Discrete Volatilities of Listed Real Estate Funds

Annah Gosebo, Donald Makhalemele, and Zinhle Simelane

Abstract The purpose of this article is to examine hedging strategies of South African real estate investment trusts using discrete volatility models. Prior studies have illustrated volatility hedging in bonds, commodities and equities appropriately illustrated by discrete volatility models, but not much has been done on real estate investment trusts, especially South African ones. This article uses both Autoregressive Conditional Heteroskedasticity and Generalized Autoregressive Conditional Heteroskedasticity family models to price discrete volatilities. The results show that information asymmetry, heterogeneity and lagging effects are inherent real estate investment trusts; therefore, volatility modelling should be done in a cautious manner. Thus, incorporating these factors in real estate investment trust hedging strategies should have a remarkable significance both in academia and in practice. The same findings apply equally both on in- and out-of-sample data.

Keyword Volatility · REITs · Hedging

1 Introduction

The analysis of volatility is relevant to various stakeholders in the capital market, including but not limited to investors, regulators, stoke brokers and relevant firms. It can be inferred from Hoesli and Reka (2013) that volatility is a measure related with the risk and uncertainty connected with unexpected changes of an instrument price. The concept of volatility in stock pricing and/or returns therefore has a significant

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impact on the hedging and risk management strategies that the investor might base its investment decisions on. Our research topic focuses on volatility analysis in real estate investment trusts (REITs) because of the nature and attributes that the REITs have when compared to the nature and behaviour of stocks which have been the topic of conversation that has been the most lacking in literature with respect to volatility hedging. Only a handful of recent literature has put the focus on REIT volatility that explores the complexities which result from underpinning of real and investment property. Our study will focus more so on listed property in the South African context, where the REIT legislation came to pass in 2013.

Due to the uniqueness of REITs to other elements in the capital market, such as common stocks, the topic of risk management has been a topic to be well explored in literature. However, due to the various models that exist to measure volatility—which represents the riskiness of a stock—it is difficult to choose one such perfect model to describe the volatility of returns while taking into consideration differences in market conditions as well as macroeconomic factors. Several studies over the years have shifted the focus to mechanisms that monitor and quantify market diversification in response to the increase in the growth of the globalization and diversification of the nature and behaviour of the economy (Ponta and Carbone 2018). The literature we have explored points out to deficiencies when it comes to the methodology as well as some overlooked variables that apply to volatility analysis, especially the one that involves REITs. Therefore, our problem will be based on exploring the various factors that continue to make risk management in the REIT industry.

The topic of REIT Volatility continues to be an interesting area of exploration in recent literature given the unique nature of REITs to the other investment vehicles that exist in the capital market. This is, according to Chaudhry et al. (2004), due to the organizational structure inherent in REITs which varies significantly from that of other common stocks, the difference between the REIT versus the common stock is also due to the close relationship inherent between the REIT and its underlying real estate property. With the stated differences in mind, the dynamics of volatility in REITs and in other common stocks are different and should, therefore, be investigated differently. Therefore, to effectively manage risk in REIT portfolios, it would be worthwhile to explore all factors that may affect the movement of returns.

While systematic risk has been widely researched by investigating industry-wide factors as well as fundamental economic factors, there is a gap in literature that supports further research into idiosyncratic risks inherent in the REITs industry (Cheng and Roulac 2007). Recent literature, such as Barkham and Geltner (1995), hypothesizes that if firm-specific factors of the underlying real estate asset influence average REIT returns, then the usage of the capital asset pricing model, their derivatives will leave a substantial amount of REIT volatility unexplained.

Then, the big question is how best can one model explain REIT volatility in the context of risk management? The contribution of this article is exactly answering that main question. To answer that main question, this article adopts the Autoregressive Conditional Heteroskedasticity (ARCH) and Generalized Autoregressive Conditional Heteroskedasticity (GARCH) family models. The results show that the presence of information asymmetry, heterogeneity and the lagging effect is reflected on the data sample, corresponding with the literature findings. Therefore, incorporating these factors in REIT hedging strategies should have a remarkable significance both in academia and in practice.

The balance of the article is as follows: Sect. 2 is on literature review, Sect. 3 is on methodology, Sect. 4 is data, Sect. 5 is on analysis and the last section concludes the article.

2 Literature Review

The subject of information asymmetry in REITs has gained more traction along the years in terms of literature as well as empirical tests. However, information asymmetry is said to be difficult to observe directly in the financial market; thus, empiricists have had to develop theoretical proxy variables to study it (Abdul-Baki 2013). Abdul-Baki (2013) further notes that there are not sufficient empirical studies that analyse the validity of the said proxies used to measure information asymmetry. His paper attempts to examine the validity of two proxies of information asymmetry that he found to be the most popular in literature. The first proxy that he used is the probability of informed trading and the second is the bid-ask spread (BAS). Among other things that contribute to information asymmetry includes (i) loan contract terms as a proxy for information asymmetry and (ii) bid-ask spreads as a proxy for Information asymmetry.

