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The Real Estate Investment Trusts Industry and the Financial Crisis: Modeling Volatility (1985-2016)

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Abstract

This work measures the sensitivity of the residual volatility of the risk premiums of various Real Estate Investment Trusts (REITs) sectors to systemically important economic events between January 2, 1985, and December 30, 2016. To this end, the residual yields of the REITs are calculated and, with them, a GARCH (1,1) model is estimated, with dummy variables that identify eleven sub-periods delimited by systemic events that occurred in the American economy. The volatility of residual yields is found to decrease with the SP500 risk premium, and increases only for some sectors with increases in Treasury Bond yields (T-Bills). Similarly, residual yield volatility increased in some periods (e.g., after the Black Monday crash, the low-quality mortgage crisis, and the Great Recession), but did not during the period of stock market collapse caused by companies in the "new economy" (known as the dot-com bubble). Knowledge of these stylized facts opens up new risk management possibilities for those investors considering in including these alternative investments in their portfolios.
JEL Classification: G10, G11, G19
Keywords: REITs, Volatility of Returns, GARCH

La industria de fideicomisos de inversión inmobiliaria y la crisis financiera: modelando la volatilidad (1985-2016)

Resumen

Este trabajo mide la sensibilidad de la volatilidad residual de las primas de riesgo de varios sectores de Fondos de Inversión de Bienes Raíces (REITs) a eventos económicos de importancia sistémica, entre el 2 de enero de 1985, y el 30 de diciembre de 2016. Con tal fin, se calculan los rendimientos residuales de los REITs, y con ellos se estima un modelo GARCH(1,1), con variables dummy que identifican once subperiodos delimitados por eventos sistémicos que se presentaron en la economía americana. Se encuentra que la volatilidad de los rendimientos residuales disminuye con el premio por riesgo del SP500; y aumenta sólo para algunos sectores con aumentos de los rendimientos de los bonos del tesoro (T-Bills). De manera similar, la volatilidad residual de los rendimientos aumentó en algunos periodos (e.g., posterior al crash del lunes-negro, crisis de las hipotecas de baja calidad, y la Gran Recesion), pero no lo hizo durante el periodo del colapso bursátil originado por las empresas de la "nueva economía" (conocida como la crisis de las dot.com). El conocimiento de estos hechos estilizados abre nuevas posibilidades de administración de riesgos para aquellos inversionistas que consideran incluir estas inversiones alternativas en sus portafolios.

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Resumen

Clasificación JEL: G10, G11, G19
Palabras clave: Fibras, volatilidad de retornos, GARCH

1. Introduction

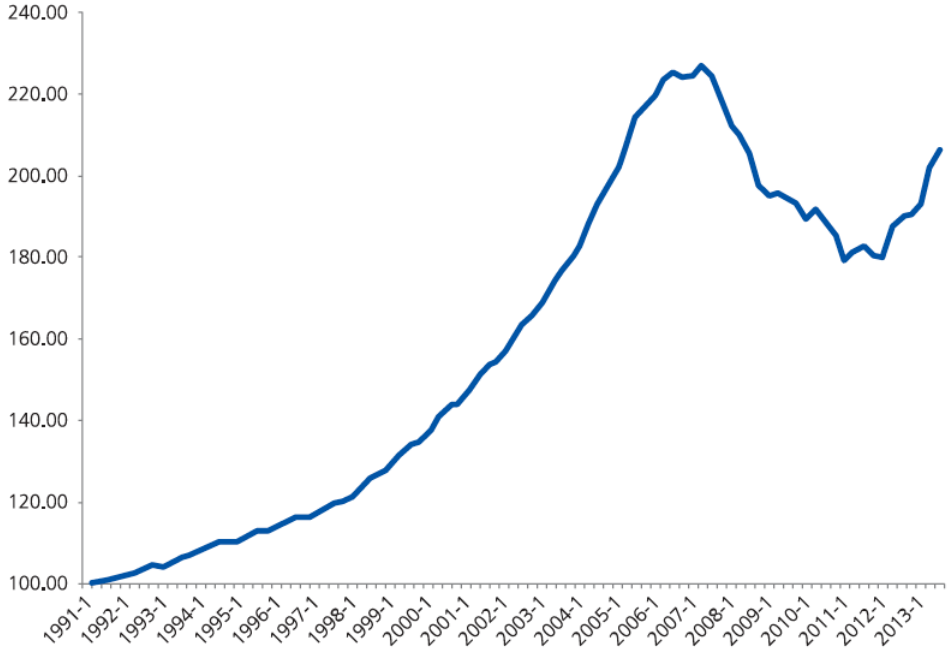
Real Estate Investment Trusts (REITs) represent a vehicle for developers to fund large-scale, income-producing real estate properties, by selling shares to the public. The legislation in the United States waives corporate-level income taxes on REITs if they qualify under certain tax provisions, the most important being that they pay down at least 90 % of their annual taxable income as dividend to their shareholders. So, while REITs are not taxed directly on their earnings, their payments "are taxable dividend income to shareholders." This feature makes REITs a very attractive investment alternative, relative to typical corporate stocks that are subject to the impact of double-taxation. In effect, the legal status enjoyed by REITs represents a tax regime choice because, besides their unique fiscal status, they are subject to the same SEC regulations than other publicly listed stocks. (Liu, 2010).

The growth of the REITs' industry received a strong impulse from their outstanding performance between 1992–1996, attracting the attention of investors. During that period numerous private entities made IPOs, increasing the number of "publicly traded REITs from 138 at the end of 1991 to 199 companies at the end of 1996". The magnitude of that impulse may be better appreciated considering that REITs issued $49.7 billion in equity (including IPOs and SEOs) in between 1990 and 1996, and their market capitalization went from $13.0 billion in 1991 to $88.8 billion in 1996, an extraordinary growth (Krewson-Kelly and Thompson, 2016).

During several years before the mortgage market meltdown of 2007-2008, house prices in the residential real estate market increased almost and accelerated almost continuously. According to the Federal Housing Finance Agency, the price index of residential property (buy side) started rising in 1991; one decade later, by the end of 2001, it was already approximately 50 % higher; and, during the next five years, from 2001 through 2006, prices raised another 50 %, to reach a compounded accumulation of approximately 125 % (see Figure 1). With hindsight, we know that real estate price increases were supported by the sustained growth of home building and an easy access to mortgage credit, which combined to produce a typical price bubble in that sector. However, the accumulation of inventory created the conditions for a more drastic collapse of prices, which begun around February of 2007. Packer et al. (2013), describe this period as "the biggest property market boom and bust since, at least, the 1920s".

At the turn of the century, the crash of the NASDAQ, the stock market where most new technology firms are listed, was transmitted to the rest of the stock market and had a significant influence on the slow-down of economic activity in the United States. Moreover, during the following years, a series of financial scandals (e.g., Xerox and Tyco in the U.S.; and, Parmalat in Europe) caused further erosion in investors' confidence and, naturally, motivated their search for alternative investments. In the short-run, many investors had lost trust in stocks and financial securities, so they redirected their cash investments towards the real estate market, which potentially promised extraordinary returns: property prices had increased at a compound annualized quarterly rate of 6.6 % for the last 10 years (Figure 1). So, the residential sector became a preferred investment alternative.

