest among all six variables. It is clear that except for RPV in case of the USA and RPV and INF in case of the UK, the skewness value for all others is negative. This means that the underlying distributions of these variables are negatively skewed. All but IRS in both the countries have high kurtosis values (very high indeed for REIT, RPV, and IIPG) and hence except for IRS, the distributions are leptokurtic. Expectedly, therefore, the J-B test statistic values show that the null hypothesis of normality is rejected for all the variables in both the countries.

Table 2.2 Summary statistics of the six variables for the USA

	REITR	RPV	INF	IIPG	IRS	SR
Mean	1.046	1.525	0.204	0.073	1.841	0.587
Median	1.293	1.127	0.208	0.090	1.985	1.101
Maximum	31.01	12.16	1.367	0.881	3.690	10.578
Minimum	-31.66	0.384	-1.786	-1.911	-0.700	-18.563
Std. dev.	5.464	1.193	0.267	0.281	1.169	4.259
Skewness	-0.764	3.706	-1.384	-1.843	-0.252	-0.812
Kurtosis	11.42	26.14	15.16	12.838	1.924	4.709
J-B statistic	916.4 (0.000)	7380 (0.000)	1945 (0.000)	1379.89 (0.000)	17.637 (0.000)	69.509 (0.000)

Note: Figures in parentheses indicate p-values

Table 2.3 Summary statistics of the six variables for the UK

	REITR	RPV	INF	IIPG	IRS	SR
Mean	0.531	0.901	0.168	-0.036	0.881	0.340
Median	0.632	0.808	0.152	0.000	0.849	0.755
Maximum	21.174	3.119	0.814	2.501	3.818	10.092
Minimum	-36.932	0.386	-0.602	-4.941	-3.608	-20.030
Std. dev.	6.011	0.378	0.191	0.914	1.513	3.630
Skewness	-1.195	2.442	0.294	-0.855	-0.129	-1.008
Kurtosis	10.414	12.136	4.666	7.071	2.345	6.494
J-B statistic	573.94 (0.000)	1028.64 (0.000)	29.54 (0.000)	185.30 (0.000)	6.197 (0.045)	203.51 (0.000)

Note: Figures in parentheses indicate p-values

2.4 Important Characteristics of the Time Series

In this section we report on the findings on the stationarity, and structural breaks in all the series.

2.4.1 Test on stationarity

We have applied the well-known augmented Dicky-Fuller (ADF) test (see, Dicky and Fuller (1979), for details) to find if all the variables are stationary. The optimum lag length for the ADF test has been chosen by the Schwarz information criteria (SIC). It can be concluded from the test results, presented in Table 2.4, that all the variables except the interest rate spread (IRS) are stationary at 1% level of significance for both the countries. Since, IRS is non-stationary, we have taken the first difference series of IRS i.e., ΔIRS which is found to stationary at 1%level of significance with the test statistic value being -12.63 and -11.00 for the USA and the UK, respectively.

Table 2.4 Values of the ADF test statistic for stationarity

Country	REIT	RPV	INF	IIPG	ΔIRS	SR
The USA	-6.77***	-11.44***	-11.34***	-4.60***	-12.63***	-16.28***
The UK	-11.19***	-12.93***	-12.61***	-18.92***	-11.00***	-14.65***

Note: ‘*’, ‘**’, and ‘***’ denote significance at 10%, 5%, and 1% level, respectively.

2.4.2 Test on structural break

The sample period from January 1990 to December 2014 is long enough a period during which some major events relating to economics and finance have happened in both the countries. The most important one, of course, is the Global Financial Crisis of 2008. This is all the more important for our study since this study is primarily concerned with REIT. It is therefore, important that proper tests be carried out to find if there have been any structural break(s) in all the series. To this end, we have applied the Bai and Perron test (1998, 2003). They proposed a few test statistics for identifying multiple break points.

Table 2.5 Bai-Perron tests for multiple structural breaks

	The USA					
Test	REIT	RPV	INF	IIPG	ΔIRS	SR
WD_{max} (Up to one break)	26.57***	36.92***	18.53***	53.46***	23.21***	20.73***
$Sup\ F_T(2\|1)$	25.92**	19.09***	14.05**	17.11***	9.18	16.51**
$Sup\ F_T(3\|2)$	3.67	11.87	7.07	3.72		12.03
Break dates	2005M04 & 2009M03	1993M08 & 2009M07	2001M07 & 2008M08	2000M05 & 2009M07	1995M07	2005M06 & 2009M04
	The UK					
Test	REIT	RPV	INF	IIPG	ΔIRS	SR
WD_{max} (Up to one break)	48.08***	30.94***	31.03***	9.46	21.02***	17.75**
$Sup\ F_T(2\|1)$	6.64	25.10***	7.73	---	9.80	4.08
$Sup\ F_T(3\|2)$						
Break dates	2007M01	2001M11 & 2009M02	2010M11		1998M10	2009M05

Note: '*', '**', and '***' indicate significance at 10%, 5%, and 1% levels, respectively.

In Table 2.5 we have reported the results of $UDmax$ test, $WDmax$ test and then sup $F_T(l+1|l)$ test. The value of the trimming parameter has been set to 0.15. It is evident from the results of the tests presented in Table 2.5 that at least one structural break is present in all the series of both the countries except for IIPG series in the UK. The $WDmax$ test statistic values are found to be higher than the critical value of 17.81 at 1% level of significance for all series in the USA. As for the UK, this test is found to be significant for REIT, RPV, and INF series and for SR series at 5% levels of significance. Hence, the null hypothesis of 'no break' is rejected in favor of alternative of 'up to one break' for all the series. To detect further if there is more than one structural break, the sequential break test has been performed. In fact, looking at $Sup\ F_T(2|1)$ test statistic values, it is evident that there are two breaks in all the series except ΔIRS in the USA and only one break in all but RPV series in the UK. However no evidence of more than two breaks has been found in any of the series in both the countries. In case of RPV series in the USA, the estimated break months are 1993M08 and 2009M07 while for the UK these are 2001M11 and 2009M02. The estimated break months for REIT series in the USA are 2005M04 and 2009M03 while for UK it is 2007M01. The break months in case of INF series in the USA have been estimated as 2001M07 and 2008M08 while for the UK it is 2010M11. For IIPG in the USA the estimated break months are 2005M05 and 2009M07 while no break has been found for IIPG in case of the UK. Further, the estimated single break month for the ΔIRS series in the USA and the UK are 1995M07 and 1998M10, respectively. Finally, for SR series the estimated break months are 2005M05 and 2009M04 for the USA while it is 2009M05 in case of the UK. On the basis of these findings, except ΔIRS, it may be concluded that all the other five series in the USA have been significantly affected by the Global Financial Crisis since point estimate of one of the break months is around 2008 / early 2009 for these five series. This effect of crisis is, however, found to be absent for REIT, IIPG, and ΔIRS for the UK; only RPV, INF, and SR series are found to have one structural break which can be attributed to the Global Financial Crisis.

2.5 Conclusions

In this chapter, we have presented plots and basic summary statistics of all the series as well as reported the findings on tests for stationarity and structural breaks for all the series. We have found that all but IRS is stationary. And structural breaks have occurred in all the series for the USA and all but IIPG series for the UK.

CHAPTER 3

RELATIONSHIP BETWEEN REIT RETURNSANDINFLATION: AN APPROACH WITH STRUCTURAL BREAKS

3.1 Introduction

As discussed in Chapter 1, a number of studies have attempted to explain the anomalous relationship between REIT returns and inflation. The term anomalous is used in the sense that the effect of inflation on REIT returns has often been found to be negative in empirical studies though it is expected to be positive from theoretical consideration. Such an expectation is primarily due to existence of positive relationship between residential real estate returns and inflation, and REIT being a securitized form of this traditional real estate investment, it is, therefore, also expected to have positive association with inflation. In this context mention may be made of the paper by Fama and Schwert (1977) who found residential real estate to be an excellent hedge against both expected and unexpected inflation. Bond and Seiler (1998) empirically analyzed the inflation hedging effectiveness of residential real estate over the period 1969 to 1994, and showed that residential real estate is a significant hedge against both expected and unexpected inflation.

In general, there is a consensus that traditional real estate investment is able to hedge against inflation (see, Miles and Mc Cue (1982),Chen and Thibodeau (1984), Brueggeman, Hartzell, Hekman and Miles (1986), Sirmans and Sirmans (1987), for instances). Gyourko and Linnenman (1988) studied the hedging ability of both traditional real estate investments as well as REIT returns. They found that the appreciation in property returns and owner-occupied homes are positively associated with inflation while REIT returns tend to be strongly negatively related with unexpected inflation. Because traditional real estate provides good inflation hedging and REIT is a securitized form of real estate, it is counter intuitive to find that REIT possesses perverse inflation hedging property. As the underlying assets of REIT are primarily real estates, REIT is expected to be inflation hedge as well.

The empirical findings on REIT's ability to hedge inflation are mixed. Only a few studies, such as Chen and Tzang (1988), and Liang et al. (1998), indicate that REIT possesses some inflation hedging properties. Chen and Tzang (1988) documented that REIT has some ability to hedge expected component of inflation. Liang et al. (1998) ruled out the possibility that a stock market-induced proxy effect is the cause for the apparent lack of relationship between REIT and inflation, and found that REIT returns are positively related to temporary or permanent components of inflation measures. However, extant evidence tends to suggest that REIT returns have negative relationship with inflation. Chan et al. (1990) analyzed monthly returns on equity REIT that were traded on major stock exchanges over the period of 1973-87, and concluded that returns from REIT is not a hedge against unexpected inflation. Liu et al. (1997) examined whether real estate securities continue to act as perverse inflation hedges from a global perspective in countries like Australia, France, South Africa, Switzerland, the UK, and the USA. With few exceptions, the results were found to be consistent with negative inflation hedging ability of REIT returns. Goebel and Kim (1989), and Park et al. (1990) also made similar conclusion of negative relationship between REIT returns and inflation.

The characteristic of perverse hedging ability is quite common in the literature of the stock market as well. Researchers have tried to explain the perverse inflation hedging in the stock market as well as in the REIT market. Geske and Roll (1983) proposed that economic shocks influence stock returns, which, in turn, affect real economic variables such as unemployment rate or corporate earnings. Consequently, tax income, budget deficit, monetary base, and inflation are affected. While Chen and Tzang (1988) found that REIT returns are closely related to interest rates, Darat and Glascock (1989) argued that federal deficits have important wealth effects on REIT returns. Hence, economic shocks have great impacts on REIT markets (e.g., Glascock et al., 2002). In fact, Glascock et al. also argued that as expected real activities reflect future economic prospects, changes in industrial production have impacts on the real estate sector as well. However, the relationship between REIT returns and inflation should become either weaker or insignificant when the effect of real economic activity is taken into account directly or through some other channels.

It may be noted that like in case of many other economic variables and financial variables, there is evidence of structural shifts in the property market as well which has been caused by the recent Global Financial Crisis in 2008. This crisis was triggered by the collapse of housing market in the USA. This Global Financial Crisis, commonly accepted as the most severe economic meltdown ever since the Great Depression, forced real property market to encounter with many serious troubles, such as hammered by sustained stock price decline, falling real estate assets values, decreasing rental income and debt burdensome.

The first study of this thesis re-examines the relationship between REIT returns and inflation with the view to understand the role of relative price variability in this relationship. To be more specific, the purpose of this study is to examine whether the fundamental economic activities, such as industrial production, contribute to this negative relationship through the effect of relative price variability on REIT returns. This aspect of relative price variability is pertinent for the explanation of REIT returns-inflation relationship in two ways. First, relative price variability may have adverse effects on the economy and second, it may be positively related to both unexpected and expected inflation (see, for instance, Kaul, 1990).

In the first study in this thesis, we focus on explaining the anomalous relationship between REIT returns and inflation by addressing to two particular inadequacies of this basic bivariate relationship *viz*., omission of relevant variable(s) and proper functional form. To that end, we have included relative price variability and also allowed for structural break(s) in the relationship. The existence of the latter introduces nonlinearity in the relationship over the whole period although it is linear in the sub-periods. This modeling approach also helps us to find if the effect of inflation has been used hitherto as a proxy for relative price variability in REIT returns-inflation relationship. Introduction of structural breaks also enables us to investigate the effect of Global Financial Crisis on this relationship. This has been done by using Qu and Perron (2007) methodology which in addition to such breaks in the individual time series allows for structural changes in the underlying relationship as well. Our results indicate that the existing significant relationship between REIT returns and inflation appears to proxy for the significant effect of relative price variability on the REIT returns in both the countries. Further, these relations involving the three variables are not stable over the entire sample period for the USA. In case of the UK, it is, however, found to be stable since there is no significant structural change in the underlying relationship.

This chapter is organized as follows. Section 3.2discusses the model and methodology applied for this study. The estimation results are presented in the next section. The chapter ends with some concluding remarks in Section 3.4.

3.2 Model and Methodology

Both the statistics and econometrics literature have a good deal of studies on inferences on structural breaks/changes with unknown break dates, most of which are specifically designed for the case of a single change (see, for details, Perron (2006)). The issue of multiple structural changes in a time series has received more attention recently, and this too in the context of single regression model only (see, in this conext, Bai and Perron (1998,2003)). However, works concerning structural changes in the context of a system of equations is only very recent and also very few in number. Among these few, the important ones are Bai and Perron (1998), Hansen (2003), and Qu and Perron (2007).

The main advantages of Qu and Perron (2007) methodology is that it provides a comprehensive treatment of issues related to estimation, inference, and computation with multiple structural changes that occur at unknown points in various linear multivariate regression models with stationary variables, that include vector autoregressive (VAR) model, certain linear panel data models, and seemingly unrelated regression (SUR) model. Changes can occur in the parameters of the conditional mean, the covariance matrix of errors, or both, and the distribution of the regressors can also be allowed to change across regimes. It may be noted that for this methodology, it is not required to assume that the regressors are independent of the errors at all leads and lags in presence of heteroskedasticity and/or autocorrelation. Let the variables of interest $Y_t = (Y_{1,t} Y_{2,t} \dots Y_{n,t})'$ be $(n \times 1)$ vector at time point t. The general model considered by Qu and Perron (2007) is given as

$$Y_t = (I \otimes x_t')S\varphi_j + u_t \tag{3.1}$$

for n equations and T time series observations. The total number of structural changes in the system is assumed to be m and the break dates are denoted by a $(1 \times m)$vector $\tilde{T} = (T_1 T_2 \dots T_m)$, taking into account that $T_0 = 1$ and $T_{m+1} = T$. The subscript j indexes a regime where $(j = 1, 2, \dots, m+1)$, subscript t indexes the temporal observation $(t = 1, 2, \dots, T)$, and i indexes the i^{th} equation (where $i = 1, 2, \dots, n$) to which a scalar dependent variable $Y_{i,t}$ is associated. The number of regressors is q and x_t is a $(q \times 1)$ vector at time t which includes the regressors from all the equations i.e., $x_t = (x_{1,t} x_{2,t} \dots x_{q,t})'$, and φ_j is the set of parameters in the model for the j^{th}regime. Furthermore, the error u_t is assumed to have mean zero and covariance matrix $\sum_j$ for $T_{j-1} + 1 \leq t \leq T_j$.

The selection matrix is denoted by S in the above equation, which involves elements that take the values 0 and 1, and thus indicate which regressors appear in each equation. When using a vector autoregressive model, x_t becomes, $x_t = (1\ y_{1,t-1}\, y_{1,t-2}\ \dots y_{1,t-q}\, y_{2,t-1}\, y_{2,t-2} \dots y_{2,t-q} y_{3,t-1} y_{3,t-2} \dots y_{3,t-q} \dots\ y_{n,t-1}\, y_{n,t-2}\ \dots y_{n,t-q})'$, which simply contains the lagged dependent variables including the intercept term, and in that case S will be an identity matrix.

This general framework of VAR has been adopted for the purpose of studying structural breaks in the relationships involved in this study, and to estimate the parameters for different regimes separately based on the Qu-Perron test. In our case, Y_t now consists of relative price variability, inflation, and REIT returns i.e.,$n = 3$and $Y_t = (RPV_t, INF_t, REIT)'$.

The method of estimation considered in their study is called the restricted quasi-maximum likelihood (RQML) that assumes serially uncorrelated Gaussian distribution for the error u_t. In this context, the set of basic parameters in regime j consists of p vector of $\varphi_j$and Σ_j. A set of r restrictions of the form $g(\varphi, \text{vec}(\Sigma)) = 0$, is used where$\varphi = (\varphi_1', \varphi_2', \dots, \varphi_{m+1}')'$,$\Sigma = (\Sigma_1, \Sigma_2, \dots, \Sigma_{m+1})$, and $g(.)$ is a r-dimensional vector.

Conditional on a given partition of the sample $\tilde{T} = (T_1,\ T_2, \dots, T_m)$, the Gaussian quasi-likelihood function is

$$L_T(\tilde{T}, \varphi, \Sigma) = \prod_{j=1}^{m+1} \prod_{t=T_{j-1}+1}^{T_j} f(Y_t | z_t;\ \varphi_j, \Sigma_j)$$

where$z_t' = (I \otimes x_t')S$ and

$f(Y_t | z_t;\ \varphi_j, \Sigma_j) = \frac{1}{(2\pi)^{n/2} |\Sigma_j|^{1/2}} \exp\left\{-\frac{1}{2}\left[Y_t - z_t'\varphi_j\right]' \Sigma_j^{-1} \left[Y_t - z_t'\varphi_j\right]\right\}$, and the quasi-likelihood ratio is

$$LR_T = \frac{\prod_{j=1}^{m+1} \prod_{t=T_{j-1}+1}^{T_j} f(Y_t|z_t;\ \varphi_j, \Sigma_j)}{\prod_{j=1}^{m+1} \prod_{t=T_{j-1}^0+1}^{T_j^0} f(Y_t|z_t; \varphi_j^0, \Sigma_j^0)}$$

where the true values of the parameters are denoted with a superscript 0.

The aim is to obtain values of $(T_1, T_2, \dots, T_m, \varphi, \Sigma)$ that maximize LR_T subject to the restriction $g(\varphi, \text{vec}(\Sigma)) = 0$. Let $lr_T(.)$ denote the log-likelihood ratio and let $rlr_T(.)$ denote the restricted log-likelihood ratio. Then the objective function is $rlr_T(\tilde{T}, \varphi, \Sigma) = lr_T(\tilde{T}, \varphi, \Sigma) + \lambda' g(\varphi, \text{vec}(\Sigma))$, where λ is the break fraction. The estimates are obtained as

$$\left(\hat{\tilde{T}}, \hat{\varphi}, \hat{\Sigma}\right) = \arg \quad \max_{(T_1, T_2, \dots, T_m, \varphi, \Sigma)} rlr_T(\tilde{T}, \varphi, \Sigma).$$

Under certain assumptions, Qu and Perron (2007) have obtained that for $j = 1,2, \dots, m$, $v_T^2(\widehat{T_J} - T_j^0) = O_p(1)$, and for $j = 1, 2, \dots, m+1$, $\sqrt{T}(\widehat{\varphi_J} - \varphi_j^0) = O_p(1)$ and $\sqrt{T}(\widehat{\Sigma_J} - \Sigma_j^0) = O_p(1)$, where v_T is either a positive number independent of T or a sequence of positive numbers that satisfy $v_T \longrightarrow 0$ and $T^{1/2}\, v_T/(\log T)^2 \longrightarrow \infty$. They have also showed that the limiting distributions of the conditional mean and the covariance matrix of the errors are the same with estimated break points as those when the break points are known.