Deng et al. (2017) analysed the different outcomes of the presence in information asymmetry between externally managed REITs and internally managed REITs. The external REITs are characterized by their reliance on outside advisory and property management. Whereas, internal REITs have an in-house team managing the property and the company. They argue that although external REITs have exhibited poor performance due to the conflict-of-interest issue that arise between the outside advisors and the REIT shareholders; external REITs are more informationally efficient. In their analysis, they use loan contract terms as a proxy for information asymmetry, advancing that loan contract terms—such as interest rates, the number of covenants, loan maturity and whether there was collateral offered for the loan—reflect information asymmetry. Their claims are supported by earlier studies such as (Sufi 2007) who proposed that loan structure negotiated between the lender and borrower is influenced by the informational transparency of the borrower.

Extensive literature employs the Bid-Ask Spread (BAS) as a proxy for information asymmetry; this is due to the strong linkages it has demonstrated both empirically and theoretically with the level of information asymmetry in financial assets (Chung et al. 2017). Earlier research (Muller and Riedl 2002) centres its examination of information asymmetry risk in REITs on the bid-ask spread specifically due to the known fact that BAS is observable whereas other proxies of information asymmetry have been found to be difficult to observe empirically. Further, theoretical literature found strong associations between information asymmetry, BAS, and cost of capital in REITs. The bid-ask spread is defined empirically as the difference between the price in which traders are willing to buy (bid) and sell (ask) a firm's securities. Furthermore, the bid-ask spread is an aggregate of three components of trading costs, namely, order processing, inventory holding as well as adverse selection costs. The latter component, adverse selection, has been the most popular in extent literature on information asymmetry due to the observation that adverse selection can yield high transaction costs as witnessed on the BAS due to information asymmetry (Muller and Riedl 2002).

The presence of heterogeneity is one of the reasons why hedging strategies in the REIT industry has difficulties. In essence, the concept of heterogeneity in the context of REITs refers to the diversification of the underlying property portfolio by property type and sector as well as geographically. Seiler et al. (1999) mentioned how REIT diversity differs from stock diversity where the latter varies only in terms of its market capitalization and industry, whereas the former varies in terms of more intrinsic property characteristics. These include the size of the property, the geographical location of the property and the asset type to name quite a few. Therefore, for a portfolio manager to enjoy the true benefits of diversification they should consider all the different ways in which the properties within the portfolio may vary to minimize risk and maximize returns.

Likewise, REIT managers could choose to diversify their REIT portfolio across the different asset classes such as residential, office, industrial as well as retail according to their performances. They could also diversify their portfolio by investing in properties across different geographical regions that could be in the form of countries or provinces within a country to minimize risk. Cheok et al. (2011) found that REITs diversified by their property types had no significant effect on risk; contrariwise, they found quite a significant impact on risk because of a geographically diversified property portfolio. Their main contribution to literature was to find the solution as to whether REITs with a homogenous portfolio yield better returns than diversified REIT portfolios, specifically in the Asian market. An earlier study by Chen and Peiser (1999) found that diversified REITs perform poorly in contrast to homogenous REIT portfolios. Moreover, Capozza and Seguin (2001) assert that homogenous REIT portfolios are simpler to monitor and are more transparent contrary to their heterogeneous counterparts. This premise reinforces the relationship between information asymmetry and heterogeneity as it can be deduced from the previous statement that diversified REIT portfolios are less transparent therefore less likely to be informationally efficient.

Cheok et al. (2011) further emphasized the notion that diversified REITs offer little marginal benefit to investors since it calls for more resources to manage properties across different regions. Additionally, they found that it would be more economically feasible to have asset managers in respective REIT firms use their knowledge and expertise of the local market to enhance the quality of the portfolio across different real estate sectors within the respective country. This implores the need for further research on the effects of diversification on REIT portfolios as well as portfolios that incorporate REITs. Diversification is partly affected by asset type.

Diversification is highly rated by portfolio managers to be an important factor in portfolio allocation and management. This is due to the fact it has been effective in reducing the effects of systematic risk in each portfolio as compared to a geographically homogenous portfolio. Moreover, it is expected that real estate returns behave differently in different locational settings due to the difference in the market and economic conditions unique to that specific region. This is in line with the premise of real estate valuation which accords the value of a property to the macroeconomic factors affecting it as its most basic principle. Nevertheless, some authors are of the notion that geographical diversifications should be further simplified into a geographical region and an economic region as these have obvious and different implications on real estate values.