Figure 1. Price index of residential properties (buy side). Quarterly data. (First Quarter of 1991=100)



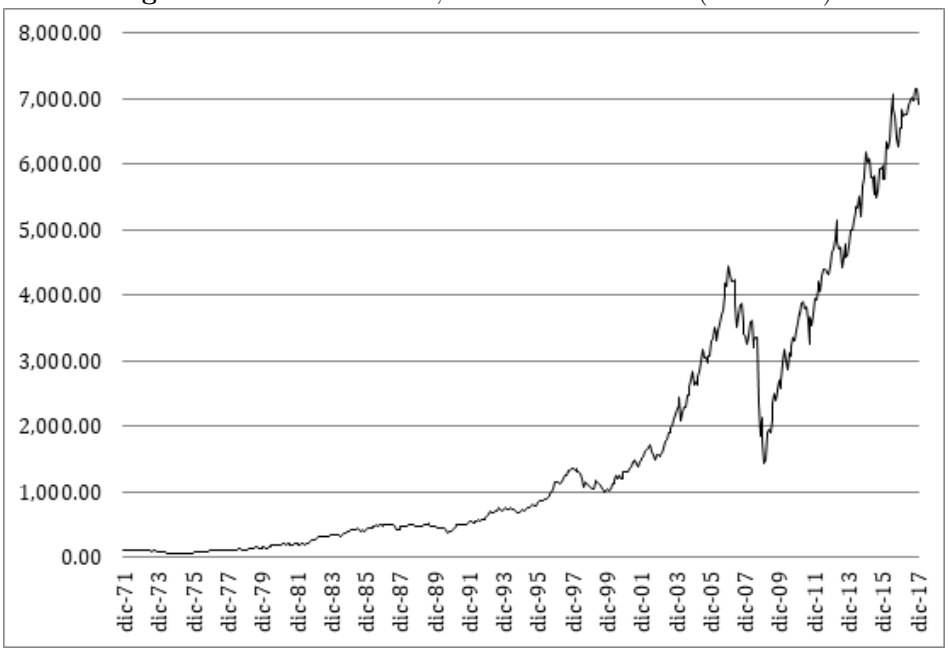
Source: Federal Housing Finance Agency. Retrieved from: http://www.fhfa.gov/Default.aspx?Page=87.

Macroeconomic conditions, including historically low interest rates in mortgages, and constant economic growth from 2002 through 2006, gave impulse to an increasing demand for residential properties, including many investors who often did not understand the real estate market well, but were willing to share in its profits.

Residential properties prices raised at an average annual rate of 6 % between the third quarter of 2000 and the third quarter of 2006 across the industry, although there were some differences by geographic area and type of housing. The average price increases during the period of reference were 42 %. After reaching a maximum annualized growth rate of nearly 10 % during the second quarter of 2005, the residential properties reached their highest prices during the first quarter of 2007, and then begun a marked decline, almost at the same time as the Federal Reserve Bank started reducing its reference rates to cushion the economic slowdown that accompanied the bubble burst.

Investors buy REITs' shares that generate stable cash flow from rents, to receive dividends from net income. As with any other stock, REITs' dividends represent the investor's yield on its shares, but REITs shares income is usually considered more stable than other types of stocks, so a milder reaction of REITs prices could have been expected in a market crash. However, the fact that real estate prices collapse also represented a significant reduction in the market value of REIT-owned properties, their stock prices responded in a very volatile fashion, as illustrated in Figure 2.

Figure 2. All REITs Index, December 1971=100 (1971-2017)



Source: FTSE Nareit U.S. Real Estate Index Series.

While there is a generalized belief that real estate prices represent a minor influence on REITs prices, Boudry et al. (2012), using transaction-based price indexes find that the relation between REIT and direct real estate returns appears to be strong. The evidence presented in Graphs 1 and 2 confirms the close association that exists between REITs prices and direct real estate prices.

This work studies the changes in volatility of the risk premium of REITs corresponding to different economic sector in the United States,. It postulates that the volatility of REITs risk premium follows a GARCH (1,1) process that responds to changing economic factors. Our modeling approach represents a pioneering analysis of the sensitivity of the volatility of REITs' risk premium, to the risk premium of the SP500, and to interest rates, during eleven sub-periods between 1985 and 2016.

Section two briefly describes the REITs industry and its recent evolution. Section three highlights some recent works on REITs and, more specifically, on REITs' volatility, and frames the analysis of this work. Section four describes the data, the methodology we follow, the econometric results, and their interpretation. Section five concludes and summarizes the findings.

2. An Overview of the Real Estate Investment Trusts Industry (REITs)

Real Estate Investment Trusts (REITs), are companies in the business of owning real estate or financing income-producing properties in a range of economic sectors. Created by the Real Estate Investment Trust Act of 1960, these companies have to meet several requirements to qualify as REITs but, once they are eligible, they are exempt from paying corporate income tax, on the condition they distribute their taxable income as dividends in a proportion of at least 90 % of the total to their shareholders and must pay out 100 percent. This exemption is a unique feature that makes them very attractive to investors worldwide. REITs must derive a minimum of 75 % of their corporate income from real estate as rent, interest income, or from the sale of real estate assets; at least 75 % of the corporation assets must be real estate assets. Also, at least 95 % of income must be

passive.[2]

Public REITs' stock is traded on stock exchanges, where they can be bought or sold like the stock of any other public company, either directly or through mutual funds or Exchange Traded Funds (ETFs) (Krewson-Kelly and Thomas, 2016). REITs are either Equity REITs (EREITs), which invest in income generating properties; Mortgage REITs (MREITs), which invest in portfolios of mortgages; or, Hybrid REITs that combine both EREITs' and MREITs' characteristics. Most REITs are equity REITs, which derive their income from rental revenue paid by tenants (Peng 2010; Felix 2013). According to the National Association of Real Estate Investment Trusts (NAREIT), REITs can be categorized as:

a) Equity REITs: own or operate income-producing real estate.

b) Mortgage REITs: provide financing for income-producing real estates. These REITs originate or purchase mortgages and mortgage-backed securities and earn income from the interest on these investments.

c) Public Non-listed REITs: registered with the SEC but do not trade on national stock exchanges.

d) Private REITs: are offerings exempt from SEC registration and whose shares do not trade on national stock exchanges.

Investors buy shares in REITs, which invest in properties to rent. REITs pay dividends to their investors from the net income that was obtained from the rentals of the properties or from the interest earned from portfolios of mortgages. Similar to corporate equity stock, the REIT dividend represents the investor's yield, but there can also be capital gains (losses) as the price of the REIT shares changes in the market in response to the news or the economic environment, among other factors.

REITs managers are conscious of the importance of their reputation and financial performance over time to gain continued affordable access to capital markets. As their legal status imposes restrictive payout requirements, to grow REITs must access capital markets regularly, and each time they are subject to the screening of investors who have many other investment opportunities (Packer et al. 2013).

According to the National Association of Real Estate Investment Trusts (NAREIT)[3], the REIT industry's aggregate equity market capitalization has increased exponentially during the last four decades. In 1980 the total capitalization of the industry was $2.3 billion, distributed as follows: Equity REITs, 41 %; Mortgage REITs, 22 %; and, Hybrid REITs, 37 %. By the turn of the century, the total capitalization had reached $138.7 billion, and the participation of Equity REITs had increased to 97 %, while that of Mortgage REITs and Hybrid REITs had diminished to 1.1 % and 1.9 %, respectively. In December of 2016, the total capitalization of the industry had reached 1, 019 billion, Hybrid REITs had disappeared, and the distribution between Equity REITs and Mortgage REITs was 94.2 % and 5.8 % respectively. Hybrid REITs were likely replaced by investors-selected portfolios that combine Equity and Mortgage REITs in the individuals' desired proportions, with a clear preference for the former. The average annual constantly compounded growth rate of the industry between 1980 and 2000 was 20.5 %, and between 2000 and 2016, 12.5 %.

From 1980 January to December 2000, the average annual return of the All-REITs Index was 10.93 %, compared to 12.24 % for the SP 500; and, from January 2001 to December 2017, the average annual return of the All-REITs Index was 10.47 %, which

[2]https://www.reit.com/
[3]https://www.reit.com/

compares highly favorably with the SP 500, which averaged annual returns of only 4.20 % (60 % less) during the same period. No wonder why REITs have proven to be popular with investors who view stocks as too risky and bonds as not giving enough yield (Lin and Lee, 2015).