As regards the Qu and Perron (2007) test procedure, they have proposed a number of test statistics for identifying multiple break points in the relations, and these are stated below.

(i) The $sup\ F_T(k)$ test i.e., a $sup\ F$-type test of the null hypothesis of no structural break *versus* the alternative of a fixed number of breaks(k).

(ii) The double maximum test, denoted as $UDmax$test and $WDmax$ test, from consideration of having equal weighting scheme and unequal weighting scheme where weights depend on the number of regressors and the significance level of the tests. For these two tests, the alternative hypothesis is that the number of breaks is unknown, but up to some specified maximum[2].

(iii) The $sup\, F_T(l+1|l)$ test i.e., a sequential test of the null hypothesis of l breaks *versus* the alternative of $(l+1)$ breaks with the starting value of l being 1.

It should be quite obvious that size and power of these tests are important issues for final conclusions on the test. To that end, similar to Bai and Perron (1998, 2003), Qu and Perron have suggested the following useful strategy. First, the $UDmax$test and the $WDmax$ test are used to find if at least one break is present. If one or both of these two tests indicate the presence of at least one break, then the number of breaks can be decided based upon the sequential examination of the $sup\, F_T(l+1|l)$ statistic which is constructed using global minimizers for the break dates. While applying these tests, we set the value of the trimming parameter to 0.15. Since the focus of this study is on the stability of the relationship among the variables of interest, we restrict our attention to tests for changes in the regression coefficients only. Once the tests for structural breaks have been carried out, the subsequent estimation of the relations involving these variables for each regime is done by VAR model. The explicit form of VAR model for our case is as follows:

$$\begin{bmatrix} y_{1t} \\ y_{2t} \\ y_{3t} \end{bmatrix} = \begin{bmatrix} \varphi_1 \\ \varphi_2 \\ \varphi_3 \end{bmatrix} + \begin{bmatrix} \varphi_1^{11} & \varphi_1^{12} & \varphi_1^{13} \\ \varphi_1^{21} & \varphi_1^{22} & \varphi_1^{23} \\ \varphi_1^{31} & \varphi_1^{32} & \varphi_1^{33} \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \\ y_{3t-1} \end{bmatrix} + \begin{bmatrix} \varphi_2^{11} & \varphi_2^{12} & \varphi_2^{13} \\ \varphi_2^{21} & \varphi_2^{22} & \varphi_2^{23} \\ \varphi_2^{31} & \varphi_2^{32} & \varphi_2^{33} \end{bmatrix} \begin{bmatrix} y_{1t-2} \\ y_{2t-2} \\ y_{3t-2} \end{bmatrix} + \cdots + \begin{bmatrix} \varphi_p^{11} & \varphi_p^{12} & \varphi_p^{13} \\ \varphi_p^{21} & \varphi_p^{22} & \varphi_p^{23} \\ \varphi_p^{31} & \varphi_p^{32} & \varphi_p^{33} \end{bmatrix} \begin{bmatrix} y_{1t-p} \\ y_{2t-p} \\ y_{3t-p} \end{bmatrix} + \begin{bmatrix} u_{1t} \\ u_{1t} \\ u_{1t} \end{bmatrix}$$

3.3 Empirical Results

Since all the series involved in this study have been found to be structurally not stable, as reported in Section 2.3 of Chapter 2, any study of the relationship involving these variables cannot be taken to be of the fixed coefficient kind. As already mentioned, the modeling framework in this work gives due

[2]The methodology of these two tests is same as that in Bai and Perron (1998).

consideration to structural changes so as to be able to explain the anomalous findings on the relationship. However, this finding of structural instability in each of the time series provides empirical justification of our approach of considering VAR model allowing for multiple structural breaks in the underlying relationship.

We now report the results of the Qu-Perron (2007) test for detecting breaks in the system of equations involving these three variables. The values of this test statistic are given in Table 3.1.

Table 3.1Test for multiple breaks in the relations based on the Qu-Perron methodology

	$WDmax$ test (up to one break)	$supF_T(2\|1)$	$supF_T(3\|2)$	Break month	Interval estimates of break
The USA	42.01***	53.57***	31.26	2005:M05 and 2009:M05	(2004:M08 -2006:M02) and (2008:M08 -2010:M02)
The UK	21.67				

Note: '***' indicates significance at 1% level.

In case of the USA, the test statistic value of the $WDmax$ test is found to be 42.01, which is significant at 1% level of significance, and hence the null hypothesis of 'no break' is rejected in favor of the alternative of 'up to one break' in this system of equations. To detect further if there is more than one structural break, the sequential break test was carried out. We note from the table that the test statistic value of $supF_T(2|1)$ is 53.57, which is significant at 1% level. So the test rejects the null hypothesis of 'one break' in favor of 'two breaks'. However, the sequential test for detecting more than two breaks i.e., $supF_T(3|2)$ test statistic yields that the underlying null hypothesis of 'two breaks' cannot be rejected in favor of 'three breaks'. Hence, no further test is required. As for the UK, it is evident from the table that the $WDmax$ test value is insignificant and hence it is concluded that there is no break in the relationship. Thus the test results indicate the presence of structural breaks in the relationship involving REIT returns, relative price variability and inflation in case of the USA while for the UK there is no structural change in the underlying relation. Finally, the break points for the

USA have been estimated following the procedure of Qu-Perron. The point estimates of these two breaks are May 2005 and May 2009. The corresponding 95% interval estimate of the first break point is from August 2004 to February 2006, and that for the second is from August 2008 to February 2010.

Explanations for these two breaks for the USA could be the following. The first break date is close to the middle of the year 2005, which coincides with the period of bubble in the real estate market. In that period real estate price peaked its high, causing high fluctuations in all the series. Though the bust in the real estate market bubble might have happened over a period of time during the years 2008 and early part of 2009, empirical finding on the structural break test and the subsequent point estimate of break point show 2009:M05 to be the break month. Two reasons can be given for this. First, this is a point estimate of the break month. The interval estimate includes this month, as already mentioned. Second, the underlying model in this context considers structural break in the relationship. Hence, the dynamics of the other variables might also have played some role in determining this break month.

In case of the UK, as already stated, there is no evidence of any structural break in the relationship involving these variables though it is obvious from the test results in Table 2.5 that each of the individual series has one or more structural breaks. This may be due to the existence of 'co-breaking' in the variables which explains that the estimation of relationship may cancel the common features that exist in the variables concerned (see, Hendry (1996); Hendry and Mizon (1998); Clements and Hendry (1999); and Hendry and Massmann (2005) for details). Further, as suggested by Hendry (1996), it is due to co-breaking that in spite of structural breaks that appear in many macroeconomic variables, their linear combination may not displays structural breaks.

Table 3.2 reports the estimation results of the three-variate VAR models separately for each of the three regimes for the USA, and the full sample for the UK. The orders of lag in these VAR models have been selected on the basis of AIC and BIC criteria both of which produced the same lag value. Accordingly, the selected lag orders are 4, 2, and 2 for the first, second and third regimes

Table 3.2 Estimated coefficients of the VAR model in the USA and the UK

Parameter	The USA			The UK
	Regime 1(i.e., *j=1*) (1990M01-2005M05)	Regime 2(i.e., *j=2*) (2005M06-2009M05)	Regime 3(i.e., *j=3*) (2009M06-2013M12)	Full sample period (1990M01-2013M12)
φ_1	-0.18	0.61	-1.04	5.79**
φ_1^{11}	0.00	0.27*	-0.19	0.15*
φ_1^{12}	-1.94	-2.67	-4.69	-0.59
φ_1^{13}	0.90*	0.28	2.10*	-2.54**
φ_2^{11}	0.08	-0.45**	-0.21*	0.06
φ_2^{12}	1.21	6.03	0.85	1.01
φ_2^{13}	-0.46	-0.99	1.17	-2.00
φ_3^{11}	-0.03			0.11
φ_3^{12}	-0.19			0.42
φ_3^{13}	-0.03			-1.65
φ_4^{11}	-0.04			
φ_4^{12}	0.37			
φ_4^{13}	0.54			
φ_2	0.19**	0.22	0.13*	0.07
φ_1^{21}	-0.00	0.01	0.00	-0.00
φ_1^{22}	0.33**	0.53**	0.35*	0.15*
φ_1^{23}	-0.04**	-0.03	-0.06	-0.04
φ_2^{21}	0.00	0.00	0.00*	0.00*
φ_2^{22}	-0.15	-0.27	-0.12	0.13*
φ_2^{23}	-0.02	0.00	0.04	0.03
φ_3^{21}	-0.00			0.00
φ_3^{22}	0.16*			0.08
φ_3^{23}	-0.01			0.03
φ_4^{21}	-0.00			
φ_4^{22}	0.02			
φ_4^{23}	0.04**			
φ_3	0.67**	1.58**	0.83**	0.612**
φ_1^{31}	0.00	-0.07**	0.00	-0.00
φ_1^{32}	-0.34	-1.65**	-0.21	0.05
φ_1^{33}	0.36**	0.38**	0.02	0.10
φ_2^{31}	0.00	0.09**	0.08**	-0.00
φ_2^{32}	0.66	0.98	0.48	0.23
φ_2^{33}	-0.10	0.05	0.13	-0.01
φ_3^{31}	-0.00			-0.00
φ_3^{32}	-0.08			-0.08
φ_3^{33}	0.08			0.19**
φ_4^{31}	-0.00			
φ_4^{32}	-0.41			
φ_4^{33}	-0.23**			

Note: '*', '**', and '***' indicate significance at 10%, 5%, and 1% levels, respectively.
'1', '2', and '3' in the superscripts for REIT returns, inflation, and relative price variability variable, respectively whereas subscripts '1', '2', '3', and '4' refer to lag values.

respectively for the USA, while it is 3 for the UK. From this table, the results indicate that neither in the USA nor in the UK inflation affects REIT returns. On the other hand, relative price variability has significant effect on REIT returns in both the countries. For instance, in the USA, RPV positively affects REIT returns in both the first and third regimes while in case of the UK, RPV has negative effect on REIT returns. These findings suggest that the causal relationship between inflation and REIT returns is spurious, and the effect of inflation on REIT returns appears to proxy for the effect of relative price variability on REIT returns. However, it is important to note that the effect of RPV on REIT for both the countries is contrasting in nature. In case of the USA, this effect is positive and the coefficient values are 0.9 and 2.10 in first and third regimes, respectively. In contrast, this effect is negative and the coefficient value is -2.54 for the UK. Eaton (1980) have argued that RPV may have positive effect on the return of an asset if the elasticity of demand of this asset and marginal propensity to consumption from the returns of this asset are large. Since returns from real estate asset have some impact on the level of future consumption (see, Brayton and Tinsley (1996), for instance) it is expected to have positive relationship between RPV and REIT returns. The negative effect of RPV on REIT in the UK is reflection of negative effect of RPV on output which, in turn, lowers the returns from REIT. The negative effect of relative price variability on output is due to misallocation of resources caused by the increased relative price variability (see, for instance, Barrow (1976); and Cukierman (1982), for further details).

Looking at the entries in Table 3.2 it is found that significant negative relation involving inflation and relative price variability exists for both the USA and the UK. Despite the existence of a large body of empirical studies reporting positive relationship (see, Parks (1978); Lach and Tsiddon (1992); Parsley and Wei (1996); Debelle and Lamant (1997), for details) a number of studies have supported a negative relationship between RPV and inflation also. For instance, Reinsdorf (1994) found this relationship to be negative during 1980s in the USA. Fielding and Mizen (2000) and Silver and Ioannidis (2001) reported the same for several European countries. They argued that this result is consistent with the fact that the law of one price tends to hold more strongly with higher inflation. In other words, if firms make adjustment to prices towards desired levels during inflationary period then price dispersion may fall. In that case relative price variability will be negatively related to inflation. Further, Rogers and Jenkins (1995) and Engel and Rogers (1997) support the hypothesis that there are frictions to the price setting process, justifying a negative relationship between price variability and inflation.

Finally we report the results of impulse response analysis involving REIT returns, RPV and INF. In the standard VAR set-up with these three variables, REIT has been kept last in order with the understanding that REIT reacts directly to the changes in RPV and INF. Figures 3.1 and 3.2 display the estimated impulse response of REIT returns to structural innovation of RPV, INF, and REIT returns itself in the USA for the different regimes and in the UK for the full sample period, respectively. In general, the main findings can be summarized as follows. For the USA, corresponding to one-standard deviation structural innovation of RPV, REIT returns increase and then fall, with the effect being less persistent. The effect is more or less the same in the first and third regimes while in the second regime the immediate effect of RPV on REIT returns is negative, and then it rises sharply to reach its initial value at the end of second month. In case of the UK, the effect of RPV shock on REIT returns is strong. REIT returns fall initially, and then rise steadily reaching the initial value after about nine months. As regards the effect of structural one-standard deviation innovation of INF on REIT returns, it is observed from both the Figures 3.1 and 3.2 that the effect is quantitatively quite small except for the second regime in the USA. Finally, it may be noted that the effect is not very persistent in both the countries.

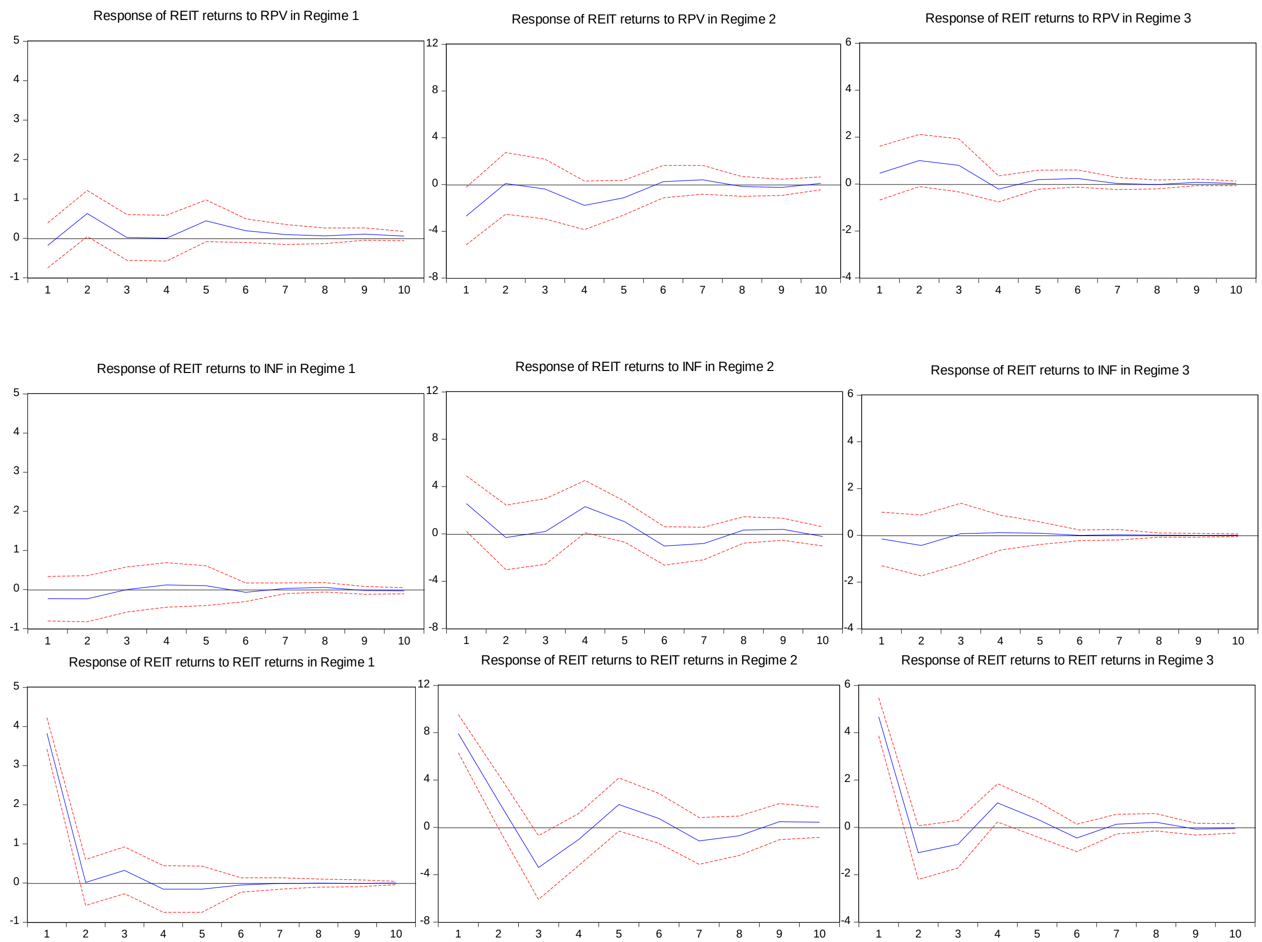

Figure 3.1 Impulse response of REIT returns to structural one S.D. innovation ± 2 S.E. in the three regimes in the USA

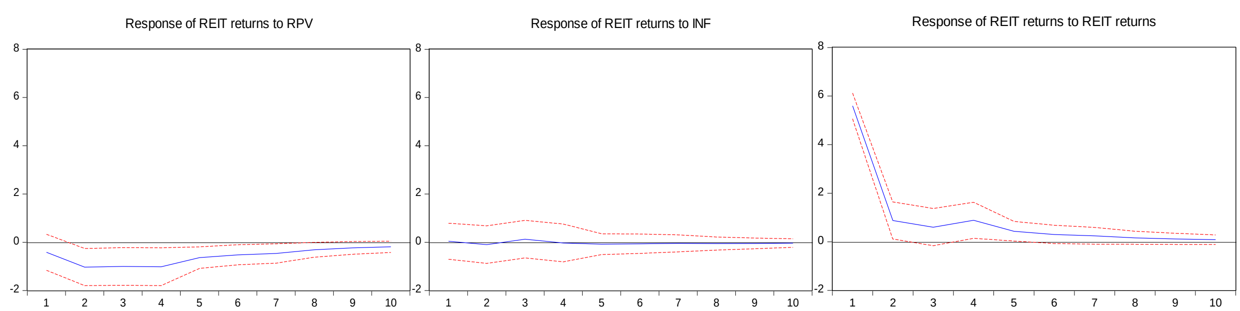

Figure 3.2 Impulse response of REIT returns to structural one S.D. innovation ± 2 S.E. in the UK

3.4 Conclusions

In this chapter, we have re-examined the anomalous relationship between REIT returns and inflation by considering structural breaks and including relative price variability. This has also helped us to study the effects of relative price variability and inflation on REIT returns. The findings show that the anomalous negative relation between REIT returns and inflation appears to proxy for the effectiveness of relative price variability on REIT returns. We have also found that the effect of relative price variability on REIT returns is positive and different across the three different regimes in the USA while it has remained unchanged in the UK over the entire sample period of February 1996 to December 2014. In other words, we have found multiple structural breaks in the relationship involving REIT, RPV and INF in the USA, whereas in the UK, there is no such structural change. It is also important to note that relative price variability and inflation is negatively related in both the countries. Our findings have important policy implications. For instance, the finding of increased relative price variability having positive effect on REIT returns in the USA combined with the observation by Kaul (1990) *viz.*, that RPV affects stock returns negatively, suggests that investors can diversify their portfolios and maximize their returns by investing more in REIT market than in any other stock market.