3. An Overview of the REIT Literature

The REIT literature has dramatically multiplied in recent decades as a response to the increasing economic importance of the industry and the significant interest it has aroused among portfolio managers. The aim of this work is not to present a comprehensive literature review, and it will be limited to the most representative lines of research to position the less abundant and promising literature that focuses on the volatility of REITs.

- Studies on the Relationship Between REIT, Stock, and Real Estate Property Prices Returns

REIT market valuation is influenced by interest rates and stock market fluctuations, and these latter are affected by economic fundamentals, and several other variables, including political events and sociological trends. Improving financial economists' understanding of the market conditions that affect REIT valuation contributes to predicting how they respond to different stimuli and helps investors improve their REIT related investment decisions.

Among the different strands of the literature interested in REIT returns determination, some authors have studied the existence of cointegration between REIT returns and the stock market (Clayton and MacKinnon, 2001 and 2003; Lin and Lee, 2015); while others have focused on REIT returns sensitivity to macroeconomic variables (He, Webb, and Myer, 2003; Bredin et al, 2007; Hong and Lee, 2013; Giliberto and Shulman, 2017).

The problem of measurement of investment performance has been a difficult challenge for those interested in the study of the real estate industry because due to the typical low frequency in the trading of different types of properties. Also, due to the inexistence of a centralized recording of the transactions, market-determined prices of real estate transactions are not readily available. Besides, the number of transactions per period is often so small that price indices do not reflect the real variability of real estate prices, and even a few atypical transactions can produce significant distortions in them. Exploring that idea further, Gyourko and Kleim (1992) analyze the relationship between the risk and return of real estate publicly traded firms and those of a standard appraisal-based index. What they find is that lagged values of publicly traded real estate portfolio returns (REITs) are capable of predicting the returns of the appraisal-based index.

Clayton and MacKinnon (2001), study the sensitivity of equity REITs' returns with respect to direct real estate investment, large-cap stock, small-cap stock and bond markets over a twenty-one year period (1978-1998) with the aim to evaluate whether REIT returns sensitivity varies over time using a multi-factor model in which REIT returns "are regressed on stock, bond, and real estate returns." One aspect that is relevant in this study is that it attacks a practical problem for those portfolio investors who contemplate the inclusion of REITs in their portfolios with diversification purposes. The authors find that the relationship between REITs and the different markets they include in their study change over time. This work's results suggest that REIT returns and real estate returns are directly linked, but the strength of that link is cyclical. REIT returns sensitivity to large-cap stocks declined through the period of analysis, and large-cap stocks have a more substantial cyclical component than small-cap returns.

Ling et al. (2003) examine REIT return characteristics over a twenty-seven-year period (1972 through 1998) and their relationship to varying interest rate proxies. Their work includes seven different interest rate proxies, which they select according to the frequency with which they appear in the literature on REIT studies. The proxies they use include

the yields on long-term government bonds and corporate bonds, the spread between the returns on long-term government bonds and T-bill rates, the spread between yields on corporate bonds and long-term government bonds, and the spread between returns on corporate bonds and government bonds. According to their OLS estimations, mortgage REITs are sensitive to all proxies, but equity REITs, which are known to produce equity-like returns, are only affected by changes in yields on long-term government bonds and corporate bonds. They also find that changes in yields of corporate bonds have most robust explanatory capacity on equity and mortgage REITs returns. Interestingly, the authors also report that the "time variation paths for sensitivities indicate that all interest rate sensitivities are time specific."

Another example is the work of Bredin et al. (2007), who investigate how do the changes in the Federal Funds Rate, the most important tool of monetary policy in the United States, affect the returns and the volatility of Equity REITs. They find that there is a strong response in "both the first and second moment of REIT returns to unexpected policy changes," and propose as an explanation that monetary policy changes directly influence aggregate demand, but through employment and income, indirectly affects occupancy demand of real estate properties. These phenomena feed on rents obtained by REITs' properties and, eventually affect the dividend they distribute to their investors. Thus, changes in dividends distributed affect the market's perceptions, as well as REIT valuation.

More recently, Boudry et al. (2012) look at the cointegration relationship between REITs, direct real estate transaction records, the large-cap SP-500, and the small-cap Russel-2000. They report that research results from different studies support the conclusion that the linkages between securitized and direct investment in real estate are weak or non-existing, and they propose that this puzzling result may be due to either the "coarseness of the measures of direct real estate returns," or the short observation periods studied. In contrast with former research, instead of the aggregate average appraisal-based returns on direct real estate investment, they use the MIT-TB1 Indexes returns (at an aggregate and sub-index level). Using cointegration analysis, they find that both REITs and the MIT TB1 Index returns converge in the long run at an aggregate as well as at a property-type level. Their results suggest that REITs and real estate share a similar long-term equilibrium; supporting positions that postulate that REITs behave like their underlying assets.

By contrast, the relationship between REITs and equity indices and bond indices shows mixed signals. Bonds appear to be more correlated with REITs in the long-run, while small-caps (Rusell 2000) only have a modest increase and the correlation with large-caps (SP500) even decreases. The differences observed between the relationship with the Russell 2000 and the SP 500 suggest the possibility that using the SP500 as the aggregate equity factor "may miss part of the small-cap equity nature of REITs."

- Factor Models and REIT performance

Among the relatively abundant number of studies that attempt to evaluate REIT performance, the reported generalized findings suggest that REITs either outperform or perform about the same as common stocks and that there are variations across alternative REIT categories. However, the way different authors evaluate REIT performance varies significantly from one study to another. For example, some adopt a performance analysis based on factor models, like Peterson and Cheng-Ho (1997), who measure REIT performance using the five-factor model of Fama and French (1993) in which time-series regressions show that "a market factor and mimicking portfolios for size and book-to-market explain returns on stocks." They identify five common risk factors in the returns on stocks and bonds, three for the stock market, including an overall market factor and factors related to firm size and book-to-market equity; and two more for the bond-market

factors, the bonds' maturity and default risks. The analysis uses monthly returns on equity and mortgage REITs from 1976 through 1992 and finds that risk premiums on equity REITs are significantly related to the risk premium on a market portfolio of stocks and the size and book-to-market matching stock portfolios. On the other hand, the mortgage REIT risk-premium is significantly related to the three stock-market-factors and the two bond-market factors. The five factors explain well the average returns on stocks and bonds.

In a more contemporaneous study, Giliberto and Shulman (2017) also evaluate the interest rate sensitivity of REITs by using a multi-factor model asset-pricing model. According to these authors, there is a generalized expectation that changes in yields of Treasury securities affect the market value of most financial securities in the market. In the case of a risk-free Treasury bond, for example, a change in its yield will be associated with its price in the secondary market. However, a corporate bond with very similar characteristics, but that is not risk-free, will show higher sensitivity to the same yield change. Moreover, in the case of stocks, their market price should also be influenced by a modification in the risk-free securities yield and other factors. According to these authors, REIT values and returns should have a higher sensitivity to interest rates than stocks. The stated reasons are: a) Their value reflects holdings of long-lived tangible assets; b) Their assets are more capital intensive than the average public corporation; c) Leverage in REITs is greater than the average industrial firm; d) The dividends paid by REITs are significantly higher than those of corporate stocks. However, while the focus of the study is centered on interest rate sensitivity, in their econometric estimations, they include other different factors, including corporate bond spreads and the SP 400 returns. They divide their analysis into eight sub-periods corresponding to important systemic trends in the stock market: a) the bull market of the mid-1990; b) the late 1990s bear market; c) the 2000-2007 bull market; d) the 2007-2009 crash; 2009-2013 surge; and e) the 2013-2016 period. They find notable temporal variations in the magnitude of their estimated coefficients and, in some cases, they also find change in sign. In effect, the results of Wald tests suggest that the only bond return coefficients that are not significantly distinct from each other are those that correspond to the crash and surge sub-periods, a fact that is most likely explained by the intense turbulence that was present in all financial markets during those periods. In effect, the authors conclude that their results suggest there is no predictive rule for how REITs react to interest rates.

- Studies on the Volatility of REITs

Krewson-Kelly and Thomas (2016) report that just during the 25 years from 2005 through 2015, the REIT industry trading volume grew dramatically. Using NAREIT data, these authors report that "the industry's average daily dollar trading volume increased at a compounded average rate of 12.5 percent, from $1.7 billion in 2005 to $6.2 billion in 2015". The increasing depth of the market was accompanied by an augmented REITs' volatility. According to the same authors, based on information from SP Global Market Intelligence, "during the 1,508 trading days in the 2000–2005 period, the RMZ (the MSCI US REIT Index (RMZ), that tracks approximately 150 publicly traded equity REITs) rose or fell by more than 3 % only 13 times; (but) in the 1,508 trading sessions of 2010–2015, the RMZ saw 51 such daily swings", that is, swings larger than 3 % recorded almost four times higher frequency during the latter period (the financial crisis period is excluded because it may not be considered representative). Notwithstanding, compared with the number of published works on several other characteristics of the REIT market, there are very few studies that analyze REIT volatility.

Among those few examples, the work of Jirasakuldech et al. (2009) studies the volatility of returns of EREITs using GARCH models for a period that goes from 1972 to 2006. Its relevance derives from the comparison of dynamic volatility performance of

monthly EREITs' returns for an early period in the REIT industry (from 1972 through 1992), with that of a more modern period (from 1993 through 2006). The results indicate that EREITs' conditional volatility is "time-varying, persistent and predictable," and that during the early EREITs' period there is a positive relationship between expected return and risk, but that during the modern EREITs' period that relationship disappears. Another significant finding is that changes in the conditional volatility of fundamental macroeconomic variables included in their analysis have a strong explanatory significance for changes in EREITs' volatility.

The dynamic volatility spillover between stocks and REITs, as well as between bonds and REITs for six Asian countries (Taiwan, Japan, Malaysia, Singapore, Hong Kong, and South Korea) is examined by Lin (2013). The study uses a GARCH (1,1) model that incorporates exogenous variables in the variance equation, finds evidence of spillovers, and reports there is a positive relation between bond and REIT volatility, and a negative effect of the stock market returns on REIT performance. Moreover, during the 2007-2009 financial crisis, the stock market effect on REITs volatility is more significant than in previous periods. The author interpretation of his results is that a favorable evolution of the stock market would benefit the REIT market, decreasing its volatility.

Sun et al. (2015) find that in the years surrounding the financial crisis, equity REIT share prices were much more volatile than the underlying commercial real estate property prices, and explore the reasons why that was the case. They examine the cross-section dispersion of REIT returns and focus on the influence of capital structure. They disaggregate the pure leverage effect from the financial distress risk and conclude that the share prices of REITs with higher debt-to-asset ratios and shorter maturity debt fell more during the 2007-2009 crisis period. They report that while REIT prices rebounded as commercial real estate prices recovered, financial distress effects remained present and became permanent.

In their work, Chung et al. (2016) explore the nature of the statistical relationship between the stock market returns volatility and REITs' future returns, during the years of the financial crisis (2007-2009). They postulate that REITs are more exposed to the possibility of default during periods of financial turbulence than, for example, corporations listed in the SP 500 Index. The REITs sensitivity es because they are highly leveraged, certainly more than a typical industrial corporation, and to the obligation they must pay practically all their earnings as dividends, leaving them with remote chances to reduce their debt levels during the typical credit crunch that happens during crises. As REITs are more exposed during turbulent periods, a negative relationship between their returns and market volatility is more likely. Another interesting finding reported by these authors is that REIT implied volatility explains as much as 69 % of the variation in observed volatility. Huerta et al. (2016) follow a similar approach to represent REIT volatility, selecting a GARCH-M specification, and using with data for the December 2001 to February 2013. They argue that the increased volatility observed in REIT returns during the Financial Crisis period (2007-2009) is, in part, explained by the liquidity crisis and investor sentiment that was present. While the banking industry experienced balance sheet stress and, as a consequence, significantly reduced its supply of credit, the REIT industry experienced reduced access to credit, and its performance was negatively affected; these findings are robust to different specifications of the econometric model. They also conclude that "investor sentiment is a significant factor in the REIT return-generating process" and that institutional sentiment has a "dominating role over individual sentiment."

The last paper discussed in this brief literature review on the volatility literature is the work of Kawaguchi et al. (2017), who analyze empirical "puzzling" episodes recorded between January 1985 and October 2012. They report a negative leverage effect in volatility before and after, but not during Greenspan's tenure from 1994 through 2006. They explain that the "positive elasticity of variance to the value of equity" during the Greenspan era

was due to the convergence between commercial mortgage yields and 10-year Treasuries, resulting in a wealth transfer from REIT equity holders to REIT debt holders. The U.S. monetary policy response to such episodes as the Russian crisis, the collapse of the Long-Term Capital Management hedge fund, and the dot-com crisis was to maintain very low short-term interest rates, inducing investors to accept lower risk spreads for short-term debt, and had positive effects on the net worth of banks. Arguably, the reduced spread allowed REITs to take on significantly more risk than usually recognized, so the average REIT stock return volatility increased significantly during the high turbulence 2007–2010 period at the time that REIT stock prices experienced an extraordinary drop.

Similarly, Real Exchange Investment Trust can offer some diversification benefits to investors, but not always. In the period 2002-2012, Bhuyan, et al. (2015) found that equity REITs offered better diversification benefits than mortgage REITs for US asset portfolios. Yokoyama et al. (2017) found that during the 2008-2014 period the Brazilian REITs offered diversification benefits to investors in other asset classes because the REITs total returns cannot be explained by the same factors driven stocks and bonds. As an explanation, Akinsomi et al. (2018) observe herding behavior, which can explain the correlation between REITs, during low volatility periods and anti-herding behavior during high volatility periods in the London Stock Exchange from June 2003 to April 2016. At the international level, Liow and Huang (2018) find that there is a strong connectedness among REIT national market indexes in the studied ten longest-stablished REIT markets during the Great Recession crisis period, which reduces dramatically after the crisis. They argue that the observed strong connectedness during the crisis is the result of relationships among local stock markets that have spillovers on the local REIT markets. As a result, the diversification benefit of REIT investment is lower than otherwise.

4. Data Description and Methodology

During the period of analysis, different events affected the evolution of the real estate industry and the United States economy. Market crashes, bubble bursts, massive bonds' default episodes and, of course, the Global Financial Crisis that started in the real estate sector, followed by a deep recession and, almost sequentially, by the Sovereign Debt Crisis in Europe.

On Monday, October 19th, 1987, the stock markets around the world crashed. The crash started in Hong Kong and then hit Europe, affecting the United States after other markets had already suffered significant losses. That day is known in history books as "Black Monday." One decade later, with the fast spread off computer systems and communication networks, the technological communications and software sector experienced a stock market boom, many new companies were created and their stock issued to the market. From 1997 to 2000, a large expansion occurred. The expectations of investors were very favorable great, anticipating all the benefits that could derive from the introduction of information technologies in every-day life activities, from manufacturing to financial services, and the stock prices of those companies rose swiftly. The seeds of a financial bubble were in play; the bubble would burst during the second semester of 2000, and the crisis continued to affect the markets during the following two years. It is true that besides the "New Economy" stocks collapse, the terrorist attacks to the World Trade Center in New York and the proliferation of accounting scandals (for example, Enron, Xerox, and Tyco) were determinant in the lengthening of the slow-down.