CHAPTER 4

RELATIONSHIP BETWEEN REIT RETURNS AND INFLATION IN PRESENCE OF RELATIVE PRICE VARIABILITY AND OUTPUT GROWTH: A REGIME-SWITCHING APPROACH

4.1 Introduction

In the preceding chapter, we examined the relationship between REIT returns and inflation by including relative price variability and allowing for structural breaks in the relationship. In this chapter, we consider the other modeling approach mentioned in Section 1.2.1 of Chapter 1 *viz*. regime-switching model along with inclusion of relative price variability and a new variable representing fundamental economic activities *viz*., output growth. To be more specific, the purpose of this study is to examine whether the fundamental economic activities, such as industrial production, contribute to this negative relationship both directly and through the effects of relative price variability on REIT returns in a modeling framework which is regime-based. This consideration to relative price variability is pertinent for the explanation of the REIT returns-inflation relationship primary for two reasons. First, relative price variability may have adverse effects on the economy and second, it may be positively related to both unexpected and expected inflation (see, Kaul (1990), for instance). Further, it is very likely that the state of the market has an important role in determining this REIT returns-inflation relationship. This has indeed been emphasized by Bernanke and Gartler (1995) who have argued that it is important to study empirically the REIT returns-inflation relationship under different REIT market conditions.

It may be pointed out that from modeling consideration, this study extends our current understanding about the relationship between inflation and REIT returns by introducing the role of regime switching behavior in explaining the anomalous nature of this relationship. Regime switching models have been applied to study real estate markets in very few studies only. For instance, Lizieri et al. (1998) used a threshold autoregressive model for the USA and the UK, and found that two distinct regimes exist in case of REITs. Liow et al. (2005) have identified regime switching behavior in international REIT markets.

Keeping in mind the primary objective of this study, we have applied both the observed and unobserved regime switching models. In particular, we have used threshold vector autoregressive (TVAR) model and the Markov switching vector autoregressive (MSVAR) model. The TVAR model is in line with the fact that movements in the REIT returns could alter the interaction among the variables. On the other hand, Markov-switching structure allows characterization of the time series dynamics in different unobserved states. The VAR structure takes care of possible endogeneity in the relationship among the variables concerned. To the best of our knowledge, regime switching model has not been applied in any earlier study on the relationship between REIT returns and inflation although the use of this kind of model is quite common for modeling many economic and financial variables. To cite a few important instances on the later, mention may be made of Hamilton (1989) who showed that the aggregate output in the US can be characterized by such a model. Raymond (1997), and Cologni and Manera (2006) applied this model to analyze the relationship between oil price shocks and business cycles in the United States (see also, Froot and Obsrfeld (1991); Liu and Mei (1992); Cai (1994); Liazieri and Satchell (1997); Driffil and Sola (1998); Bollen et al. (2000); Hansen and Poulsen (2000); Duan et al. (2002); Cheung and Edlandsson (2005), for details on some other important applications).

Our main finding in this chapter is that the negative relationship between REIT returns and inflation appears to proxy for the significant effect of relative price variability on output growth and REIT returns. Further, the direction and magnitude of the causal relationship among the variables are different across the different regimes. This chapter is organized as follows. Section 4.2 provides details about the methodology. The estimation results are presented and discussed in Section 4.3. The paper ends with some concluding remarks in Section 4.4.

4.2 Model and Methodology

In this section, first we have discussed about the observed regime-switching model i.e., TVAR model, and then the unobserved regime-switching model as given by the MSVAR model

4.2.1. Threshold Vector Autoregressive (TVAR) Model

As it is quite well-known, this model allows for capturing the asymmetric response to external shocks or the possibility of multiple equilibria. It also facilitates to distinguish between the effects of the variables under different regimes. Following Balke (2000) and Li and St-Amant (2010), TVAR model can be specified as

$$Y_t = \begin{cases} C_1 + A_1^1 Y_{t-1} + A_2^1 Y_{t-2} + \cdots + A_p^1 Y_{t-p} + U_{1t} & if \quad \bar{r}_t^k \leq 0 \\ C_2 + A_1^2 Y_{t-1} + A_2^2 Y_{t-2} + \cdots + A_p^2 Y_{t-p} + U_{2t} & if \quad \bar{r}_t^k > 0 \end{cases} \tag{4.1}$$

where Y_t represents a $(n \times 1)$ vector of stationary endogenous variables, C_j $(j = 1,2)$ represent two $(n \times 1)$ vectors of constants, A_i^j $(i = 1, \dots, p; j = 1,2)$ is the $(n \times n)$ matrix of parameters, U_{jt} $(j = 1,2)$ is the $(n \times 1)$ vector of structural disturbance term and $\bar{r}_t^k$ is the threshold variable. $\bar{r}_t^k$ is defined as the average of the past k values of REIT returns i.e., $\bar{r}_t^k = \frac{\sum_{i=1}^{k} r_{t-i}}{k}$, as suggested by Chen (2009) and Kundu and Sarkar (2016). Obviously, appropriate choice of k is a relevant issue. What we have done is to make several choices of k and then choose that value for which the AIC / BIC value is minimum. The TVAR model is estimated by least squares which minimizes jointly the sum of squared errors.

4.2.2 The Markov-Switching Vector Autoregressive (MSVAR) Model

The MSVAR model, as proposed by Hamilton (1994), allows the structural coefficients and the covariance matrix of the model to be dependent on an unobserved state variable S_t which is assumed to follow a first order Markov chain. The general framework is described by the following equation:

$$\begin{cases} Y_t = x_t \,.\, \beta_{S_t} + u_t & ; \quad t = 1, \dots\dots, T \\ u_t |\, S_t \sim N\left(0, \sum_{S_t}\right) & ; \qquad S_t = \{0,1\} \end{cases} \tag{4.2}$$

where Y_t, as before, is a $(n \times 1)$ vector of stationary endogenous variables, x_t is a $(n \times \overline{np+1})$ vector of p lagged endogenous variables including the intercept term, S_t is an unobserved state (or regime) taking two values, $\beta_{S_t}$is a $(\overline{np+1} \times 1)$ vector of parameters, u_t is an innovation process with a variance covariance matrix $\sum_{S_t}$ assumed to be Gaussian. T is the sample size. The covariance matrix $\sum_{S_t}$ takes the form

$$\sum_{S_t} = \sigma_S^2(S_t) \,.\, I_p. \tag{4.3}$$

Following Hamilton (1994), the transition probability matrix, denoted as P, is defined as

$$P = \begin{bmatrix} \mathbb{P}(S_t = 0 \,|S_{t-1} = 0) & \mathbb{P}(S_t = 1 \,|S_{t-1} = 0) \\ \mathbb{P}(S_t = 0 \,|S_{t-1} = 1) & \mathbb{P}(S_t = 1 \,|S_{t-1} = 1) \end{bmatrix}$$

$$= \begin{bmatrix} p_{00} & p_{01} \\ p_{10} & p_{11} \end{bmatrix}.$$

The maximum likelihood (ML) estimation of the model is based on an implementation of the expectation of maximization (EM) algorithm proposed by Hamilton (1990) for this class of model. The EM algorithm introduced by Dempster et al. (1977) is designed for a general class of models where the observed time series depends on some unobservable stochastic variables – for MSVAR models these are the state variable S_t.

4.3 Empirical Results

In this section we report the empirical findings from both the observed and un-observed regime switching models. As already discussed in Chapter 2, all the variables concerned *viz*., REIT returns, inflation, relative price variability, and output growth are stationary.

4.3.1. TVAR model

TVAR model is linear in nature regime-wise, but it is non-linear over the entire sample. Before estimating TVAR model, it is, therefore, appropriate to test if the overall relationship is nonlinear in nature. To that end, a statistical test has been performed, (see, for details, Lo and Zivot (2001)) where the null hypothesis sets equality of the constant term and the auto regressive parameters across the two regimes, and the alternative is a two – regime TVAR model. The result of this test rejects linearity in favor of the nonlinear model with two regimes. The test statistic value for the USA and the UK are 61.17 and 70.95, respectively, and the null hypothesis of a single linear VAR model is rejected against the alternative of a two-regime VAR model at a very high level of significance with p- value 0.0001. In the literature on threshold autoregressive (TAR) model, the choice of threshold variable is often taken to be a past value of its own. In our case, as given in equation 4.1, is taken to be $\bar{r}_t^k$, where $\bar{r}_t^k$ is the average of the past k monthly returns of REITs i.e., $\bar{r}_t^k = \frac{\sum_{i=1}^{k} r_{t-i}}{k}$. Insofar as choice of the value k is concerned, what we have done is to make several choices of k and then choose the one for which the underlying log-likelihood value for our model is found to be maximum. The two regimes are then classified as ‘bull’ market and ‘bear’ market depending on whether the average of the past k values of REIT returns is positive or non-positive.

Estimated values of the parameters from the TVAR model for the USA and the UK are given in Tables 4.1 and 4.2, respectively. Based on both the AIC and BIC criterion, the lag length of the estimated TVAR model has been found to be 2 for the USA and 1 for the UK. The first column of both the tables depicts the scenario of bear market where the average of past values of REIT returns is non-positive and the second column those of bull market situation where the average of past returns is positive. The bear market regime for both the countries reveals that output growth affects REIT returns positively and significantly. In this market situation, investors generally start moving their money out from REIT equities and invest them into fixed-income securities until there is a positive sign from the market. When output growth increases, it gives a positive indication to the potential investors. Accordingly, demand for commercial real estate increases and so does for REIT securities as investors wish to buy REIT securities in that favorable market situation. This causes the REIT price to increase with the increase in output growth in the bear market condition.

As regards the effect of relative price variability on REIT returns is found to negative and significant in bear market situation with coefficient value of -2.33 in the UK, while it is not significant in case of the USA. It may be pointed out that we had a similar finding only for the UK in the preceding chapter *viz*., that this effect is negative. Thus, the explanation given there holds here as well i.e., the negative effect of RPV on REIT returns is reflection of negative effect of RPV on output growth, which, in turn, lowers the returns from REIT. The negative effect of relative price variability on production process is due to misallocation of resources caused by the increased

Table 4.1 Estimated coefficients of the TVAR(2) model for the USA

Parameter	Regime 1	Regime 2
C_1	-0.01	0.25
a_1^{11}	0.12	-0.03
a_1^{12}	0.74	0.77**
a_1^{13}	1.31**	0.63
a_1^{14}	-1.82	-2.28
a_2^{11}	-0.23***	-0.03
a_2^{12}	-0.77	0.05
a_2^{13}	2.324***	-0.05
a_2^{14}	3.40	1.25
C_2	1.44**	0.85***
a_1^{21}	-0.03***	0.00
a_1^{22}	0.59***	0.21***
a_1^{23}	0.10	-0.18
a_1^{24}	-1.41**	-0.28
a_2^{21}	0.06***	0.03***
a_2^{22}	-0.24***	0.13**
a_2^{23}	-0.65***	-0.30***
a_2^{24}	0.39	0.70***
C_3	0.49***	0.19**
a_1^{31}	-0.01***	0.00
a_1^{32}	-0.17***	-0.02
a_1^{33}	0.10	0.05
a_1^{34}	0.71***	0.00
a_2^{31}	0.00	0.01
a_2^{32}	-0.10**	0.01
a_2^{33}	0.23***	0.16***
a_2^{34}	-0.88***	-0.15
C_4	0.03	0.24***
a_1^{41}	0.00***	-0.00
a_1^{42}	-0.01	-0.05***
a_1^{43}	0.03	-0.04
a_1^{44}	0.50***	0.03***
a_2^{41}	0.00**	0.00
a_2^{42}	0.07**	0.01
a_2^{43}	0.12***	0.00
a_2^{44}	0.00	-0.24***

Note: '*', '**', and '***' indicate significance at 10%, 5%, and 1% levels, respectively.

'1', '2', '3', and '4' in the superscripts for REIT returns, relative price variability, output growth, and inflation variables, respectively whereas subscripts '1' and '2' refer to lag values.

Table 4.2 Estimated coefficients of the TVAR(1) model for the UK

Parameter	Regime 1	Regime 2
C_1	2.95***	1.77
a_1^{11}	0.16**	0.11
a_1^{12}	-3.86***	-0.52
a_1^{13}	2.68***	-0.11
a_1^{14}	1.76	0.15
C_2	0.85***	0.76***
a_1^{21}	0.00	-0.02***
a_1^{22}	0.04	0.18**
a_1^{23}	-0.10***	-0.01
a_1^{24}	0.20	-0.02
C_3	0.08	0.25
a_1^{31}	-0.03***	-0.00
a_1^{32}	-0.19*	-0.15
a_1^{33}	-0.17	-0.32***
a_1^{34}	0.28	-0.62
C_4	0.21***	0.11***
a_1^{41}	-0.00	-0.00
a_1^{42}	-0.10*	-0.04
a_1^{43}	0.04**	-0.02
a_1^{44}	0.27***	0.17**

Note: '*', '**', and '***' indicate significance at 10%, 5%, and 1% levels, respectively

'1', '2', '3', and '4' in the superscripts for REIT returns, relative price variability, output growth, and inflation variables, respectively whereas subscripts '1' and '2' refer to lag values.

relative price variability (see, for instance, Barrow, 1976; and Cukierman, 1982). This negative relationship is evident from the result for the UK where the relative price variability is found to have negative and significant impact on output growth in the bear market with the coefficient value being -0.19 .

In case of bull market, we find from results that there is no significant effect of output growth on REIT returns in case of both the USA and the UK. It may be due to the fact that investors have a tendency to demand more REIT equities in the bull market situation even if output growth does not change. But it is worth noting that the effect of relative price variability on REIT returns is positive and significant in this regime for the USA. In Chapter 3 also, we made the same conclusion on this effect for the USA. In this situation, increased relative price variability may give negative signal to the investors of other equity markets as increased relative price variability causes misallocation of resources. This creates more demand in the REIT equity market in the bull market situation. Hence returns on REIT increase with the increase in relative price variability in the bull market. The negative impact of RPV on output growth in the USA is also evident from Table 4.1 where the coefficient value of 0.17 is found to be highly significant.

Another important finding is that the effect of inflation on REIT returns is insignificant in both the regimes in both the countries. This finding supports the view of Glascock et al. (2002) who showed that effect of inflation is negative if fundamental economic activities are not taken into account while this effect is insignificant if these are included in the analysis. Although we have a different modeling framework, we find, in our study also, that with the inclusion of output growth and relative price variability, the effect of inflation on REIT returns is insignificant.

4.3.2 MSVAR model[3]

In the modeling framework considered in this chapter, we have imposed switching specification in a VAR framework. Hence, as in case of TVAR model in preceding section, it is relevant and important to test explicitly whether or not we can reject the null hypothesis of a single linear model in favor of the Markov switching model. Though in this study the specification of regime switching is used in a VAR framework, this test is available at the univariate level only. Accordingly, we perform this test for each of the variables separately. The null hypothesis sets the equality of the intercept and autoregressive parameters across all the assumed regimes. It is noteworthy that the usual likelihood

[3] In this section, we have presented the results of MSVAR model for the USA only as the underlying iterative procedure for obtaining the estimates did not converge in case of the UK.

ratio (LR) test has a problem because of the presence of nuisance parameters. To be specific, the parameters p_{11} and p_{22} are not identified under null hypothesis, and hence the conventional LR test does not yield the standard asymptotic distribution although many researchers continue to use the LR test to draw their conclusions (see, Hamilton (1996), for details). We have, however, used the Hansen (1992, 1996) approximation of the LR test statistic. This test requires computing the constrained estimates of the likelihood function over a grid of possible values for the set of parameters which do not converge to any fixed population parameters under the null hypothesis of a single linear model.

Results of testing for the Markov switching model for each of the four variables are presented in Table 4.3 for the USA. The values of standardized LR test statistic show that the null hypothesis of a single linear AR model is rejected in favor of the Markov switching model for all the variables except inflation. For the RPV series, the model under the null i.e., a single AR(1), model is rejected at 1% level of significance whereas for REIT and IIPG the null model of AR(2) is rejected at 5% and 10% levels of significance, respectively[4].

Table 4.3 Results of the LR test for the Markov regime-switching model

Variable	Model under null	Switching parameters	Standardized LR test statistic value	p-value
REIT	AR(2)	(μ, φ_2)	2.992	0.05
RPV	AR(1)	(μ, φ_1)	9.644	0.00
IIPG	AR(2)	(μ, φ_1)	2.785	0.09
INF	AR(1)	(μ, φ_1)	2.211	0.31

Note: μ is the intercept term, and φ_1 *and* φ_2 are the first and second-order autoregressive coefficients, respectively.

We now report our findings on the relationship involving the variables considered in this study for the USA. The estimation results of the four-variate VAR model under a two-state MSVAR model are given in Table 4.4, and the smoothed probabilities based on this model are plotted in Figure 4.1.

[4] The appropriate lag values of the underlying AR models have been obtained using usual model selection procedures.

The order of the MSVAR process has been found to be 1 by both the AIC and BIC criteria. From the estimated variance-covariance matrices of the two states which are presented in Table 4.5, the first regime is identified as the low variance regime and the second one as the high variance regime since the estimated variance of each of the four variables is higher in state 2 than in state 1. It is estimated that the expected duration of first regime is 7.88 time periods, whereas it is 2.39 time periods for the second regime. The transition probability matrix has been estimated to be

$$\hat{P} = \begin{bmatrix} \widehat{p_{11}} & \widehat{p_{12}} \\ \widehat{p_{21}} & \widehat{p_{22}} \end{bmatrix} = \begin{bmatrix} 0.87 & 0.42 \\ 0.13 & 0.58 \end{bmatrix}.$$

The values indicate that the first state is very persistent while the degree of persistence in the second state is moderate.

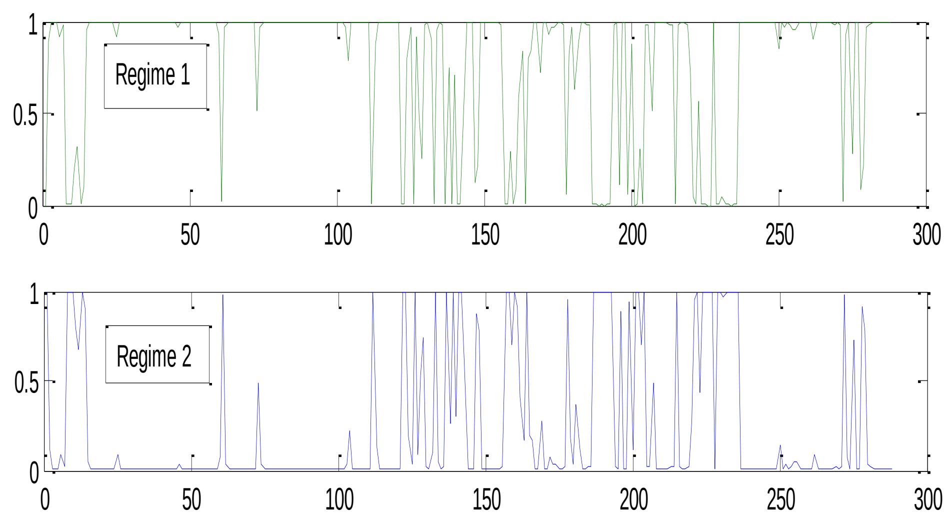

Figure 4.1 Smoothed probabilities for the MSVAR (1) model with REIT, RPV, IIPG, and INF for the USA

Table 4.4 The estimated coefficients of the MSVAR (1) model

Parameter	Regime 1	Regime 2
C_1	-0.14	4.65**
β_1^{11}	-0.02	0.15
β_1^{12}	1.07***	-1.28
β_1^{13}	0.79	3.19***
β_1^{14}	-1.79	2.11
C_2	0.94***	3.10***
β_1^{21}	-0.02**	-0.07**
β_1^{22}	0.31***	0.08
β_1^{23}	-0.08	0.50**
β_1^{24}	-0.58***	-0.22
C_3	0.51***	-0.04
β_1^{31}	0.01	-0.00
β_1^{32}	-0.19***	0.06
β_1^{33}	0.16	-1.33
β_1^{34}	-0.02	0.12
C_4	0.19***	0.23**
β_1^{41}	-0.00	0.01**
β_1^{42}	-0.04***	-0.02
β_1^{43}	0.34***	0.06***
β_1^{44}	-0.03	0.06

Note: '*', '**', and '***' indicate significance at 10%, 5% and 1% levels, respectively.

'1', '2', '3', and '4' in the superscripts for REIT returns, relative price variability, output growth, and inflation variables, respectively whereas subscripts '1' and '2' refer to lag values.

Table 4.5 Estimated variance-covariance matrix of the MSVAR(1) model

State 1				State 2			
16.11***	0.00	0.00	0.00	68.11***	0.00	0.00	0.00
0.00	0.21***	0.00	0.00	0.00	2.35***	0.00	0.00
0.00	0.00	0.22***	0.00	0.00	0.00	1.43***	0.00
0.00	0.00	0.00	0.01***	0.00	0.00	0.00	0.16***

Note: '***' indicates significance at 1% level.

It is evident from the results on the significance or otherwise of the coefficients in the two regimes, as reported in Table 4.4, that relative price variability has differential effects on REIT returns. In the first state which is characterized by low variance, RPV has significant positive effect whereas it is insignificant in the second regime where the variance is high. It is worthwhile to note that in the context of observed regime-switching model RPV also has been found to have significant positive effect on REIT returns in the bull market regime. As discussed in Chapter 3, Eaton (1980) has argued that RPV may have positive effect on the returns of an asset if the elasticity of demand of this asset and marginal propensity to consumption from the returns of this asset are large. Since returns from real estate asset have significant impact on the level of future consumption (see, for instance, Brayton and Tinsley, 1996), it is expected to have positive relationship between RPV and REIT returns. On the other hand, output growth (IIPG) has positive and significant effect on REIT returns in the second regime i.e., the high variance regime. It may be noted that in case of TVAR model where the state variable is observed, we have found similar conclusion in the bear market. From the entries in Table 4.4, it is also evident that RPV has an adverse effect on IIPG in State 1 since the coefficient value is negative (-0.19) and significant. But this effect in case of State 2 is positive (0.06) but insignificant. As discussed earlier, this significant negative effect in State 1 arises mainly because of misallocation of resources and efficiency loss due to this misallocation. This has been as mentioned earlier, *inter alia*, by Barro (1976) and Cukierman (1982) who showed analytically that increased relative price variability causes efficiency loss to the extent that it leads to increase in the dispersion of actual output around the full employment output level. Empirical evidence shows that the relationship is indeed negative which lends support to the theory. However, the causal relationship between RPV and IIPG is not uni-directional. Output growth also has significant positive effect on RPV in the second state while in the first state the effect is insignificant. In other words, IIPG has differential effects on RPV. Finally, it is important to note that the effect of inflation on REIT returns is insignificant in the MSVAR model. It is thus evident from this study that the observed negative relationship between REIT returns and inflation appears to proxy for the significant effect of RPV on both output growth and REIT returns. It is also worth mentioning that unlike some of the previous studies (see, Choi (2010), for details), this study finds that the relationship between relative price variability and inflation is negative and that it is not stable over the entire sample period.

4.4 Conclusions

As in the preceding chapter, in this chapter also we have re-examined the relationship between inflation and REIT returns, but in the framework of a regime switching model where additional macroeconomic variables of relevance and importance *viz.*, output growth and relative price variability have been included. The evidence shows that the anomalous negative relationship between REIT returns and inflation appears to proxy for the effectiveness of relative price variability and output growth on REIT returns. The effect of inflation on REIT returns is thus found to be insignificant in presence of these two variables. We have also found that the REIT returns–inflation relationship which also includes the other two variables *viz*., relative price variability and output growth, is non-linear in nature. It is evident from both TVAR and the MSVAR models that output growth has positive impact on REIT returns in a market condition where the average values of the past returns on REIT are non-positive and variance is high. On the other hand, effect of RPV on REIT returns are positive and significant in case of the USA while this effect is negative and significant where the average values of the past REIT returns is positive with low variance.

Our findings have important policy implications. For instance, in case of the USA, the finding of increased relative price variability having positive effect on REIT returns combined with the observation made by Kaul (1990) *viz.*, that RPV affects stock returns negatively, suggests that investors can diversify their portfolios and maximize their returns by investing more on REIT market than on any other stock market.

CHAPTER 5

INTERDEPENDENCES BETWEEN REIT RETURNS, A MONETARY POLICY VARIABLE AND OUTPUT GROWTH: A STRUCTURAL VAR ANALYSIS

5.1 Introduction

Over the last few decades, monetary policy has become the main instrument in the stabilization of inflation and output. To some extent, the achievement of low and stable inflation has not simultaneously brought about a more stable asset price environment. Central banks have faced daunting challenges due to swings in various types of asset prices. The importance of monetary policy changes and the transmission of information contained therein to asset markets has been a subject of interest in a number of papers in recent years. Cecchetti et al. (2000) pointed out that monetary policy makers should react to perceived misalignments in asset prices to reduce the likelihood of asset price bubbles forming. Bernanke and Gertler (1999, 2001) argued that monetary policy should react to asset price movements only to the extent that they affect expected inflation. Rigobon and Sack (2001) found that short term interest rates react significantly to movements in broad equity price index, reflecting the expected endogenous response of monetary policy to the impact of stock price movements on aggregate demand. Filardo (2000) also studied the role of asset prices in monetary policy and drew a similar conclusion. On the other hand, in a paper in 2004, Rigobon and Sack found the reverse causality where asset prices react to changes in monetary policy.

Moreover, the recent US sub-prime crisis and the subsequent financial crisis have increased the focus on asset price developments, especially among central bankers. This is primarily due to collateral role of asset prices. Since this crisis was triggered by the busting of asset prices, which led to, *inter alia*, negative real effects, asset prices can be important sources of macroeconomic fluctuations that the central bank may want to respond to (see, Bernanke et al. (2000); Bernanke and Gertler (1989), for details). Goodhart (2000) and Bernanke and Gertler (2000) also expressed the view that monetary policy should react to asset price movements.

In this chapter, we have examined the relationship involving REIT returns, a monetary policy variable, and output growth taking into account the potential contemporaneous interdependences between them in a limited way by using structural VAR model with simple recursive restrictions. The output growth variable is included to capture the business cycle effect in these relationships. The inclusion of output growth, in this context, is also justified on the ground that one of the important goals of monetary policy changes is to affect output growth, and financial market prices reflect the expectation of market participants about future economic and monetary developments. There are some studies that have used the conventional VAR model to identify the interdependences between monetary policy variables and securitized real estate (see, Mc Cue and Kling (1994); Anderson (2011); Chou and Chen (2014), for details). However, the conventional VAR model does not allow for capturing the contemporaneous interaction between monetary policy variables and REIT returns. It is important to examine the contemporaneous interaction between monetary policy variables and REIT returns as financial variables show quick responses to monetary policy changes.

Most of such studies have examined the channels by which the effects of monetary policy shocks on REIT returns are explained without considering the fact that shock of REIT returns may also have some effect on the monetary policy variables. It may be pointed out that these studies generally lacked consensus regarding the nature of REITs as REITs are investment vehicles with shares that trade on exchanges and investment that goes directly into the real estate. Also REITs must payout at least 90% of their tradable income in shareholders' dividends each year, which are considered to be high-yield investment. The main attraction associated with REITs' investment is the high dividend payouts. If the interest rate increases, government Treasury bond and other bonds might become attractive to the investors. This is because investors will prefer holding government securities with very little default risk as against REITs if the yields are the same. Therefore, as an instrument of high-yield investment, REITs may have greater sensitivity to interest rate increase.

Moreover, the REIT price spikes, in particular, and unstable housing prices, in general, can push Fed to respond to such price movements with accommodating monetary policy. For example, either due to the exuberant expectations about the economic prospects or due to structural changes in the real estate market, a credit boom might begin that can lead to increase in the demand for REIT assets, and hence, rise in their prices. This rise in the REIT asset values may encourage further lending against these assets and consequently, an increase in demand. Also, due to some kind of irrational exuberance, the credit standards may ease as the lenders become less concerned about the ability of the borrowers to repay loans, and instead might rely on further appreciation of the REIT assets to protect themselves from losses. However, at some point, the exuberance bubble might burst, leading to the reversal of the feedback loop affecting credit supply, asset prices, eroding the balance sheets of the financial institutions, diminishing credit and investment across a wide range of these REIT assets. In the extreme, the collapse of the REIT prices may impede the overall operation of the financial system. Especially with 2008 US financial crisis at the hindsight, it is difficult to reconcile the fact that Fed will remain unresponsive to any such REIT boom. Therefore, capturing both way interactions between monetary policy and REITs returns is important. And, in this chapter, this is what has been done through structural VAR model, so that the contemporaneous effects of shocks on the variables through impulse response analysis can as well be studied.

In this study, the monetary policy variable is represented by term structure or interest rate spread which is actually the difference between the short-term interest rate and the long-term bond yield. The short term interest rate is taken to be the Federal funds rate and the interbank rate for the USA and the UK, respectively. In this context, mention may be made of Chen and Tzang (1988), Liang et al. (1995), Sanders (1997), He et al. (2003), and Bredin et al. (2007) who have studied the sensitivity of short term interest rate to REIT returns. However, in order to fully understand the projection of REIT prices over the longer horizon, knowledge of what is called the "forward looking variables" is the key. Mei and Saunders (1995) and Chang et al. (2011) have used the term structure or interest rate spread as a partly forward looking variable, and shown that the effect of term spread on REIT returns is negative. The forward looking variables might include inflation expectation, future real economic activity and asset returns. It might not be possible for the short-term rates to fully reflect information on such forward looking variables. It is well-known that the term structure contains information about future inflation, future real activities as well as asset returns. Thus, it is justified to consider the term structure as a partly forward-looking variable. And with this consideration, term structure or interest rate spread has been included in this analysis.

The relationship involving these three variables *viz*., REIT returns, output growth as measured by IIPG, and interest rate spread has been studied allowing for possible structural changes in the relations, as done in Chapter 3. Since the discussions as to why this modeling approach is appropriate and realistic have already been made in Chapter 3, these are not being repeated here.

This chapter has been organized as follows. The next section discusses about the model methodology. Section 5.3 presents the empirical results and also the analysis from impulse response function. The chapter closes with some concluding remarks in Section 5.4.

5.2 Model and Methodology

As in Chapter 3, we have employed the Qu and Perron (2007) methodology with multiple structural breaks in the relations in this study as well. By applying this methodology, which has been described in Chapter 3, the test of structural breaks in the relations has been performed first. Subsequent estimation of the relations involving these variables for each sub-period has been done by structural VAR model. In what follows, the structural VAR model is described briefly.

The structural VAR model considered in this chapter consists of three variables *viz.*, output growth which is measured by $IIPG$, first difference of interest rate spread (ΔIRS)[5] and REIT returns ($REIT$). Let Y_t represent the (3× 1) vector of these variables ordered as follows i.e., $Y_t = [IIPG_t,\ \Delta IRS_t,\ REIT_t]^/$.

Structural form of the VAR model with lag p for a process Y_t is given as,

$$A_0 Y_t = \gamma + A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + u_t \tag{5.1}$$

where the vector of variables of interest, Y_t, is a (3×1) column vector for the t^{th} observation. γ is a (3×1) column vector of intercept term, A_0 is a (3×3) matrix of parameters which measures the contemporaneous relationship among the variables, A_k, for $k = 1,2, \ldots, p,$ are (3×3) matrices of coefficients of the lag-dependent variables and u_t is the (3×1) vector of error term with $E(u_t) = 0$, and dispersion matrix $\sigma^2 I_{3\times3}$. It may be stated that the econometric identification of the model is obtained through restrictions on A_0. Assuming that the inverse of A_0 exists, the corresponding reduced form of the above model can be obtained by pre-multiplying equation (5.1) by A_0^{-1}, which takes the form:

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[5] In Chapter 2, we have found that the interest rate spread (IRS) variable is non-stationary, and hence for this study ΔIRS which is stationary, is being used.

$$Y_t = d + \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} + \cdots + \Phi_p Y_{t-p} + \varepsilon_t \quad (5.2)$$

where $d = A_0^{-1}\gamma$, $\Phi_k = A_0^{-1}A_k$, $k = 1,2, \ldots, p$ and $\varepsilon_t = A_0^{-1}u_t$. Φ_k is thus a (3×3) matrix containing the coefficients of lag-dependent variables for the reduced form VAR model. The reduced form errors ε_t are linear combinations of the structural errors u_t $E(\varepsilon_t) = 0$ and dispersion matrix $\Omega = \sigma^2 A_0^{-1}(A_0^{-1})^{/}$.

In structural VAR model, identification of the equations in the model is a practical issue. To deal with this problem, restrictions on the element of A_0 are imposed. To that end, one solution is to specify A_0 to be a lower triangular matrix i.e.,

$$A_0 = \begin{bmatrix} 1 & 0 & 0 \\ a_{21} & 1 & 0 \\ a_{31} & a_{32} & 1 \end{bmatrix} \quad (5.3)$$

This identification condition is essentially a recursive restriction on A_0. It is important to note that the 'orthogonalization' of the reduced-form residuals by applying the Cholesky decomposition is appropriate only if the recursive structure is embodied in A_0, which can be justified on economic grounds. We follow the identification scheme made in Christiano (1999, 2005) where they identify monetary policy shocks by assuming that macroeconomic variables do not contemporaneously react to monetary policy variables, while a contemporaneous reaction from the macroeconomic variables to monetary policy variables is allowed.

Regarding the interaction between REIT returns and our monetary policy variable i.e., interest rate spread, we have imposed two different orderings in the contemporaneous relationship matrix i.e., A_0, with the interest rate spread and REIT returns alternating as the ultimate and penultimate variables. Standard Cholesky decomposition is imposed to account the impulse responses of interest rate spread and REIT returns to a shock on each of interest rate spread and REIT returns. The shocks are normalized so that the shock in interest rate spread increases the interest rate spread by one percentage point in the first month, while, likewise, the REIT returns shock increases REIT returns by one percentage point in the first month.

Thus, we have used two different order specifications where in the first specification monetary policy shock is ordered below the REIT returns shock and the reverse order in the second specification in order to understand the contemporaneous interaction between monetary policy and REIT returns. Further, through this identification condition, we have also assumed that REIT returns shock have no immediate impact on output growth. This is appropriate since, macroeconomic variables, by their nature, usually react to shocks with a lag effect, while REIT returns can respond immediately to a shock in output growth.

5.3 Empirical Results

In this section, first we have reported the test results of the Qu and Perron (2007) methodology regarding structural stability in the relationship involving the three variables. This has been followed by estimation results of the reduced form VAR model. The impulse response analysis are reported at the end of this section.

5.3.1 Test results of Qu-Perron model

It is evident from the Qu-Perron test statistic values reported in Table 5.1 that there is a single structural break in the relations involving REIT returns, output growth, and change in interest rate spread in case of the USA, while no such structural break is found for the UK.

The point estimate of break month for the USA is estimated as April 2007, and interval estimate for the same is 2006:M01-2008:M08. Hence, for the USA, we have done the structural VAR analysis for the pre and post break periods separately.

Table 5.1 Results of the Qu-Perron's structural break test

	$WDmax$ test (up to one break)	$supF_T(2\|1)$	Break month	Interval estimate of break month
The USA	34.32***	32.65	2007:M05	2006:M01- 2008:M08
The UK	21.67			

Note: '***' indicates significance at 1% level.

5.3.2 Estimation results of reduced-form VAR model

Table 5.2 presents the estimated coefficient values for the reduced-form VAR model. We find from this table that there is no lag-interdependences between REIT returns and ΔIRS in both the countries. As regards the lag-interdependences between IIPG and REIT returns, first lag of REIT returns has positive impact on IIPG in the UK whereas in case of the USA, the impact is insignificant. The reverse impact is insignificant for both the countries. Insofar the other lag-interdependences are concerned, the monetary policy variable has significant lag effect on IIPG only in the second sub-period for the USA. Both first and second lag of output growth have significant positive effect on REIT returns in the second sub-period in the USA while in the first sub-period it is not significant. In the UK, also this effect is found to be insignificant. In case of the effect of IIPG on ΔIRS, both first and second lag of IIPG has negative effect on ΔIRS only in the second sub-period in the USA.