However, another bubble was in the making in the market of Subprime Mortgages during the first years of the decade. From 2004 to 2006, the number of outstanding subprime (or low quality) mortgages increased substantially, as an effect of the relaxation of lending standards. The interest rate of many of the new mortgages was adjustable and, also, speculation in the real estate sector had significantly inflated housing prices. By the mid-2006, housing prices declined abruptly, and during the following year, the bubble

busted. Interest rates rose substantially. As a result, the amount owed on adjustable-rate mortgages substantially augmented. Many debtors had problems in making mortgage payments and defaulted. The decline of real estate prices more difficult the refinancing of loans. Securities backed with mortgages, many of them sub-prime mortgages, lost their value, so investors got rid of their mortgage-backed securities and the consequences were severe for many financial and non-financial institutions that held them in their portfolios. One of the most critical consequences was the credit-crunch that resulted, as banks saw their equity base reduced, thus substantially reducing their ability and willingness to lend.

At the end of 2007, the Great Recession combined with the Sub-Prime Financial Crisis. The burst of the housing bubble resulted in large financial losses in many financial institutions, all of which had large exposures to mortgage back securities and credit backed securities. The introduction of higher credit standards because of the crises only aggravated the economic situation. As consumer spending and business investment came to a stop, and many people lost their jobs.

By mid-2009, a slow economic recovery followed, but the recovery was sluggish and with many drawbacks. Unemployment was high, wages stagnated, and the recovery of income was painfully slow. Also, during 2011 and 2012 the financial markets turmoil originated by the Sovereign Debt Crisis in Greece, Portugal, Ireland, and Spain, continued to inhibit a more sustained recovery. However, by the first months of 2013, the economic panorama improved. That year the U.S. economy had a stronger performance and jobs creation was substantial; GDP also showed signs of steady growth. The following year, 2014, the U.S economy had the strongest economic growth since the recession, a trend that continued in 2015. That economic performance was sustained through 2016, but at a slower pace.

For analytical purposes, we divide the whole period of observation into nine different sub-periods, delimited in time by major systemic events. The sub-periods are: 1) the period before "Black Monday" (October 19, 1987), i.e., before the second semester of 1987; 2) the period that goes from the Black Monday crisis, through the second semester of 1988; 3) the recovery period, from the beginning of 1988 to December of 1996; 4) the Dot.Com bubble growth, from the beginning of 1997 and until the end of 2000; 5) the Dot.Com bubble burst, from the beginning of 2001 to the end of 2002; 6) the stable interperiod that followed, during 2003; 7) the Sub-Prime market boom, from 2004 to 2006; 8) the Sub-Prime market crash, in 2007, from January to November; 9) the Great Recession, from the beginning of December 2007 until the end of the first semester of 2009; 10) the recovery period, from the beginning of the second semester of 2009, until the end of 2012; and, finally, 11) the stable growth period, from the beginning of 2013, until the end of 2016.

The Capital Asset Pricing Model (CAPM), introduced by Treynor (1961, 1962), Sharp (1964), Lintner (1965) and Mossin (1966) is a model that relates expected return of the assets with the systematic risk of the market. That is, the return of asset i, $r_{i,t}$ will be a function of the risk-free rate $r_{f,t}$ and a factor that depends on the market risk-premium $Mrp_t, r_{i,t} - r_{f,t}$, which measures systematic market risk, see for example, Valencia-Herrera and López-Herrera (2018),

$$r_{i,t} = r_{f,t} + b_i Mrp_{i,t} + \eta_{i,t} \qquad (1)$$

From equation (1), the risk premium of an asset, $rp_{i,t} = r_{i,t} - r_{f,t}$ is a function of the risk premium of the market, Mrp_t, as equation (2) shows,

$$rp_{i,t} = b_0 + b_{1,i} Mrp_t + \eta_{i,t} \qquad (2)$$

The paper uses the SP500 index as the market portfolio and the 28 days Treasury Bill as risk-free rate. So the market premium expressed as $SP500rp_t$ is equal to the difference between the daily return of the SP500 and the 28 days Treasury Bill yield, $TB28yield_t$.

In the case of each of the REIT indexes, the risk premium is the daily return of the respective REIT inde3x over the 28 days Treasury Bill yield, $TB28yield_t$. Besides, REITs returns are highly sensitive to interest rates, so the higher the short-term interest rate, the lower return on REITs; that is, the coefficient of the 28 days Treasury Bill yield will be negative. Equation (2) illustrates the resulting level equation

$$REITrp_{i,t} = b_0 + b_{1,i}SP500rp_t + b_2TB28yield_t + \eta_t \qquad (3)$$

As is the case with many financial assets, the volatility of the error term of the REIT equation is assumed to follow a GARCH (1,1), process, which allows considering an autoregressive structure on the data and volatility changes over time (Bollerslev, 1986). Equation (4) illustrates a simple GARCH (1,1) model, where the next period variance is a combination of the last periods squared error return, v_{t-1}^2, and the last period conditional variance, σ_{t-1}^2,

$$\sigma_t^2 = \alpha_0 + \alpha_1 v_{t-1}^2 + \beta_1 \sigma_{t-1}^2, \qquad (4)$$

where $\alpha_0 > 0$, $\alpha_1 > 0$, $\beta_1 > 0$, and $\alpha_1 + \beta_1 < 1$. The error return, in the simple model, comes from an autoregression of the return, as illustrated in equation (5).

$$r_t = \alpha_0 + \alpha_1 r_{t-1} + \eta_t \qquad (5)$$

Here, residual volatility in equation (2) is assumed to decrease along with the market risk premium. The equation assumes that if market returns are largely positive, the REITs volatility is low. Similarly, if interest rates are high, the REITs' return volatility will be greater because high interest rates are often associated with more volatility. Different periods affect volatility in different ways. During periods of crisis, volatility is high; and, during periods of growth and stability, volatility is expected to remain at low levels. Table 1 shows the dummies considered in the volatility equation to identify and analyze the main sub-periods.

Table 1. Dummy Variables in Volatility Equation

Dummy Variable	Period	Value
DBC_t	Black Monday crash	= 1 on and after July 1st, 1987; 0 otherwise
DBR_t	Recovery from Black Monday	= 1 on and after January 1st, 1988; 0 otherwise
DDB_t	Dot.com bubble	= 1 on and after January 1st, 1997; 0 otherwise
DDC_t	Dot-com crash	= 1 on and after January 1st, 2001; 0 otherwise
DIN_t	Inter-period	= 1 on and after January 1st, 2003; 0 otherwise
DSM_t	Subprime-market boom	= 1 on and after January 1st, 2004; 0 otherwise
DSC_t	Subprime-market crisis	= 1 on and after January 1st, 2007; 0 otherwise
DGR_t	Great Recession	= 1 on and after December 1st, 2007; 0 otherwise
DRE_t	Recovery from the Great Recession	= 1 on and after July 1st, 2009: 0 otherwise
DEN_t	Stable growth period	= 1 on and after January 1st, 2013; 0 otherwise

Source: Own elaboration

Equation (6) illustrates the volatility equation of each REIT index considering the previously discussed elements

$$\begin{aligned}\sigma_t^2 = c_1 + c_2\eta_{t-1}^2 + c_3\sigma_{t-1}^2 + c_4 SP500rp_t + c_5 TB28Yield_t \\ + c_6 DBC_t + c_7 DBR_t + c_8 DDB_t + c_9 DDC_t + c_{10} DIN_t \\ + c_{11} DSM_t + c_{12} DSC_t + c_{13} DGR_t + c_{14} DRE_t + c_{15} DEN_t + \epsilon_t\end{aligned} \qquad (6)$$

During periods of crisis, volatility is expected to increase. That is, the coefficients that correspond to a crisis, DBC_t (Black Monday crash), DDC_t (Dot.com crash), DSC_t (Subprime market crisis) and DGR_t (Great Recession) should have a negative sign. Similarly, volatility is also expected to increase during booms. In this case, those coefficients that correspond to boom periods are expected to be positive, DDB_t (Dot.com bubble), DDB_t (Dot.com bubble) and DSM_t (Sub-prime market boom). During the period of recovery

after a crisis, volatility is expected to decrease. So, the coefficients that correspond to the DBR_t (Black Monday recovery), DIN_t (Inter-period, after the dot.com bubble burst) and DRE_t (Great Recession recovery) are expected to be negative. During periods of stable growth, volatility is expected to be lower. The coefficient that corresponds to the DEN_t (stable growth period) is expected to be negative.