Table 5.2 Estimated coefficients of the reduced form VAR (2) model

Parameters	The USA		The UK
	Regime 1 (1990M01-2007M05)	Regime 2 (2007M06-2013M12)	Full sample period (1990M01-2013M12)
d_1	0.07	-0.00	-0.01
φ_1^{11}	0.06	0.25**	-0.28***
φ_1^{12}	-0.00	0.00	0.02***
φ_1^{13}	-0.09	0.20	-0.27
φ_2^{11}	0.21	0.20*	-0.06
φ_2^{12}	0.08	0.01***	0.01
φ_2^{13}	-0.01	-0.28***	-0.06
d_2	1.23	0.80	0.36
φ_1^{21}	0.64	5.58***	0.43
φ_1^{22}	-0.00	0.03	0.16***
φ_1^{23}	-0.78	4.90	-1.91
φ_2^{21}	-1.79	8.24***	0.71*
φ_2^{22}	0.08	-0.34***	0.03
φ_2^{23}	0.85	0.71	0.1.98
d_3	0.02	0.01	0.00
φ_1^{31}	-0.14	-0.12*	0.00
φ_1^{32}	0.00	0.00	-0.00
φ_1^{33}	0.37	0.12	0.43***
φ_2^{31}	-0.10	-0.18**	-0.00
φ_2^{32}	-0.00	0.00**	0.00
φ_2^{33}	-0.13	-0.04	-0.05

Note (i)'*', '**', and '***' indicate significance at 10%, 5% and 1% levels, respectively.

(ii)Superscripts '1', '2', and '3' represent the variables for IIPG, REIT returns, and interest rate spread, respectively.

(iii)Subscripts '1' and '2' refer to order of lag.

5.3.3 Impulse response analysis

The figures depicting the nature of impulse responses of output growth, changes in interest rate, and REIT returns to monetary policy shocks as well as REIT returns shocks under the standard Cholesky decomposition are shown in Figure 5.1 through Figure 5.6. Here the magnitude of each shock has been taken as structural one standard deviation $\pm$ 2 S.E. In case of the USA, since the relationship is structurally stable sub-period wise, this analysis has been carried out for each of these two sub-periods separately. Further, as already stated in Section 5.2, the impulse response analysis has been done for two different orderings of variables for both the countries. It is depicted from Figure 5.1 and Figure 5.5 for the first sub-period in case of the USA and the UK, respectively, the interest rate spread shock has a strong impact on REIT returns which immediately falls for increase in the 100 basis-point of interest rate spread. The REIT returns increases quickly and is back to its previous position at the end of about two and-a-half months. The intuition behind the negative effect of monetary policy shock on REIT returns is that when short-term interest rate falls due to expansionary monetary policy, inflation expectation rises which causes the long-term bond yield to increase. Since long-term interest rate rises and the short-term rate decreases, the interest rate spread increases. As already discussed, the main attraction associated with the REITs investment is that it payouts high dividend, and hence, if the long-term interest rate increases, government Treasury and other bonds might become attractive to the investors. This is because investors will prefer holding government securities as it has very little default risk. Thus, the increase in long-term bond yield shifts the focus of the investors from REITs to government bonds which, in turn, lead to fall in returns from the REIT. Therefore, as high-yield investment, REITs may have greater sensitivity to long-term interest rate.

On the other hand, from Figure 5.2, for the second sub-period in the USA, it is observed that this impact of REIT returns is positive. REIT returns rises immediately by 2 percent for an increase in 100 basis point of change interest rate spread. This can be explained with the evidence of falling short-term interest rate in this phase. It is argued in Chang et al (2011) that the decrease in short-term interest rate increases the interest rate spread, and it is possible for the potential customers of the commercial real estate to depend heavily on the short-term rolling-over loan for finance, which would have significant effect on the amount of commercial real estate rental. Therefore, a cut in the short-term rate might encourage them to switch to higher proportion of short-term financing which is followed by an increase in commercial real estate returns. This leads to a positive sloping yield curve following an increase in returns from REITs.

Looking at Figures 5.3 and 5.6 for the first sub-period in the USA and the UK respectively, it is evident that the immediate impact on interest rate spread due to shock in REIT returns is negative. After that, interest rate spread rises steadily to reach its previous position after the end of two and-a-half months. In case of the USA, this impact is positive in the second sub-period. The effect of REIT returns shock immediately raises interest rate spread by 0.7 percent. The explanation is that rise in REIT asset values may encourage further lending against assets, which in turn, leads to an increase in demand. The increased demand due to wealth channel affects consumption which further leads to increase in the future expectation of inflation. Hence, long-term interest rate increases with the increased future expectation of inflation. This can explain the immediate effect of REIT returns shock on interest rate spread. As regards the nature of effect of a shock in IIPG on REIT returns, it has immediate negative impact in the USA whereas it is positive in case of the UK. On the other hand, a shock in IIPG has immediate positive impact on interest rate spread in the USA while it is negative in the UK.

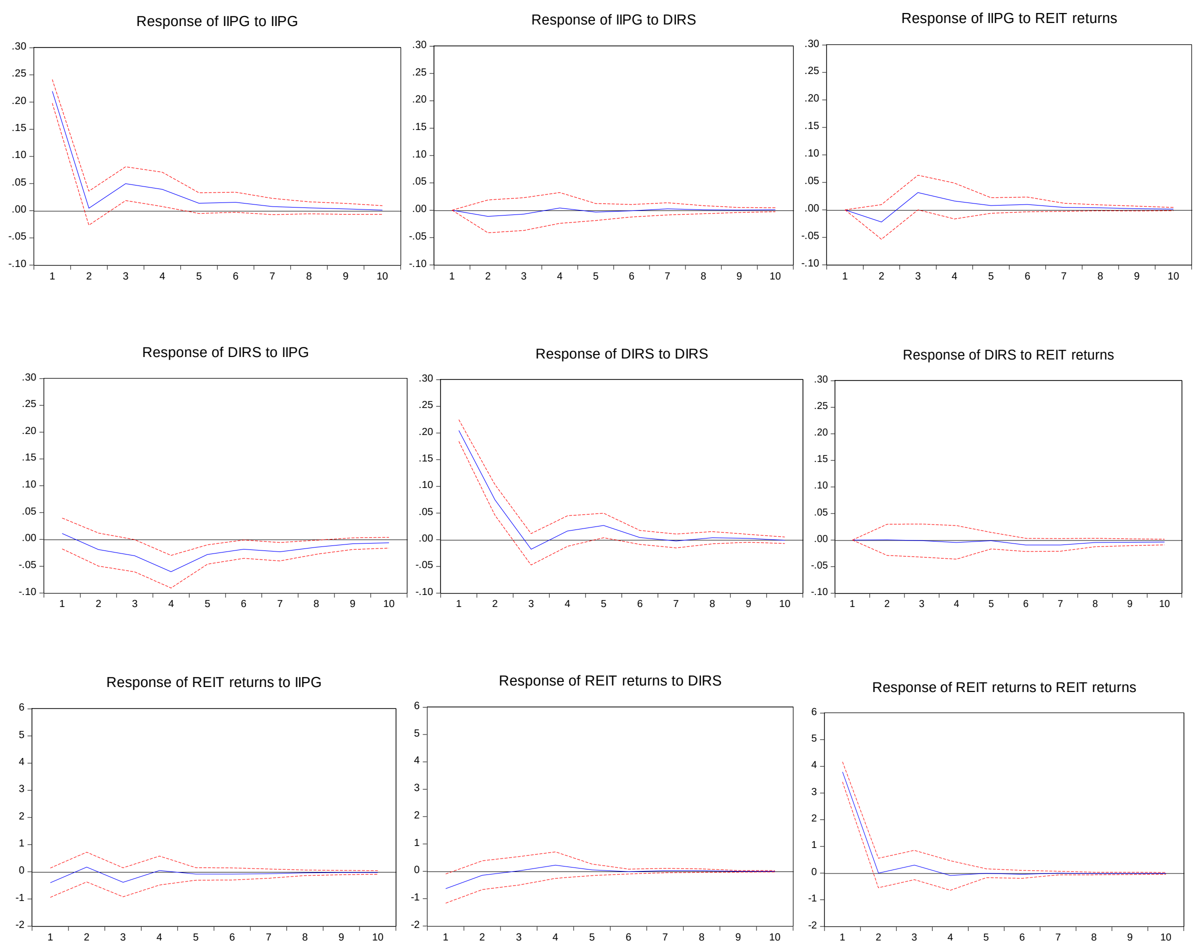

Figure 5.1 Impulse responses of IIPG, ΔIRS[6], and REIT returns to structural one S.D. innovation ± 2 S.E for the first sub-period in the USA (REIT returns variable is placed below the interest rate spread in order)

[6] In all the figures i.e., Figure 5.1 through 5.5, we have denoted ΔIRS as DIRS.

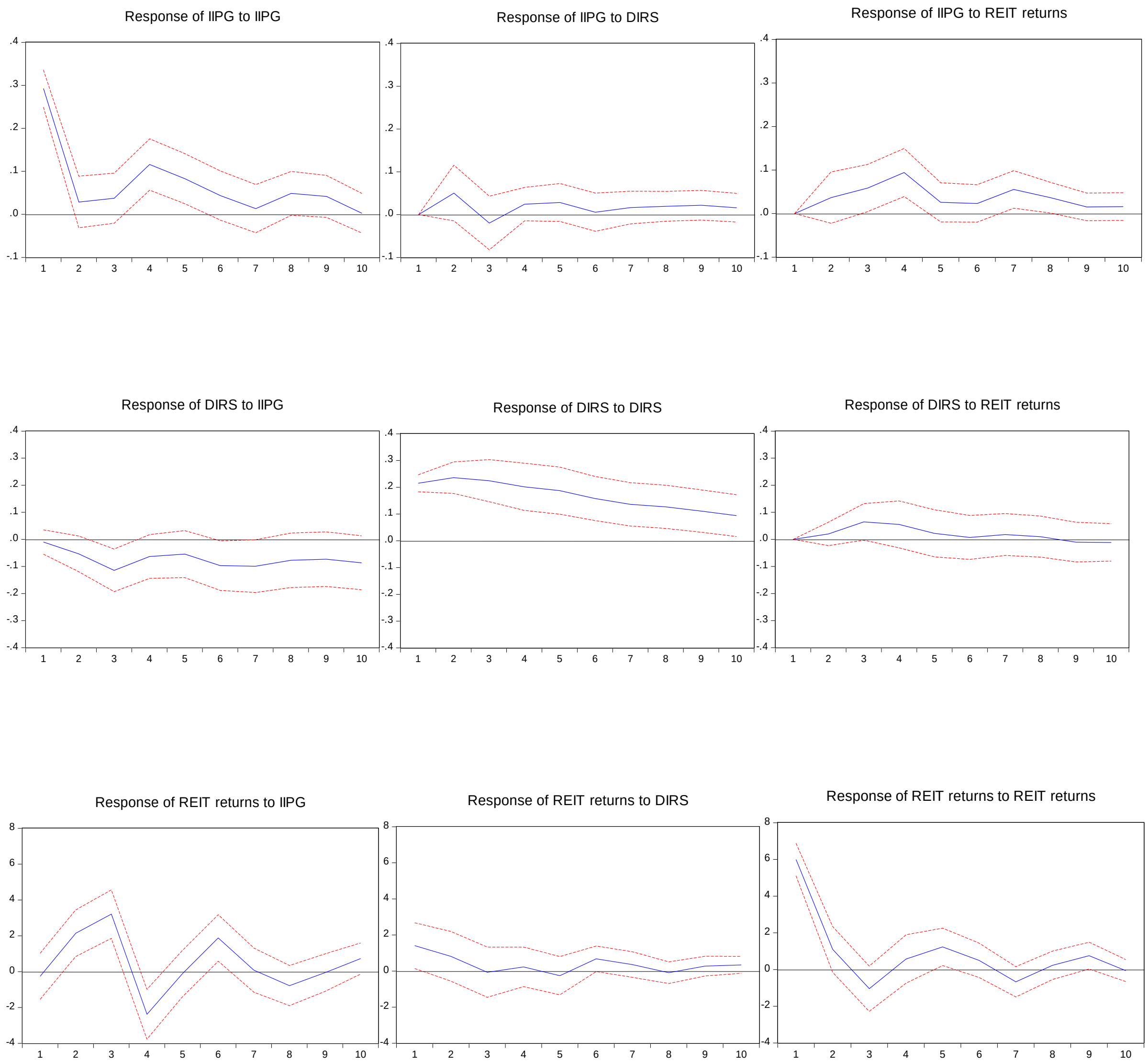

Figure 5.2 Impulse responses of IIPG, IRS, and REIT returns to structural one S.D. innovation $\pm$ 2 S.E for the second sub-period in the USA (REIT returns variable is placed below the interest rate spread in order)

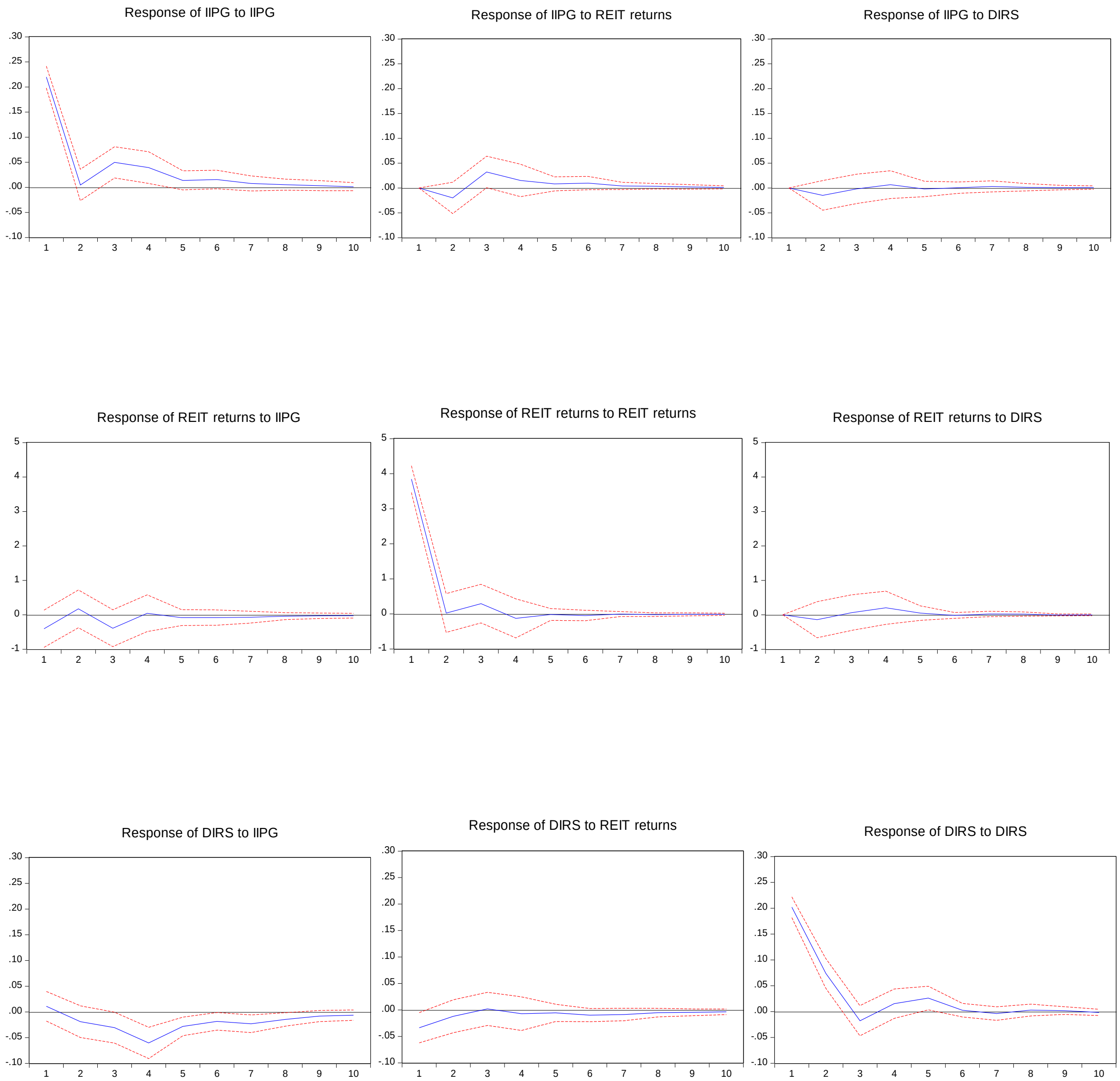

Figure 5.3 Impulse responses of IIPG, IRS, and REIT returns to structural one S.D. innovation ± 2 S.E for the first sub-period in the USA (interest rate spread variable is placed below the REIT returns in order)

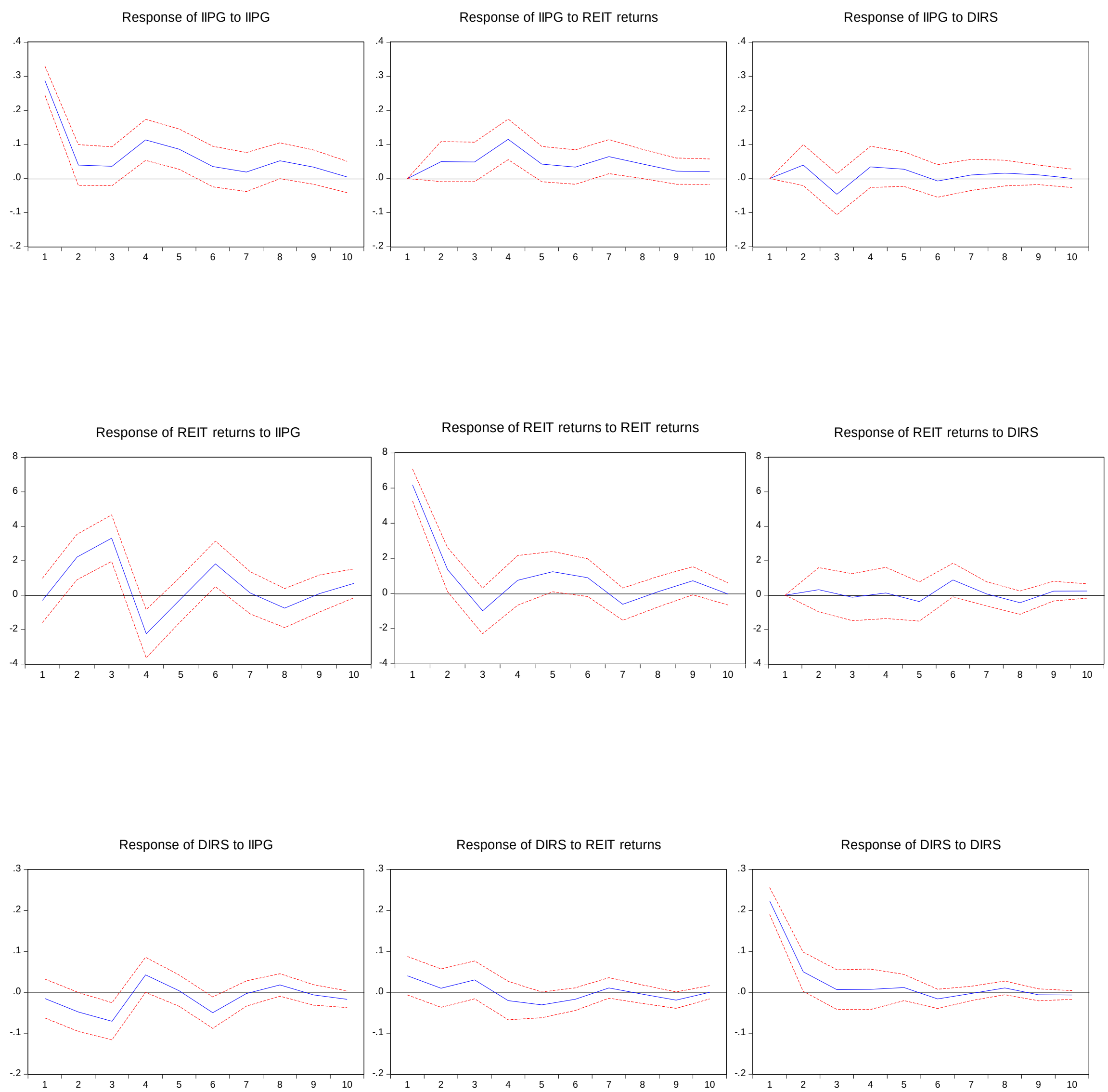

Figure 5.4 Impulse responses of IIPG, IRS, and REIT returns to structural one S.D. innovation ± 2 S.E for the second sub-period in the USA (interest rate spread variable is placed below the REIT returns in order)

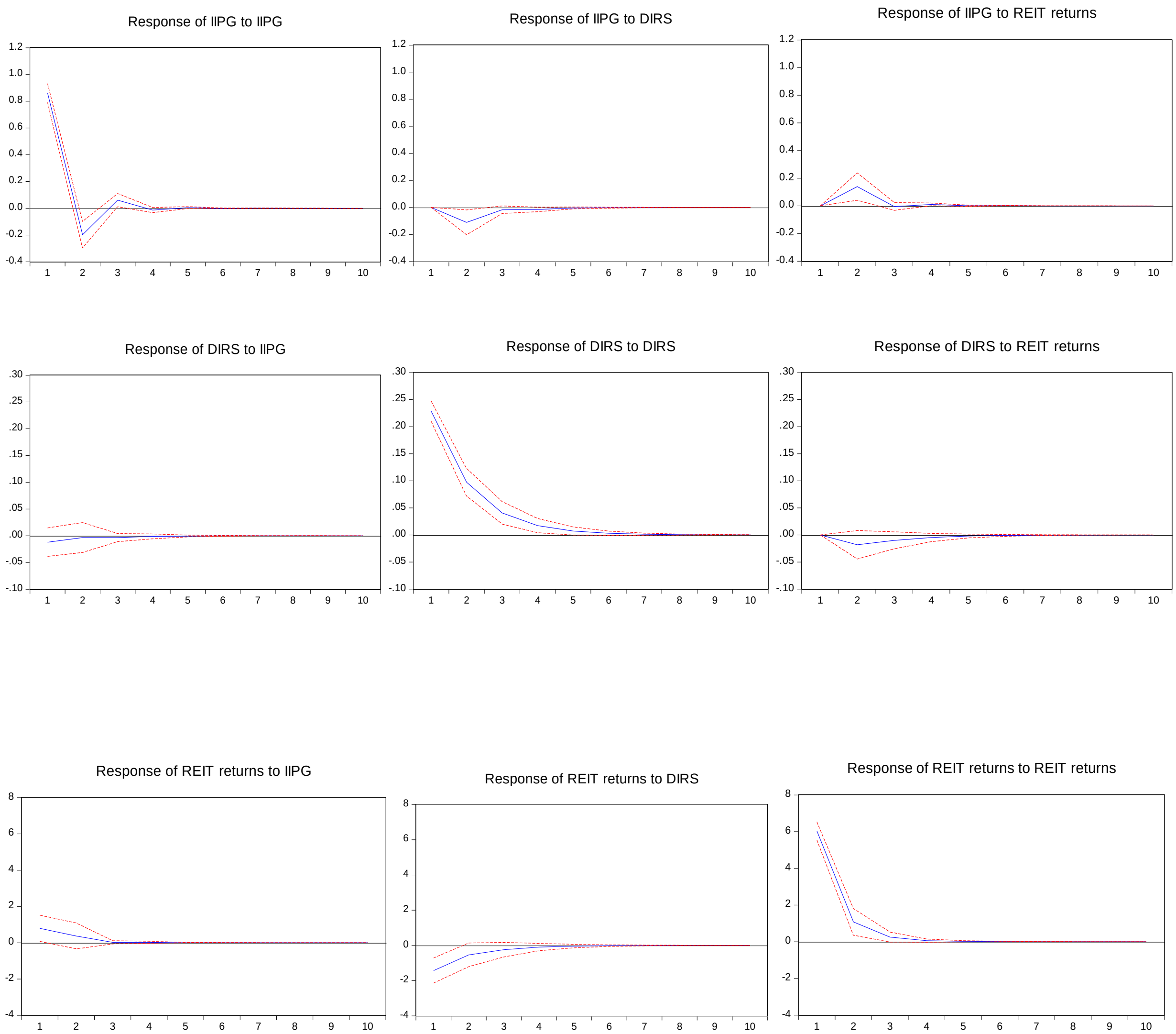

Figure 5.5 Impulse responses of IIPG, IRS, and REIT returns to structural one S.D. innovation $\pm$ 2 S.E for the UK (REIT returns variable is placed below the interest rate spread in order)

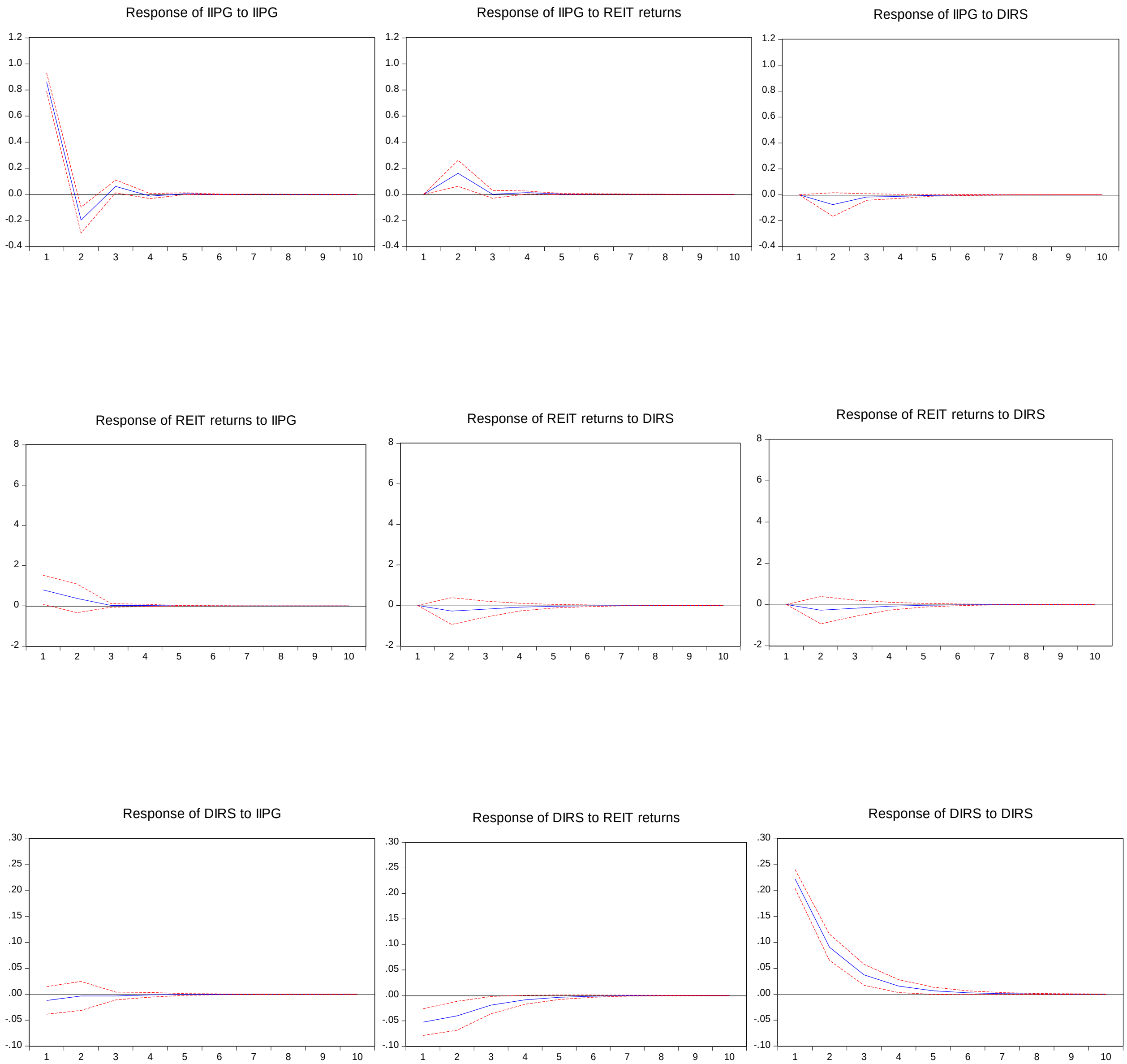

Figure 5.6 Impulse responses of IIPG, IRS, and REIT returns to structural one S.D. innovation ± 2 S.E for the UK (interest rate spread variable is placed below the REIT returns in order)

5.4 Conclusions

In this chapter, we have examined the interdependences between REIT returns, output growth, and a monetary policy variable using interest rate spread as the instrument for monetary policy. This has been done by using the structural VAR model so that the contemporaneous effects of the variables can be captured. Before doing structural VAR analysis, we have examined the structural stability in the relationship among the variables involved in this study. Based on the Qu-Perron test results, it is concluded that there is a break in the relations in case of the USA while there is no such evidence of break for the UK. Further, the impulse response analysis suggests that effect interest rate spread shock on REIT returns is negative for the first sub-period of the USA as well as for the UK while the shock affects positively only in the second sub-period of the USA. On the other hand, a REIT returns shock has immediate negative impact on interest rate spread in the first sub-period for the USA and also for the UK whereas in the second sub-period of the USA the shock has positive impact on interest rate spread. The immediate impact of an output growth shock on REIT returns is negative in the USA while it is positive in the UK.

CHAPTER 6

MEAN AND VOLATILITY SPILLOVERS BETWEEN REIT AND STOCKS RETURNS: A STVAR-BTGARCH-M MODEL

6.1 Introduction

Recent years have seen substantial development of the REIT market in the USA. Much of this increased interest of the investors in REIT market has taken place due to some important factors, which include the improvement of liquidity, strong performance of this asset relative to other assets like stocks, bonds, and also imperfect covariance of REIT with these assets. Further, inclusion of REIT in the mainstream benchmark indices of S&P 500 is also influencing investors' willingness to consider REIT as their multi-asset portfolio. According to Markowitch (1952), investors have to understand that a successful portfolio investment decision depends crucially on the correlation among asset-returns contained there in the portfolio. Subsequent studies which have been mentioned in Section 1.2.4 on the literature review in Chapter 1, give extensive evidence that diversifying across different asset markets, given the low correlation of returns between them, would enable investors to reduce their total portfolio-risk without lowering returns. Hence, REITs have become a popular investment vehicle to be included in a well-diversified portfolio.

Many studies have focused on the characteristics of REIT returns and its relationship with other financial variables for the purpose of portfolio diversification. But, less attention has been paid to studying the volatility aspect of REIT returns. As volatility plays an important role in hedging, derivative pricing, portfolio selection and financial risk control (see, for instance, Zhou and Kang

(2011), for details), studying of volatility and its spillovers across different markets is very important. In the context of equity returns, Kyle (1985) indicated that volatility of price revealed much information than price itself. Following him, a numbers of studies have examined the return-volatility relationship in different financial markets. These studies have documented that risk premium in one market is determined not only by that particular market but also by other financial markets as the capital markets become increasingly integrated. Chan et al. (1992) also suggested that risk premium of an asset depends on its covariance with other assets. Very recently, Kundu and Sarkar (2016) have studied the effect of volatility spillover between stock markets of some emerging and developed economies in the framework of regime-switching VAR as well as multivariate GARCH-M model. Although there are few studies where dependences between REIT returns and stock returns have been studied in the framework of multivariate GARCH (MGARCH) model (see, Cotter and Stevension (2006); Michayluk (2006); Fei et al. (2010); Yang et al. (2012), for details), there are, to the best of our knowledge, no such studies involving REIT and stock returns where regime consideration and incorporation of direct effect of volatility in mean returns have been done in the MGARCH framework. Hence, it has become very important to examine the return and volatility spillovers and conditional correlation between REIT returns and asset returns.

To be specific, in this chapter, we have studied the volatility spillover effect between REIT returns and stock returns in a framework where volatility is directly and explicitly allowed to affect the conditional mean through the incorporation of GARCH-in-mean component. In this study, bivariate GARCH-in-mean (BGARCH-M) model has been used to examine the return and volatility linkages between REIT and stock returns. The advantage of using this model is that it not only provides a framework for analysis of volatility and the accompanying inter–linkages between the assets concerned, but also allows study of own as well as cross market risk–return relationships. By applying this modeling framework, we can address several important issues concerning volatility, some of which are stated below.

(a) Does the volatility of stock market returns transmit to REIT market and affect the volatility of REIT market returns, and also *vice-versa*?

(b) Does the volatility of stock market transmit to REIT market directly through its conditional variance or indirectly through its conditional covariances and also *vice-versa*?

(c) Does a shock in stock market increase the volatility of REIT market, and if so, is the impact the same for negative and positive shocks of the same magnitude?

Insofar as the conditional mean model is considered, we have used the VAR model with consideration to regime-switching behavior. The regime switching behavior of stock returns are very well documented (see, for instances, Lundbergh and Terasvirta (1998); Hamilton (1989); Turner et al. (1989); Hamilton and Susmel (1993); Chkili and Nguyen (2014) etc., for details) while for REIT the evidence is very few. In any case, in Chapter 4, we have found that two regimes which have been identified from consideration of market condition as bull and bear markets exist for the USA and the UK REIT markets. Because of this empirical evidence, we have thought it appropriate to introduce regimes in the conditional mean model. A gradual transition between different regimes is thus more applicable and that can be obtained by considering a continuous smooth transition function. The conditional mean model thus have a smooth transition function in VAR which is abbreviated as STVAR, and the GARCH-in-mean (GARCH-M) component in VAR structure. As already stated, by incorporating “in-mean” component in the conditional mean we can examine own and cross effects of volatility in the risk – return relationship involving REIT and stock markets. Lastly, the choice of smooth transition function has been made from consideration of capturing different impacts of different market conditions such as bull and bear markets and the switch over is slow rather than abrupt from one market condition to another. Our empirical results suggest that there is a significant spillover effect from mean, variance, as well as GARCH-in-mean component between REIT returns and stock returns in the two market conditions.

The remainder of this chapter is laid out as follows. The model and methodology used in this study is discussed in the Section 6.2. Section 6.3 outlines several tests of hypotheses of interests. The empirical results are presented and discussed in Section 6.4. The chapter ends with concluding observations in Section 6.5.

6.2 Model and Methodology

In this section, we present the model, briefly though, from issues and considerations mentioned in the preceding section. In order to do so, we first state the conditional mean model which is actually a smooth transition VAR (STVAR) model including a GARCH-in-mean component also, and then present the standard multivariate GARCH model with constant as well as dynamic conditional correlation (DCC) representation. Thereafter, we describe the STVAR-BTGARCH-M model as a whole. The estimation of the model is described at the end of this section.

6.2.1 The conditional mean model

The general framework of an MGARCH model conditional on the σ- field generated by the past information on r_t up to time $t-1$ and denoted by ψ_{t-1}, is specified as

$$r_t = \mu_t(\theta) + \varepsilon_t \tag{6.1}$$

where r_t is an $N \times 1$ vector of returns at time t on N equity indices within a country, $\mu_t(\theta)$ is the $N \times 1$ conditional mean vector which also include the 'in-mean' component, $\varepsilon_t = H_t^{1/2}(\theta)\eta_t$, with $E(\eta_t) = 0$ and $V(\eta_t) = I_N$, I_N is the identity matrix of order N, and θ is a finite vector of parameters.

Further $H_t^{1/2}(\theta)$ is assumed to be a $(N \times N)$ positive definite matrix such that $H_t(\theta)$ is the conditional variance-covariance matrix of r_t. Both $H_t(\theta)$ and r_t depend on the unknown vector θ. Under this assumption on $H_t^{1/2}(\theta)$, $H_t(\theta)$ is also a positive definite matrix.

As discussed in Section 6.1, following Kundu and Sarkar (2016) the conditional mean model is taken to have a VAR (1) representation along with a vector representing the in-mean component with two market situations – bull and bear. Hence the model for r_t is

$$r_t = \left(a^1 + B^1 r_{t-1} + \Lambda^1 vech\,(H_t(\theta))\right) \odot \left(\mathbf{1} - \boldsymbol{G}\left[\bar{r}_{it}^k, \gamma\right]\right)$$

$$+ \left(a^2 + B^2 r_{t-1} + \Lambda^2 vech\,(H_t(\theta))\right) \odot \boldsymbol{G}\left[\bar{r}_{it}^k, \gamma\right] + \varepsilon_t \qquad (6.2)$$

where a^1 and a^2 are each $N \times 1$ vector of intercept term, B^1, B^2 are $(N \times N)$ matrices of coefficients attached to r_{t-1} in the two market situations, and Λ^1 and Λ^2 are both $N \times N(N+1)/2$ matrices whose elements stand for own risk aversion as well as cross risk aversion parameters in bear and bull markets, respectively. The underlying transition function is a continuous function $\boldsymbol{G}[\bar{r}_{it}^k, \gamma]$, most often the logistic function, which changes smoothly from 0 to 1 as $\bar{r}_{\boldsymbol{it}}^{\boldsymbol{k}}$ increases (see, for details, Terasvirta, 1994), where $\bar{r}_{\boldsymbol{it}}^{\boldsymbol{k}} = \frac{\sum_{j=1}^{k} r_{i,t-j}}{k}$, as defined in Chapter 4, is the average of the past k returns on the i^{th} equity market $(i = 1, 2)$ in our case. Hence, the logistic transition function incorporates the monotonically changing market condition from bear to bull. Note that the bull market is characterized by $\bar{r}_{\boldsymbol{it}}^{\boldsymbol{k}} > 0$ and the bear market situation by $\bar{r}_{\boldsymbol{it}}^{\boldsymbol{k}} \leq 0$. The two regimes are associated with very small and large values of the transition variable, $\bar{r}_{\boldsymbol{it}}^{\boldsymbol{k}}$. The threshold value has been taken to be zero for both the returns to define the bull and bear market conditions, as suggested by Chen (2009).