5. Results, Discussion, and Analysis

REIT index series are value-weighted indexes retrieved from the CRSP/Ziman Real Estate Data Series Collection; and, the 28 days Treasury Bill yields and SP500 price index series are obtained from Bloomberg. The data is daily from January 2nd, 1985 to December 30th, 2016. The indices that are analyzed correspond to the General REIT index (General), which combines a diversified sample of REITs, plus specialized indices, that correspond to eight industrial sectors, i.e.: the Mortgage REIT Index (Mortgage), the Equity REIT Index (Equity), the Healthcare REIT index (Healthcare) the Industrial and office REIT Index (IndOff), the Lodging REIT Index (Lodging), the Retail REIT Index (Retail), Self-storage REIT Index (Selfstorage), and the unclassified REIT Index (Unclassified).

Table 2 shows basic REIT returns statistics. The mean daily return of the REITs indices is slightly different depending on the REIT. The lowest yields are observed for the lodging REIT (0.000331), the mortgage REIT (0.000335), the industrial and office REIT (0.000339), the unclassified REIT (0.000374) and the general REIT (0.000451). The most substantial mean daily yields correspond to the self-storage REIT (0.000644), healthcare REIT (0.000596), the residential REIT (0.000549) and the equity REIT (0.000477). The volatility, measured by the standard deviation of the REIT returns, is smaller for the general REIT index (0.0136), most likely due to the diversification effect. Other low volatility indexes include the unclassified REIT (0.0138), the equity REIT (0.0140), the mortgage REIT (0.0143), the healthcare REIT (0.0144) and the retail REIT (0.0148). Volatility is the largest for the lodging rate (0.0247), the self-storage REIT (0.0161), and the industrial and office REIT (0.0159). All REIT returns distributions are not normal, due to leptokurtosis and skewness to the right. Extreme values are also observed, with maximum daily returns of more than 15 % and minimum daily returns below -12 %.

Table 2. REIT Daily Returns

	General	**Mortgage**	**Equity**	**Healthcare**	**Ind&Off**
Mean	0.000451	0.000335	0.000477	0.000596	0.000339
Median	0.0006	0.0007	0.0006	0.0007	0.0004
Maximum	0.1745	0.2477	0.1791	0.1681	0.1949
Minimum	-0.1847	-0.165	-0.192	-0.1656	-0.2237
Standard Deviation	0.0136	0.0143	0.014	0.0144	0.0159
Skewness	0.4486	0.6701	0.4296	0.2971	0.2079
Kurtosis	36.6124	46.1691	36.746	24.6786	33.3749
Observations	8068	8068	8068	8068	8068
	Lodging	**Residential**	**Retail**	**SelfStorage**	**Unclassified**
Mean	0.000331	0.000538	0.000549	0.000644	0.000374
Median	0	0.00045	0.0006	0	0.0004
Maximum	0.2475	0.1828	0.2157	0.192	0.1838
Minimum	-0.2258	-0.1936	-0.1935	-0.1837	-0.1349
Standard Deviation	0.0247	0.0147	0.0148	0.0161	0.0138
Skewness	0.5526	0.5368	0.6343	0.2275	0.3458
Kurtosis	17.2108	32.679	38.0814	24.3865	20.9363
Observations	8068	8068	8068	8068	8068

Source: Own elaboration.

Table 3 shows the unit-root test using the Augmented Dickey-Fuller test on each REIT sector risk premium and the SP500 risk premium considering only a constant and

a lag length selected using the Schwarz information criterion. In all of the analyzed risk premiums series, the hypothesis that the series has a unit root is rejected. Therefore, all risk premium series are stationary.

Table 3. Unit root test: Augmented Dickey-Fuller test statistic of Risk Premiums

Risk Premium	Augmented Dickey-Fuller test statistic	Probability
General	-15.36226	0
Mortgage	-93.88572	0.0001
Equity	-17.38714	0
Healthcare	-70.11892	0.0001
Ind&Off	-104.1507	0.0001
Lodging	-104.9177	0.0001
Residential	-104.1679	0.0001
Retail	-102.325	0.0001
Self-Storage	-43.90514	0
Unclassified	-100.6351	0.0001
SP500	-68.3736	0.0001

The null hypothesis is the variable has a unit root. MacKinnon (1996) one-sided p-values. The 1 % test critical value is -3.430984 for all analyzed risk premiums, except for the equity risk premium, which 1 % test critical value is -3.430793.
Source: Own elaboration.

Table 4 shows the results obtained from the return equations. All REIT risk premiums depend on the risk premium of the market (SP500RP), at a 99 % confidence level. The lodging REIT returns have the strongest dependence on the market, with a beta of 0.791, followed by the unclassified REIT, with a beta of 0.5250. Betas for the self-storage REIT (0.3977), the healthcare REIT (0.3918), the mortgage REIT (0.3820), the industrial and office REIT (0.3563) and the retail REIT (0.3055) are in the 0.30 to 0.40 beta range. The equity REIT index exhibits the lowest beta (0.1151), followed by residential REIT with a beta of 0.2871 and the general REIT with a beta of 0.2931.

As expected, all REIT indexes show a negative dependence on the short-term interest rate (TB28YIELD). That relation is also statistically significant at 99 % for almost all REIT returns, with the exception of lodging REIT returns, which have a coefficient on the TB28YIELD variable that is statistically significant at only 5 %, and the healthcare and residential REIT returns that dont show a statistically significant relation with TB28YIELD.

Table 4. Return Equations

	General	Mortgage	Equity	Healthcare	Ind&Off
C	0.0010 **	0.0009 **	-5.46E+0 **	0.0006 **	0.0010 **
	-0.0002	(0.000)	(1.1541)	0	0
SP500RP	0.2931 **	0.3820 **	0.1151 **	0.3918 **	0.3563 **
	-0.0037	(0.0078)	-0.0043	-0.0077	(0.0082)
TB28YIELD	-6.1500**	-4.9277 **	0.0010 **	1.9121	-5.0786 **
	-1.142	(1.619)	0	-1.985	-1.749
	Lodging	**Residential**	**Retail**	**SelfStorage**	**Unclassified**
C	0.0008 **	0.0006 **	0.0009 **	0.0009 **	0.001 **
	-0.0003	-0.0002	(0.0002)	(0.0003)	-0.0002
SP500RP	0.7901 **	0.2871 **	0.3055 **	0.3977 **	0.525 **
	(0.0118)	(0.0070)	(0.0054)	(0.0095)	-0.0086
TB28YIELD	-5.7376 *	-2.2356	-4.7883 **	-2.6657	-6.5461 **
	-2.403	-1.672	-1.411	-2.319	-1.643

** Statistically significant at the 99 %. * Statistically significant at the 95 %. Standard errors are in parenthesis. Source: Own elaboration.