6.2.2 CCC and DCC representations

Bollerslev (1990) proposed a class of MGARCH models where the conditional correlations are taken to be constant and hence the conditional covariances are proportional to the product of the corresponding conditional standard deviations. These restrictions greatly reduce the number of unknown parameters and thus simplify the estimation of the model. Such a model called the constant conditional correlation (CCC) model of H_t, based on N equity returns, is defined as:

$$H_t = D_t R D_t = (\rho_{ij}\sqrt{h_{ii,t}\, h_{jj,t}}) \tag{6.3}$$

where $D_t = diag(h_{11,t}^{1/2}, \dots.., h_{NN,t}^{1/2})$ where $h_{ii,t}$ is the univariate conditional variance model for the i^{th} equity returns. Most often the usual GARCH model which is symmetric in nature is used. But an asymmetric GARCH specification like the EGARCH model by Nelson (1991) or the GJR-GARCH model by Glosten et al. (1993) can as well be taken, especially in case of stock returns for which asymmetry in volatility has been found to be more appropriate. Finally, $R = (\rho_{ij})$ is a symmetric positive definite matrix whose elements are the constant conditional correlation, ρ_{ij}. The original CCC model has the GARCH (1,1) specification for each conditional variance in D_t i.e.,

$$h_{ii,t} = \omega_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i h_{ii,t-1}, \qquad i = 1, \dots \dots, N. \tag{6.4}$$

The H_t matrix defined in equation (6.3) is positive definite if and only if all the N conditional variances are positive and R is a positive definite matrix. The unconditional variances are easily obtained, as in the univariate case, but the unconditional covariances are difficult to compute because of the nonlinearity involved in the elements of H_t. He and Terasvirta (2002) used a VEC-type formulation for $(h_{11t}, h_{22t}, \dots.., h_{NNt})^{/}$, to allow for interactions between the conditional variances, and they called the resultant model as the extended CCC model.

It is quite obvious that the assumption of conditional correlations being constant is unrealistic in many empirical applications. Christodoulakis and Satchell (2002), Engle (2002), and Tse and Tsui (2002) proposed generalizations of the CCC model by making the conditional correlation matrix time dependent in different ways. Accordingly, the dynamic conditional correlation (DCC) model is defined as

$$H_t = D_t R_t D_t = (\rho_{ij,t} \sqrt{h_{ii,t}\, h_{jj,t}}) \tag{6.5}$$

where $R_t = (\rho_{ij,t}, \rho_{ij,t})$ being the time dependent conditional correlations. The requirement that this H_t is positive definite is guaranteed under simple conditions on the parameters, as stated in Bauwens et al. (2006).

The DCC model of Christodoulakis and Satchell (2002) uses the Fisher transformation of the correlation coefficient. This model which is only for a bivariate set-up, is easy to implement because the property of positive definiteness of the conditional correlation matrix is guaranteed by the Fisher transformation. The DCC models of Tse and Tsui (2002) and Engle (2002), on the other hand, are generally multivariate in nature and are useful when modeling high-dimensional data sets. Though we consider returns on two markets *viz.* REIT market and a stock market in this study, we take the DCC model of Engle (2002) for our study simply because the model by Engle (2002) has several advantages compared to other such models. First, it is less restrictive in terms of number of variables included in the model. Second, it accounts for heteroscedasticity by estimating the dynamic correlation coefficients of the standardized residuals. The DCC model of Engle, denoted by $DCC_E(1,1)$ is given as

$$R_t = diag\left(q_{11,t}^{-1/2}, \ldots, q_{NN,t}^{-1/2}\right) Q_t\, diag\left(q_{11,t}^{-1/2}, \ldots, q_{NN,t}^{-1/2}\right) \tag{6.6}$$

where the $N \times N$ symmetric positive definite matrix $Q_t = (q_{ij,t})$ is given by

$$Q_t = (1 - \varphi_1 - \varphi_2)\bar{Q} + \varphi_1 \varepsilon^*_{t-1} \varphi_1 \varepsilon^{*/}_{t-1} + \varphi_2 Q_{t-1} \quad (6.7)$$

where $\varepsilon^*_t = (\varepsilon^*_{1t}, \dots., \varepsilon^*_{Nt})^/$, $\varepsilon^*_{it} = \varepsilon_{it}/\sqrt{h_{ii,t}}, i = 1, \dots, N$ and ε_{it} is the random term associated with the given model for r_t, as given in equation (6.2), $\bar{Q}$ is the $N \times N$ unconditional variance-covariance matrix of ε^*_t, and φ_1, and φ_2 are non-negative scalar parameters satisfying $(\varphi_1 + \varphi_2) < 1$. It may be noted that unlike the DCC model of Tse and Tsui (2002), this model has the advantage that it does not formulate the conditional correlation as a weighted sum of past correlations. Note that when $\varphi_1 = \varphi_2 = 0$, the DCC_E model reduces to the CCC model. This condition can, therefore, be tested for checking if imposing conditional correlations to be constant is empirically relevant for a given series.

Engle (2002) considered $h_{ii,t}$ to be a univariate GARCH model and then stated the following conditions on the parameters for H_t to be positive definite for all t: $(i) \omega_i > 0, (ii) h_{ii,0} > 0, (iii)$ α_i and β_i are such that $h_{ii,t}$ will be positive with probability one. (iv) the roots of the polynomial of GARCH equation lie outside the unit circle, (v) $\varphi_1 > 0$, (vi) $\varphi_2 > 0$, and (vii) $(\varphi_1 + \varphi_2) < 1$.

6.2.3 STVAR-BTGARCH-M model

We have basically used the STVAR-BTGARCH-M model proposed by Kundu and Sarkar (2016) based on considerations already mentioned in the preceding sub-section. Thus, this model which considers two market situations *viz., bull* and *bear,* has the conditional mean equation, specified in equation (6.2) is given by smooth transition VAR (STVAR) and also an ‘in-mean’ volatility component, with H_t as given in equation (6.5). The underlying transition function is a continuous function $\boldsymbol{G}[\bar{r}^k_{it}, \gamma]$, as already stated. Accordingly, the STVAR-BTGRACH-M model for this study where $N = 2$, is given by

$$r_t = \left(a^1 + B^1 r_{t-1} + \Lambda^1 vech\,(H_t(\theta))\right) \odot (\mathbf{1} - \boldsymbol{G}[\cdot])$$

$$+ \left(a^2 + B^2 r_{t-1} + \Lambda^2 vech\,(H_t(\theta))\right) \odot \boldsymbol{G}[\cdot] + \varepsilon_t \qquad (6.8)$$

where $r_t = \begin{pmatrix} r_{1t} \\ r_{2t} \end{pmatrix}$, $a^1 = \begin{pmatrix} a_1^1 \\ a_2^1 \end{pmatrix}$, $a^2 = \begin{pmatrix} a_1^2 \\ a_2^2 \end{pmatrix}$, $B^1 = \begin{pmatrix} b_{11}^1 & b_{12}^1 \\ b_{21}^1 & b_{22}^1 \end{pmatrix}$, $B^2 = \begin{pmatrix} b_{11}^2 & b_{12}^2 \\ b_{21}^2 & b_{22}^2 \end{pmatrix}$, $\Lambda^1 = \begin{pmatrix} \lambda_{11}^1 & \lambda_{12}^1 & \lambda_{13}^1 \\ \lambda_{21}^1 & \lambda_{22}^1 & \lambda_{23}^1 \end{pmatrix}$, $\Lambda^2 = \begin{pmatrix} \lambda_{11}^2 & \lambda_{12}^2 & \lambda_{13}^2 \\ \lambda_{21}^2 & \lambda_{22}^2 & \lambda_{23}^2 \end{pmatrix}$, $H_t = \begin{pmatrix} h_{11t} & h_{12t} \\ h_{12t} & h_{22t} \end{pmatrix}$, $vech(H_t) = \begin{pmatrix} h_{11t} \\ h_{12t} \\ h_{22t} \end{pmatrix}$, $\varepsilon_t = \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix}$, $\boldsymbol{G}[\cdot] = \begin{pmatrix} g(\bar{r}_{1t}^k,\ \gamma_1) \\ g(\bar{r}_{2t}^k,\ \gamma_2) \end{pmatrix}$, and $g(\bar{r}_{it}^k,\ \gamma_i), i = 1,2$, are the usual logistic functions with parameters γ_1 and γ_2 corresponding to two different market conditions. H_t is the conditional variance-covariance matrix of the DCC model as given in equation (6.5). All other notations have their usual meanings as already described. Superscripts 1 and 2 refer to 'bear' and 'bull' markets, respectively. It is to be noted that in our study, we have accounted for potentially asymmetric response of volatility to positive and negative shocks on returns by assuming the conditional variance components to follow GJR-GARCH (*p*, *q*) process of Glosten et al. (1993). In its simple form, this process in our context, is defined as

$$h_{ii,t} = \omega_i + \sum_{j=1}^{q} \alpha_{ij} \varepsilon_{i,t-j}^{*2} + \sum_{j=1}^{q} d_{ij} I(\varepsilon_{i,t-j}^{*} < 0) \varepsilon_{i,t-j}^{*2} + \sum_{j=1}^{p} \beta_{ij} h_{i,t-j} \qquad (6.9)$$

where the indicator function, $I(\cdot) = 1$when the condition, $\varepsilon_{i,t-j}^{*} < 0$ holds, otherwise $I(\cdot) = 0$. The parameter d_{ij} measures the leverage effect. The reason for assuming this form for asymmetric volatility is that volatility in returns on different stock indices of various countries have often been found to be asymmetric in nature because of 'leverage effect' in stock returns, and that this form has performed quite well (see, Kundu and Sarkar (2016), for details). Further, it is also likely that REIT returns would be affected by 'leverage effect' and hence its volatility is likely to be asymmetric in nature.

6.2.4 Estimation of STVAR-BTGARCH-M model

Insofar as estimation of this model is concerned, the method of maximum likelihood (ML) has been applied. A useful feature of the DCC model is that this can be estimated consistently using a two-step procedure (see, for instances, Engle and Sheppard, 2001; Bauwens et al., 2006). Assuming bivariate normality for the conditional distribution of $\varepsilon_t|\psi_{t-1}$, where ψ_{t-1} is the set of past information on all variables up to time $t-1$, $\varepsilon_t|\psi_{t-1} \sim N\ (0, H_t)$, the log-likelihood function (up to a constant), based on T observations, is given as:

$$L(\theta) = -\frac{1}{2}\sum_{t=1}^{T}(\ln|H_t| + \varepsilon_t^{/} H_t^{\ -1}\varepsilon_t). \tag{6.10}$$

Obviously, obtaining the ML estimate of the parameter vector θ requires maximizing this log-likelihood function. The objective function involved is evidently highly nonlinear, and the required codes were obtained from Kundu and Sarkar (2016).

As in Chapter 4, in order to choose the appropriate value of k for the threshold variable $\bar{r}_{it}^{k}$, several choices of k were considered and for each one of those values, the maximized log-likelihood value based on a similar model at the univariate level was obtained. That value of k for which the value of the maximized log-likelihood for the univariate model was found to be the highest was taken to be the value of k.

6.3 Tests of hypotheses

In this section, we briefly describe the statistical tests carried out in this chapter. Before discussing the different hypotheses of interests pertaining to STVAR-BTGARCH-M model, we first mention about a test for linearity against non-linearity in the data generating process using a bivariate framework. This test, proposed by Camacho (2004), is described below. It is worthwhile to note that this test also enables us to find which of the two standard transition functions – logistic and exponential – is appropriate for the underlying model. After testing nonlinearity as well as the appropriate type of transition function, we carry out a set of tests based on the Wald test to conclude on the different kinds of spillovers in mean, volatility, and BTGARCH-in-mean effects based on this model.

6.3.1 Nonlinearity and model selection tests

In the spirit of the seminal methodology of Tsay (1989), Camacho (2004) proposed a step-wise procedure for modeling the nonlinear VAR model with a smooth transition specification. In this context, one single-regime linear VAR model which is the case under the null is specified and then the hypothesis of smoothness in transition between regimes is tested. The null hypothesis of linearity is that the smooth transition parameter γ is equal to zero, i.e., $H_0 : \gamma = 0$, and the alternative hypothesis is $H_1 : \gamma > 0$. Since the model is not identified under the null hypothesis, any statistical test which takes regime switching model as the alternative suffers from a serious problem called the nuisance parameter problem. To avoid this nuisance parameter problem, a standard Lagrange Multiplier (LM)-type test based on an auxiliary regression which is obtained from a suitable Taylor series expansion of the transition function around the point $\gamma = 0$, is used (see, Granger and Terasvirta (1993), for details). In line with this proposal for the univariate case, Camacho (2004) proposed the following two auxiliary regressions for the bivariate case:

$$r_{1t} = \tau_1 + \sum_{h=0}^{3} \xi_{1h}^{/} X_t w^h + u_{1t} \quad (6.11)$$

and

$$r_{2t} = \tau_2 + \sum_{h=0}^{3} \xi_{2h}^{/} X_t w^h + u_{2t} \quad (6.12)$$

where $X_t^{/} = (r_{1\,\overline{t-1}}, r_{2\,\overline{t-1}})$, ξ_{1h} and ξ_{2h} are (1×2) coefficient vectors, and the variable w is the transition variable which is the lag value of returns. The null hypothesis of linearity thus corresponds to $\xi_{11} = \xi_{12} = \xi_{13} = \xi_{21} = \xi_{22} = \xi_{23} = 0$.

If linearity i.e., one single regime, is rejected in favor of additional regimes, the model selection test is then required to decide between logistic and exponential transition functions. To that end, a sequence of nested hypotheses is formulated for the two auxiliary regressions. Following Camacho (2004), the null and alternative hypotheses for the nested tests along with the choice of appropriate transition function are presented in the following tabular form. In this testing exercise, three test statistics are involved. These are denoted as Test 1, Test 2, and Test 3. Under the respective null hypothesis, these test statistics follow non-standard distributions, and their critical values are available in Camacho (2004).

Table 6.1 Model selection tests

Hypothesis	Test 1	Test 2	Test 3	Choice
Null	$\xi_{i3} = 0$	$\xi_{ij} = 0$, $j = 2,3$	$\xi_{ij} = 0$, $j = 1,2,3$	…….
Alternative	$\xi_{i3} \neq 0$	$\xi_{i2} \neq 0$ $\xi_{i3} = 0$	$\xi_{i1} \neq 0$ $\xi_{ij} = 0$ $j = 2,3$	…….
Test conclusion	Reject null	……	………	Logistic
	Do not reject null	Reject null	Do not reject null	Exponential
	Do not reject null	Do not reject null	Reject null	Logistic
	Do not reject null	Reject null	Reject null	No conclusion

6.3.2 The Wald test

Once the above-mentioned tests have been carried out, we can perform the Wald test for testing the significance of own and cross spillover effects of returns, volatility and 'in-mean' component involving REIT and stock markets and the two market situations by placing appropriate restrictions on the relevant parameters in equation (6.8). To that end, we state below the different null hypotheses which specify the absence of each of three different kinds of spillovers or transmissions for REIT market and stock market as well as equality of spillovers in the two market movements – bull and bear.

1. *Tests of spillovers in conditional mean*

   (a) H_{01}^{a}: No spillovers in mean from stock market to REIT market in both bull and bear market movements i.e., $b_{12}^{1} = b_{12}^{2} = 0$.

   (b) H_{01}^{b}: No spillovers in mean from REIT market to stock market in both bull and bear market movements i.e., $b_{21}^{1} = b_{21}^{2} = 0$.

2. *Tests of equality of spillovers in bull and bear market movements for REIT and stock markets*

   (a) H_{02}^{a}: Equality of spillovers in mean in bull and bear market conditions form stock market to REIT market i.e., $b_{12}^{1} = b_{12}^{2}$.

   (b) H_{02}^{b}: Equality of spillovers in mean in bull and bear market conditions form REIT market to stock market i.e., $b_{21}^{1} = b_{21}^{2}$.

3. *Tests of no BTGARCH-in-mean effect from one market to another*

   (a) Equality of own volatility spillover on REIT returns in bull and bear markets i.e., H_{03}^{a}: $\lambda_{11}^{1} = \lambda_{11}^{2}$.

   (b) Equality of volatility spillover of stock market on REIT returns in bull and bear markets i.e., H_{03}^{b}: $\lambda_{13}^{1} = \lambda_{13}^{2}$.

   (c) Equality of own volatility spillover on stock returns in bull and bear markets i.e., H_{03}^{c}: $\lambda_{23}^{1} = \lambda_{23}^{2}$.

   (d) Equality of volatility spillover of REIT market on stock returns in bull and bear markets i.e., H_{03}^{d}: $\lambda_{21}^{1} = \lambda_{21}^{2}$.

4. *Test of equality of each of the parameters of BTGARCH-in-mean in bull and bear market movements*

   H_{04}: $\lambda_{11}^1 = \lambda_{11}^2$; $\lambda_{12}^1 = \lambda_{12}^2$; $\lambda_{13}^1 = \lambda_{13}^2$; $\lambda_{21}^1 = \lambda_{21}^2$; $\lambda_{22}^1 = \lambda_{22}^2$; $\lambda_{23}^1 = \lambda_{23}^2$.

5. *Test of asymmetric volatility (due to leverage effect) of REIT and stock markets*

   No asymmetric volatility i.e., H_{05}: $d_{1j} = d_{2j} = 0$ for all j.

6. *Test of equality of dynamic conditional correlation*

   No dynamic conditional correlation i.e., H_{06}: $\varphi_1 = \varphi_2 = 0$.

6.4 Empirical Analysis

We first discuss the results of model selection tests including test of linearity. Following this, estimation results from STVAR-BTGARCH-M model are presented and discussed. Summary statistics and the other important characteristics of the data, such as conclusions based on unit root test and structural break tests have already been presented in Chapter 2 for all the variables involved in this study. Since the monthly time series of stock returns (S&P 500 for the USA and FTSE ALL for the UK) are being used in this chapter, it may be useful to restate that these two series were found to be stationary. Further, the S&P 500 series for the USA has been found to have two structural breaks while FTSE ALL series for the UK has single break.

6.4.1 Results of the tests of model selection including linearity

The results of the test of linearity and other model selection tests, as stated in Section 5.3.1 are given in Table 6.2. As mentioned, the test has been done by taking two different choices of the transition variable *viz.*,$r_{1,t-1}$ and $r_{2,t-1}$. Based on the test results, it is concluded that the null hypothesis of linear specification against the alternative of regime-switching model which is regime-wise linear but overall non-linear, is rejected for both the countries at 1% level of significance. For instance, in case of $r_{1,t-1}$ being the transition variable, the test statistic values are 43.54 and 15.30 for the USA and the UK, respectively, both of which are higher than their respective critical values. Thus, the regime-switching nature in the relationship between REIT returns and stock returns is confirmed for both the USA and the UK. Further, as evident from the entries of this table, logistic transition function is appropriate for the USA in case $r_{2,t-1}$ is the transition variable, while no conclusive inference on this could be drawn for the other transition variable in the USA, and the same is the case for both the transition variables in case of the UK.

Table 6.2 Results of test of linearity and other model selection tests

	The USA		The UK	
	Transition variable		Transition variable	
	$r_{1,t-1}$	$r_{2,t-1}$	$r_{1,t-1}$	$r_{2,t-1}$
Test of linearity	43.54***	35.44***	15.30***	14.26***
Test 1	5.88	12.87***	2.42	3.87
Test 2	2087.75***		2143.98***	2146.46
Test 3	2125.41***		2156.86***	2156.85
Decision	No decision	LSTVAR	No decision	No decision

Note: '***' indicates significance at 1% level.

6.4.2 Findings from STVAR-BTGARCH model

The model STVAR-BTGARCH as specified in equation (6.8) is based on DCC representation. The ML estimates of the parameters of this model for both the countries are reported in Tables 6.3 through 6.6. We first discuss about the estimates of the parameters, given in Table 6.3, that capture the spillover effects of mean.

Table 6.3 Estimates of mean parameters

Parameter	The USA		The UK	
	Bear market (i.e., i =1)	Bull market (i.e., i =2)	Bear market (i.e., i =1)	Bull market (i.e., i =2)
a_1^i	-0.16***	-0.03	-0.07***	0.68***
b_{11}^i	0.06*	-0.13***	0.20***	-0.00
b_{12}^i	0.65***	0.17***	-0.42***	0.01
a_2^i	0.07***	0.43***	0.46***	0.44***
b_{21}^i	-0.00	-0.01	0.121***	0.05***
b_{22}^i	0.16***	-0.03	0.18***	0.06

Notes (1): '*', '**', and '***' indicate significance at 10%, 5% and 1% levels, respectively.

and (2): '1', '2' in the subscript stand for REIT returns and stock returns, respectively.

It is evident from these results that in case of the USA, the spillover effects from the stock returns to REIT returns i.e., b_{12}^i, is significant and positive in both the regimes while the mean spillover from REIT returns to stock returns i.e., b_{21}^i, is insignificant in both bull and bear regimes. In case of the UK, the mean spillover effect from stock returns to REIT returns is negative and significant in the bear regime only while this effect from REIT returns to stock returns is positive and significant in both the regimes.

Now we discuss the estimation results of the volatility-in-mean parameters which are given in Table 6.4. It is evident that in both the countries, own risk-return relationship of REIT which is captured by λ_{11}^i, is positive and significant only in the bear market while for the stock market, the parameter indicating own risk return relationship i.e., λ_{23}^i, is insignificant in the USA in both the market conditions, but it is negative in the bear market condition and positive in the bull market situation for the UK. Kim and Zumwalt (1979) have argued that in the bear market situation investor would require a premium for taking some risk for their investment. Thus, in the bear market situation, risk-return relationship is positive. The negative risk-return relationship of stock market in the UK can be explained by volatility feedback hypothesis which states that if there is a risk associated with an investment on an asset, then the investor will not be interested to invest on that asset. Thus, return would fall with an increase in risk.

Table 6.4 Estimates of the volatility-in-mean parameters

Parameters	The USA		The UK	
	Bear market (i.e., i =1)	Bull market (i.e., i =2)	Bear market (i.e., i =1)	Bull market (i.e., i =2)
λ_{11}^{i}	0.04***	0.01	0.07***	-0.00
λ_{12}^{i}	-0.16***	0.06***	0.01	0.20***
λ_{13}^{i}	0.04*	0.02	-0.19***	-0.09***
λ_{21}^{i}	0.04***	-0.05***	-0.05***	0.00
λ_{22}^{i}	-0.18***	0.23***	0.5***	-0.35***
λ_{23}^{i}	0.03	-0.03	-0.19***	0.23***

Note: ‘*’, ‘**’, and ‘***’ indicate significance at 10%, 5% and 1% levels, respectively.

In case of the cross risk-return relationship involving REIT returns and stock returns in the USA, the two relevant parameters i.e., λ_{21}^{i} and λ_{13}^{i} have been found to be positive in the bear market, while in the bull market only the risk in REIT market has significant negative effect on stock market returns. It is expected that in the bear market situation if risk increases in one asset then investors shift their choice in some other assets from their portfolios for investment. Hence, return from the latter increases due to rise in risk in the former asset. And the findings suggest that this happened for the USA. However, in case of the UK, the cross risk-return effect for both REIT and stock returns are negative in both bull and bear market situations.

Now, looking at the parameters of smoothness i.e., γ_1 and γ_2, we find from Table 6.5 that these two parameters are positive. The values of these parameters have been found to be neither closed to zero nor very high, which implies that the transition from bear market situation to bull market situation is smooth. Hence, the validity of the smooth transition in the conditional mean model is empirically justified for both the countries.

Table 6.5 Estimates of the parameters of smoothness, GJR – GARCH and DCC models

Paremeters	The USA	The UK
γ_1	4.61***	4.65***
γ_2	5.22***	5.25***
c_1	1.18***	4.27***
c_2	1.44***	4.20***
α_1	0.29***	-0.07***
α_2	0.15***	0.01
d_1	-0.11***	0.15***
d_2	0.10***	0.39***
β_1	0.76***	0.86***
β_1	0.72***	0.46***
φ_1	0.08***	0.32***
φ_2	0.40***	0.45***

Note: '*', '**', and '***' indicate significance at 10%, 5% and 1% levels, respectively.

Insofar as the behavior of the conditional variance model i.e., BTGARCH, is concerned, we find that the parameters in the GARCH component of the model i.e., α_1, β_1, and β_2, are all significant except α_2 in the UK. Now, looking at d_{1j} and d_{2j}, the two coefficients capturing asymmetry in the conditional variance, we note that these two parameters are highly significant in both the countries. Thus, consideration of asymmetry in the risk-return relationship between REIT and stock markets is empirically established. Further, we find that the coefficients involved in the dynamic conditional correlation i.e., φ_1 and φ_2, are significant for both the USA and the UK, which justifies that the DCC modeling approach is useful in explaining the volatility dynamics between returns on REIT and stock markets.

Finally, we report, in Table 6.6, the results of several tests of hypotheses of interest involving various kinds of spillover effects in bull and bear markets and also the dynamic nature of the conditional correlation in the BTGARCH model including the aspect of asymmetric effect of volatility. From the entries in row 1 and 2 of Table 6.6, we find that the null hypothesis of 'no spillover in mean' is rejected in case of both the USA and the UK except the case of mean spillover

Table 6.6 Results of the Wald test on equality of coefficients for bull and bear markets

Row No.	Null hypothesis	The USA	The UK
1	$b_{12}^1 = b_{12}^2 = 0$	64.56***	25.01***
2	$b_{21}^1 = b_{21}^2 = 0$	0.41	12.87***
3	$b_{12}^1 = b_{12}^2$	32.95***	8.68***
4	$b_{21}^1 = b_{21}^2$	0.18	1.28
5	$\lambda_{11}^1 = \lambda_{11}^2$	2.64	6.27***
6	$\lambda_{13}^1 = \lambda_{13}^2$	0.42	2.75
7	$\lambda_{21}^1 = \lambda_{21}^2$	15.34***	5.57***
8	$\lambda_{23}^1 = \lambda_{23}^2$	2.46	74.65***
9	$\lambda_{ij}^1 = \lambda_{ij}^2$	52.95***	107.02***
10	$d_1 = d_2 = 0$	20.33***	51.06***
11	$\varphi_1 = \varphi_2 = 0$	290.70***	312.87***

Note: '***' indicates significance at 1% level.

effect from REIT returns to stock returns in the USA. The null hypotheses of equality in the mean spillover effects from stock returns to REIT returns in the bull and bear markets are rejected at 1% level of significance for both the countries whereas the null hypothesis of equality in the mean spillover effect from REIT returns to stock returns cannot be rejected for both the countries.

As regards the null hypothesis of equality in volatility-in-mean components in the bull and bear market situations we find from rows 5 and 8 of Table 6.6, that the null hypothesis cannot be rejected in case of the own risk-return relationship for both REIT and stock markets in the USA while for the UK this null hypothesis is rejected at 1% level of significance. In rows 6 and 7, we have reported the results of the Wald test for testing the null hypotheses of equality of the cross risk-return relationship involving REIT returns and stock returns across bull and bear market conditions. The results suggest that the null hypothesis of equality of the effect of risk from REIT market to stock market returns in both bull and bear market situations is rejected for both the USA and the UK, while this null hypothesis in case of effect of risk from stock returns to REIT returns cannot be rejected for both the countries. Finally, we note that the results of the tests of the two null hypotheses *viz*., 'no leverage effect' and 'no dynamic behavior' in the conditional correlation, respectively, suggest rejection of both these null hypotheses for both the countries. The rejection of the first null hypothesis is clear from the test statistic values of 20.33 and 51.06, respectively, for the USA and the UK, which are found to be significant at 1% level. Similar values for the null hypothesis of 'no dynamic behavior' are 290.70 and 312.87 for the USA and the UK, respectively, which also clearly suggests rejection of the null hypothesis at 1% level of significance.

6.5 Conclusions

In this chapter, we have examined the volatility transmission between REIT returns and stock returns by applying a bivariate GARCH-M model in VAR framework with smooth transition nature of conditional mean, which also captures the asymmetric nature of mean and volatility spillovers in the bull and bear market situations. To that end, dynamic conditional correlation representations of bivariate GARCH and GJR-GARCH specification of volatility have been considered. We have empirically found that the mean spillover effect from stock returns to REIT returns is significant for both the countries while the same from REIT returns to stock returns is significant only in case of the UK. It is evident from the results that in both the countries own risk-return relationship of REIT market is positive and significant only in the bear market situation while for the stock market own risk-return relationship is insignificant for both the bull and bear markets in the USA, but it is negative in the bear market condition and positive in the bull market situation for the UK. We have also found the asymmetric nature in the conditional variance and dynamic behavior in the conditional correlation as well. Finally, several tests of hypotheses regarding equality of various kinds of spillover effects in the bull and bear market situations have shown that these spillover effects are not the same in these two market conditions in most of the aspects considered in this study.

Chapter 7

Conclusions

7.1 Introduction

The central focus of this thesis is to empirically model REIT returns and examine its relationship with some macroeconomic, monetary policy, and financial variables for two most developed economies *viz*., the USA and the UK. In this study, two modeling approaches – one with structural breaks in the relationship and the other regime-switching – have been used. These two approaches essentially allow for non-linearity in the relationship over the whole sample although sub-period/ regime-wise the relation is linear. Using time series observations at monthly level from January 1990 to December 2014, four models based on these two approaches have been estimated and findings discussed in the chapters of this thesis. In this last chapter, a brief summary of all the findings are presented. In the next section, we state the focus of each chapter and then present with the major conclusions. This chapter concludes with a very description of a future idea in Section 7.3.

7.2 Major Findings

In Chapter 2 of this thesis, the data sets used in this study have been briefly described along with their plots against time and the usual descriptive statistics. Thereafter the stationarity property and presence of structural breaks in each of these series have been examined. It has been found that barring interest rate spread (IRS), all the other variables *viz*., REIT returns (REIT), inflation (INF), relative price variability (RPV), output growth (IIPG), and stock returns (SR) are stationary for both the USA and the UK. It has also been found that in all but output growth series in case of the UK, there is evidence of structural break(s).

In Chapters 3 and 4 of this thesis, we have basically studied the relationship between REIT returns and inflation to explain the anomalous negative relationship found in empirical studies involving these two variables. In Chapter 3, we have considered a model where the issue of presence of structural breaks has been explicitly considered not only for the variables concerned but also for the underlying relationship. In Chapter 4, the other modeling approach *viz*., regime switching behavior of REIT – both observed and unobserved regimes – have been applied. Another modeling aspect considered in these two chapters to deal with this anomalous negative relation is the inclusion of relevant macroeconomic variables in the model. To that end, relative price variability has been included in Chapter 3 and this as well as output growth in Chapter 4.

In Chapter 3, we have found, based on the Qu-Perron test, two structural changes in the relationship involving REIT, RPV and INF in the USA, whereas there is no such structural change in this relationship in case of the UK. Further, relative price variability and inflation have been found to be negatively related in both the countries. This means that the anomalous negative relationship between REIT returns and inflation appear to proxy for the effectiveness of relative price variability on REIT returns.

The most important finding in Chapter 4 is that the effect of inflation on REIT returns is not significant in presence of relative price variability and output growth. We have also found that regime-switching behavior holds for REIT returns, and that the overall relationship is thus non-linear in nature. It is evident from both TVAR and MSVAR models that output growth has positive impact on REIT returns in a market condition where the average values of the past returns of REIT are non-positive in respect of TVAR model and variance is high in respect of MSVAR model. On the other hand, effect of RPV on REIT returns are positive and significant in case of the USA while this effect is negative and significant in a market condition where the average values of the past returns of REIT are positive for TVAR model and variance is low for MSVAR model.

In the next chapter i.e., in Chapter 5, we have examined the interdependences between REIT returns and a monetary policy variable as also the contemporaneous effect of monetary policy on REIT returns by using structural VAR model. Here interest rate spread has been taken as the monetary policy variable. Qu and Perron methodology of structural break has once again been applied to find if there is any structural change in the relationship among the variables involved. Keeping in mind, the likely effect of business cycle on this relationship we have also included output growth as in the preceding chapter.

In this chapter we have found that there is a structural break in the relationship in case of the USA while there is no evidence of structural break in the UK. Our results suggests that the contemporaneous effect of interest rate spread on REIT returns as well as contemporaneous effect of REIT returns on interest rate spread is significant. However, the impact of contemporaneous effect is different in different sub-periods in case of the USA.

Chapter 6 essentially studies the volatility spillovers as well as volatility-in-mean effect between REIT returns and stock returns by applying a bivariate GARCH-M model where the conditional mean is specified by a smooth transition VAR model. Dynamic conditional correlation approach has been applied with the GJR-GARCH specification so that the intrinsic nature of asymmetric volatility in case of positive and negative shocks can be duly captured.

The major findings that we have empirically found in this chapter is that the mean spillover effect from stock returns to REIT returns is significant for both the countries while the same from REIT returns to stock returns is significant only in the UK. It is evident from the results in both the countries that own risk-return relationship of REIT market is positive and significant only in the bear market situation while for the stock market own risk-return relationship is insignificant for both the bull and bear markets in the USA but it is negative in the bear market condition and positive in the bull market situation for the UK. We have also found that asymmetric nature of conditional variance and dynamic behavior in the conditional correlation also hold. Finally, several tests of hypotheses regarding equality of various kinds of spillover effects in the bull and bear market situations show that these spillover effects are not the same in the two market conditions in most of the aspects considered in this study.

7.3 Limitations of This Study and Some Ideas for Future Work

In this last section, we mention about two main limitations of this study and also two ideas/extensions of this work. The first limitation refers to our inability to examine the interactions between monetary policy and REIT returns taking into account the potential contemporaneous interdependences between them in the set-up of structural VAR model with recursive restrictions. With simple recursive restrictions, it is not possible to explore the simultaneity of interdependences between them. It would be more appropriate to study this issue in greater detail by using other meaningful restrictions for better identification of shocks.

Therefore, as an extension of this study, we intend to focus on the interaction between REIT prices and monetary policy in the US and the UK using a VAR model that takes into account the potential simultaneity of contemporaneous interdependences. The simultaneity problem would be solved by imposing a combination of short and long-run restrictions on the multiplier of the shocks, acknowledging the two-way interactions between monetary policy and real REIT returns. The identification can be achieved by assuming that monetary policy can have no long-run effect on real REIT returns, which is a common long-run neutrality assumption. Many studies have shown that money is 'neutral' in the long-run in the sense that money growth will be eventually matched with the proportional price growth i.e., inflation. Thus, if the central banks cut the short-term rate and increase the nominal money supply permanently, it may influence the REIT prices only in the short-run.

Another shortcoming of this work relates to non-inclusion of other relevant variables in the context of resolving the anomalous relationship between REIT returns and inflation. To be more specific, it can be argued that monetary policy variables should be included since these might have some impact on this relationship. We intend to explore this in a future work.

Accordingly, a relatively new idea for further research along this line is discussed briefly. To be specific, the basic idea is to study the effect of monetary policy transmission in imperfect markets in important emerging economies like the BRICS group of countries.

The main focus of monetary policy stance is generally conditioned by the balance between inflation and economic growth. Monetary policies primarily aim at achieving high growth in a non-inflationary manner. However, high growth in excess of potential growth level could trigger inflation, which, in turn, may lead to the growth path becoming volatile. Hence, monetary policies tend to do a careful balancing act so that potential level of growth is maintained without any stimulus to inflation. However, there are periods of rising inflation and falling growth below its potential. In case of countries under this group, this is evident from the different phases of monetary policy stances pursued by these countries, where rebalancing of growth and inflation has faced various challenges. In this context, the role of monetary policies pursued by these economies can be questioned, especially in understanding to what extent monetary policies have made impacts on their economic growths.

As for monetary policy transmission, considerable attention has been paid to the question whether a small change in interest rate and/or other policy rates really matters to an economy or not. This question leads to an assessment of how policy rate changes affect market rates, the cost of credit, and ultimately the investment and consumption decisions of economic agents. Moreover, the magnitude of change in market interest rate may be different ranging from money market rate to lending rate. Another important question in this regard is: How does a policy rate impact lending rate in the transmission channels? To be more specific, it is pertinent to ask how policy rate changes affect the economic growth of such an important emerging country through the impact of bank lending rate. The answer to such questions actually depends on the concerned country's financial structure. Relevant factors for capturing market imperfectness include the extent of the country's links with the external financial markets, its exchange rate regime, the size and composition of its formal financial market, the degrees of development of its money, bond, and stock markets, the liquidity of its market for real assets, and both the costs of banking operations and ensuring competitive environment in the banking sector.

These countries, in general, the nature of these financial markets is imperfect, and through this channel the transmission of monetary policy is conducted, and consequently the bank lending rate is affected. Hence, the degree of market imperfection effectively determines how fast the banks are able to change the lending rate due to monetary policy changes. This lending rate is indeed the source that creates problem to the rebalancing of growth and inflation since with the markets being imperfect, impacts of policy stimulus with a lag from earlier phases persist. Thus, nominal lending rate determination in the market becomes a complex process, and understanding how changes in lending rate impact overall economic growth becomes even more uncertain. Hence, explaining monetary transmission in the presence of imperfect financial intermediaries is the primary challenge for the members of this important group of emerging economies.

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