Table 5 shows the results of heteroskedasticity tests on the residuals of the regressions of each REIT risk premium series on the SP500 risk premium and the 28 treasury bills yields assuming a GARCH (1,1) model for the residuals volatility. The employed ARCH test is the Lagrange multiplier test for autoregressive conditional heteroskedasticity in the residuals (Engle, 1982). In Table, the F-statistic corresponds an omitted variable test for the joint significance of all lagged squared residuals. The Obs*R-squared statistic corresponds to the Engle's LM test statistic. The tested null hypothesis is that the squared residuals do not depend on the previous period squared residuals. With one period lag, both the F-statistic and the Obs*R squared statistic of the ARCH-LM tests show the rejection at the 1 % significance level of the null hypothesis in all analyzed sectors, except in the lodging and self-storage sectors, where the null hypothesis cannot be rejected at the 5 % significance level. Therefore, all analyzed residual series, except in the lodging and self-storage equations, exhibit autoregressive conditional heteroskedasticity (ARCH effects).

Table 5. ARCH Heteroskedasticity Test with GARCH (1,1) Volatility of Residuals.

Equation Sector	F-statistic	Probability F(1,8065)	Obs*R-squared	Probability Chi-Square (1)
General	46.267	0	46.015	0
Mortgage	11.113	0.0009	11.100	0.0009
Equity	23.218	0	23.157	0
Healthcare	13.146	0.0003	13.128	0.0003
Ind&Off	16.390	0.0001	16.360	0.0001
Lodging	1.140	0.2858	1.140	0.2857
Residential	11.427	0.0007	11.414	0.0007
Retail	39.149	0	38.969	0
Self-Storage	1.144	0.2849	1.144	0.2848
Unclassified	30.576	0	30.468	0

F-statistic of omitted variable test for the joint significance of all lagged squared residuals. The Obs*R-squared is the Engle's (1982) LM test statistic. Tests assume one lag residuals.
Source: Own elaboration.

Table 6 shows the results of the variance equations. All analyzed REIT return series exhibit statistically significant GARCH(1,1) coefficients, i.e., all REITs' current volatility depends on previous volatilities, and change over time.

The volatility of all analyzed REIT series also increases with the SP500 risk-premium, with a 5 % statistical significance. When the market premium is larger, the volatility is greater. The positive relation of the REITs volatility with the short-term interest rate does not always hold. Only the healthcare REIT volatility, the industrial and office REIT volatility, the lodging REIT volatility, the self-storage REIT volatility, and the unclassified REIT volatility have a positive statistically significant relation with TB28YIELD. When government short-term interest rates increase, the volatility of the REITs in these sectors increases too. In these cases, the hypothesis that higher interest rates are associated with greater REIT volatility hold. In the other sectors, the coefficients were small and even negative.

During periods of crisis, it is expected that volatility increases. That is, the coefficients that correspond to a crisis: DBC_t (Black Monday crash), DDC_t (Dot.com crash), DSC_t (Sub-prime market crisis) and DGR_t (Great Recession) have negative signs. Similarly, coefficients that correspond to recovery or growth periods are expected to be negative, that is, DBR_t (Black Monday recovery), DDB_t (Dot.com bubble), DIN_t (Inter-period), DSM_t (Sub-prime market boom), DRE_t (Great Recession recovery) and DEN_t (stable growth period).

During the Black Monday crash period (DBC), the hypothesis that REIT volatility increases in times of crises hold for all REITs analyzed, except for the healthcare REIT

and retail REIT sectors, that is, their volatility equations have a negative DBC coefficient. The positive relation was statistically significant at 99 % for the Industrial and office sector and the residential sector. It was statistically significant at the 95 % for the unclassified sector.

During the Dot.com crisis (DDC), the behavior was inconsistent with the hypothesis that REIT volatility increases in times of crisis. The equity REIT volatility, the health-care REIT volatility, the industrial and office REIT volatility, and the unclassified REIT volatility decreased during the period, with a statistical significance of 99 %. In the other sectors, the relation was not statistically significant during the period. It is possible that the dot.com crisis only affected that sector, which it is located only in specific locations in the United States. So, it did not have a general effect on the economy, particularly, in the considered REITs.

During the sub-prime crises period (DSC), volatility increased in all analyzed REIT returns. The increase was statistically significant at the 99 %, in the mortgage, the equity, the industrial and office, and lodging sectors and, at the 95 %, in the general, the residential, the retail and the unclassified sectors.

During the great recession (DGR), volatility also increased in all analyzed REIT returns. The relation was statistically significant at 99 % in all considered sectors except the equity and industrial and office sectors, where it was not statistically significant.

Concerning the hypothesis that residual volatility decreases in recovery periods, we observed that residual volatility diminished during the Black Monday recovery period for all analyzed sectors. Changes were inconsistent during the inter-period, after the dot.com burst period. Some sectors had higher residual volatility, while others had it lower. Residual volatility also decreased during the great recession recovery period in all sectors, except in the case of equity REITs.

During the Black Monday recovery (DBR) period, the residual volatility in all analyzed REIT sectors decreased. The null hypothesis of non-decreasing residual volatility was rejected with a statistical significance of 99 percent in the industrial and office sector, and in the residential sector. It was rejected with a 95 statistical significance in the retail, self-storage, and unclassified sectors.

During the inter-period (DIN), after the dot.com burst, changes in residual volatility were inconsistent. Residual volatility increased in all analyzed sectors, except the mortgage, health-care and unclassified sectors, in which it decreased. The increment was statistically significant at the 99 percent significance only in the industrial and office sectors.

During the great recession recovery period (DRE), residual return residual volatility decreased in all analyzed sectors except the equity sector, where it increased. The decrement was statistically significant at the 99 percent level in all sectors, except in the lodging sector.

During the two boom analyzed periods, the dot.com bubble period and the sub-prime market boom period, residual volatility increased during the former, and the behavior by sectors was inconsistent during the latter.

Residual volatility during the dot.com bubble (DDB) increased in all REIT sectors. The behavior was consistent with the hypothesis that residual volatility increases during market booms. The increase was statistically significant in all analyzed sectors except the lodging and the residential sectors.

Residual volatility behavior was inconsistent during the sub-prime market boom period. During the sub-prime market boom period (DSM), residual volatility increased in all analyzed sectors except the equity, lodging, self-storage, and unclassified sectors. The increase was statistically significant at the 99 percent level in the industrial and office, residential and retail sectors, and the decrease was statistically significant at the 99 percent level in the equity, lodging, and self-storage sectors.

Table 6. Variance Equations

	General	Mortgage	Equity	Healthcare	Ind&Off	Lodging	Residential	Retail	SelfStorage	Unclassified
C	0.000000702**	0.00000309**	0.00000302**	0.00000327**	0.0000014**	0.00000158**	0.00000217**	0.00000146**	0.00000968**	0.000000934**
	(1.42E-7)	-0.000000466	-0.000000376	-0.000000682	-0.000000456	(5.13E-7)	-0.000000404	-0.000000272	(5.52E-7)	-0.000000234
v_{t-1}^2	0.1131**	0.1181**	0.1803**	0.0797**	0.0815**	0.0488**	0.1129**	0.0912**	0.0717**	0.0585**
	-0.0055	-0.0039	-0.0088	-0.0046	-0.0047	-0.0029	-0.0051	-0.0047	-0.0027	-0.0033
σ_t^2	0.8446**	0.8497**	0.6776**	0.8808**	0.9021**	0.9435**	0.8553**	0.8757**	0.9039**	0.92**
	-0.0072	-0.0048	-0.0138	-0.007	-0.0049	-0.0028	-0.0068	-0.0062	-0.0042	-0.0044
SP500RP	-0.000125**	-0.000265**	-0.000124**	-0.00022**	-0.000273**	-0.000824**	-0.000182**	-0.000132**	-0.000293**	-0.000242**
	-0.0000111	-0.0000319	-0.0000109	-0.0000338	-0.0000281	(5.70E-5)	-0.0000214	-0.0000144	(3.74E-5)	-0.0000256
TB28YIELD	0.001	-0.00274	-0.00287	0.0056**	0.0036**	0.0114**	0.0065**	-0.00015	0.0184**	0.0034**
	-0.0007	-0.002	-0.0016	-0.0021	-0.0018	-0.0024	-0.0018	-0.0011	-0.003	-0.0013
DBC	0.00000026	0.00000181	0.000000791	-0.00000132	0.00000212**	0.0000006	0.00000253**	0.00000103	-0.00000172	0.000000931*
	(3.11E-7)	-0.00000106	-0.000000819	-0.000000913	-0.00000164	-0.00000124	-0.000000683	-0.00000067	(4.00E-6)	-0.00000045
DBR	-0.000000347	-0.00000175	-0.00000108	-0.000000756	-0.00000287**	-0.00000191	-0.0000041**	-0.00000145*	-0.0000083*	-0.00000108*
	-0.000000306	-0.00000102	-0.000000801	-0.000000786	-0.00000161	-0.00000122	-0.000000684	-0.00000066	(4.03E-6)	-0.000000445
DDB	0.000000862**	0.00000207**	0.0000029**	0.00000236**	0.000000556**	0.000000622	0.000000177	0.000000327**	0.000000917**	0.00000223**
	(1.35E-7)	-0.000000459	-0.000000326	-0.000000215	-0.000000153	-0.000000329	-0.000000147	-0.0000000933	(2.88E-7)	-0.00000042
DDC	-0.000000245	-0.00000108	-0.00000159**	-0.00000125**	-0.000000849**	0.000000409	0.000000284	-0.0000000671	-0.000000679	-0.0000013**
	(2.40E-7)	-0.000000578	-0.00000044	-0.000000325	-0.000000238	(5.33E-7)	-0.000000361	-0.000000202	-0.000000391	-0.000000476
DIN	0.000000745	-0.000000918	0.000000312	-0.0000000934	0.000000731**	0.0000000214	0.00000045	0.000000412	0.00000351**	-0.000000124
	(4.79E-7)	-0.000000525	-0.000000548	-0.000000472	-0.00000037	(5.85E-7)	-0.000000556	-0.000000399	(4.69E-7)	-0.000000467
DSM	0.00000195**	0.00000084	-0.00000155**	0.00000175**	0.000000862**	-0.00000149**	0.00000194**	0.00000254**	-0.00000154**	-0.000000533
	(6.04E-7)	-0.000000482	-0.000000449	-0.000000448	-0.0000000387	(4.09E-7)	-0.000000645	-0.000000565	(4.68E-7)	-0.000000368
DSC	0.00000466*	0.00000644**	0.00000252**	0.00000161	0.00000163**	0.00000148**	0.00000449*	0.00000484*	0.00000404	0.00000123*
	(2.27E-6)	-0.00000163	-0.000000581	-0.00000151	-0.00000153	(4.21E-7)	-0.00000211	-0.00000231	(2.07E-6)	-0.00000061
DGR	0.0000254**	0.0000144**	0.000000618	0.0000171**	0.0000102**	0.0000025	0.0000256**	0.000021**	0.0000137**	0.00000736**
	-0.00000656	-0.00000453	-0.000000804	-0.00000388	-0.00000358	(1.60E-6)	-0.00000655	-0.00000698	(5.24E-6)	-0.00000171
DRE	-0.0000306**	-0.0000221**	0.00000243**	-0.0000187**	-0.0000121**	-0.0000029	-0.0000289**	-0.0000269**	-0.0000183**	-0.00000803**
	-0.00000631	-0.00000431	-0.000000779	-0.00000367	-0.00000328	-0.00000158	-0.00000631	-0.00000676	(4.91E-6)	-0.00000163
DEN	-0.000000508	-0.000000308	0.00000558**	0.000000606	-0.0000000706**	-0.0000000684	-0.00000101	-0.000000129	0.000000633	-0.00000064*
	(5.26E-7)	-0.000000311	-0.00000112	-0.000000489	-0.000000384	-31000000	-0.000000763	-0.000000541	(4.40E-7)	-0.000000263

** Statistically significant at the 99 %. * Statistically significant at the 95 %. Standard errors are in parenthesis.
Source: Own elaboration.

During the stable growth recovery period (DEN), residual volatility changes were inconsistent. Residual volatility increased with a 99 percent significance in the equity REITs sector, but it decreased in the industrial and office REITs sector. With a 95 percent of significance, it decreased in the unclassified sector.

6. Conclusion

The REIT industry has gained considerable importance as a source of funding for new and large-scale real estate projects for different economic sectors. For portfolio investors, REITs represent an attractive alternative asset class, with characteristics that make it a hybrid security, which generates fixed income payments, but its price is market determined and depends on the value of underlying real estate properties which are, at the same time, influenced by the economy and the particular conditions that prevail in that industry. As it would be expected, the volatility of returns of different REITs sectors has not been stable through the period of analysis, as different types of REITs are more sensitive than others to environmental factors and events.

Using daily observations for the General REIT index, which combines a diversified sample of REITs, plus specialized indices that correspond to eight different industries along with daily yields for the 28 days Treasury Bill yields and the SP500 price index series, this work explores the sensitivity of different types of REIT returns to systemically important environmental events during the period that goes from January 2nd, 1985 to December 30th, 2016. The considered specialized REIT indexes are: the Mortgage REIT Index, the Equity REIT Index, the Healthcare REIT index the Industrial and Office REIT Index, the Lodging REIT Index, the Retail REIT Index, Self-storage REIT Index, and the unclassified REIT Index.

The main findings of the econometric estimations are that the residual volatility of REIT returns in all sectors exhibit statistically significant GARCH (1,1) behavior. Also, residual volatility in all REIT sectors is higher when the SP500 risk premium is lower. However, the residual volatility of returns increases with Treasury Bill yields only for certain REIT sectors. Residual volatility in almost all REIT return series increased during the post-Black Monday crash period, the Sub-Prime crisis period, and the Great Recession period, but not during the dot.com crisis period. During the Black Monday crash period, almost all sectors increased their residual volatility, except the healthcare and retail sectors, and similar behavior was observed during the Subprime Crisis period, which raises appealing portfolio diversification possibilities for REIT investors.

A residual volatility reduction was observed in all analyzed sectors during the Black Monday recovery period and the Great Recession recovery period, except for the equity sector in the latter case. Its behavior was inconsistent during the inter-period, after the dot.com burst, when some sectors had weakened residual volatility, but others had a strengthened residual volatility. During the boom periods, residual volatility increased during the dot.com bubble period, but the behavior was inconsistent during the subprime period: Residual volatility increased in some sectors and, in others, it decreased. During the stable growth recovery period, residual volatility increased in some sectors, but in others, it decreased. Again, their behavior was inconsistent.

REITs are used as alternative investment vehicles with many desirable characteristics, but they also have some disadvantages. This study finds that REITs are not good vehicles for risk diversification, because of their volatility's close relation with the market risk premium; i.e., their volatility increases with down movements in the SP 500 risk premium, but their volatility increases also during periods of crisis. It should be concluded that the statistical evidence on the volatility of different types of REITs cannot be relied upon completely as a roadmap to future crisis episodes expected volatility behavior, because

inconsistent behavior patterns can often be detected. However, the valuable insights obtained from the analysis presented in this paper suggest some stylized facts that can be used by investors to design strategies and manage their portfolios during different market episodes.

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