As a result, researchers have embarked on designing models that would be used to describe how heterogeneity evolves in the REITs globally. In a financial time series, it is unlikely that the variability of the "error term" will be fixed over time (Brooks 2008). Consequently, that leads to non-stochastic behaviour. This non-stochastic behaviour is due to the non-linearity of the current value of the series relative to previous values of the "error term" (Brooks 2008). Over time, researchers have found methods of modelling and forecasting volatility, namely the GARCH family model. Volatility is a key input for many financial applications, including asset allocation, risk management and option pricing (Zhou 2016).

Using the models does not solve the problem but gives direction to finding factors that influence REITs price variation. Also, the models help to understand the emergence of heterogeneity as mentioned prior. One of the factors that influence REITs price variation is "volatility spillover effects". Volatility spillover effects can be between international markets and between different financial and real estate assets (Nikbakht et al. 2016). The literature on volatility and financial performance of REITs is insufficient without an understanding of the transmission of spillovers from other subsectors, as well as global REITs. The real estate market also revealed a significantly increased volatility, more specifically between the latter half of 2006–2009. Dania and Dutta (2017) assert that the GARCH model is what is mainly used to test for the volatility spillover effect. The knowledge of volatility linkage between different markets and assets is crucial before any testing of whether there exists volatility spillover between markets or assets are conducted (Dania and Dutta 2017).

The 2008 subprime crisis caused a market disorder that had significant adverse costs in the United States. Specifically, the finance sector was the most affected by the crisis. Financial institutions failed, specifically the banks and the conditions of the market were unsettled. The REIT industry, on the other hand, was not safe from this financial adversity. This crisis led to harsh implications on banks and financial institutions as their capacity to fulfil credit commitments was eroded; this phenomenon was observed by Huerta et al. (2016). Nikbakht et al. (2016) further stated that after the real estate and financial crisis, studies on the volatility linkage and volatility spillover between local and international received more attention. The authors further state that the volatility spillover effect is not only restricted to certain sectors, industries, or regions, for example, but financial assets and real assets are also all possible. Koutmos and Booth (1995) observed how the announcement of bad news because of these spill overs caused by the financial crisis effecting one county would cause an effect on the other countries. Similarly, when Guirguis et al. (2007) conducted an empirical analysis in the housing market amongst regions with a different population with respect to price transmission mechanism, the results revealed a unidirectional spill over price effect from bigger regions relative to smaller regions. This empirical analysis was conducted using a bivariate General Autoregressive Conditional Heteroskedasticity model. Also, Reyes (2001) as referenced by the authors concentrating on market value indexes demonstrated using the autoregressive model that international spill over is not the only spill over effect that exists.

Concerning the lagging effect, it is crucial to first understand what the differences that exist between real estate investment trusts and common stocks are to pinpoint the impracticality of trying to use what would only work for the other securities other than the real estate investment trusts. Lin and Lee (2012) stated that real estate investment trust futures could not be hedged by existing futures used in contracts for stocks, commodities, metal, and interest rates that trying to hedge real estate investment trusts returns by the aforementioned could be a vain exercise. In that light, they further show how by coming up with the right REIT hedging returns will also enable investors to deal with the complexities that pertain to the risk dynamics that come with the REITs.

Literature shows the underlying problem that exists with the relationship between REIT values and values of the underlying real asset to be the time-varying aspect; this is often referred to as the lagging effect. Fisher et al. (2003) attributed this problem to the inefficiency of the real estate market, stating that the lack of a central market to show timeous transactions of the whole real assets causes the lag found in REIT values. While most listed REITs are required to conduct and report on the valuation of each of the properties on their portfolios, this may only be at certain periods (property valuations are done annually, on average) to disturb the market and cause insider trading by announcing sudden firm-related information. This is due to the long-standing notion that any slight change in real estate values will be echoed more swiftly by changes in REIT values (Seiler et al. 1999). They further argued that this lagging phenomenon may be due to the high transaction costs associated with direct property investment as opposed to the lower transaction costs associated with investing in securitized real estate which makes it easy for investors to use the information to their advantage. This is a concept founded by Chan (1992) when he investigated the lead-lag relation in the stock index. Sometimes the lagging effect is caused by whether an asset is listed or held in physical form.

Seiler et al. (1999) assert that unsecuritized real estate values lag those of REITs; however, he did not state to what degree which then opens it as an unexplored area of literature. Earlier studies by Gyourko and Keim (1992) and Barkham and Geltner (1995) have also found upon research the effect of the lagging effect between real property and securitized real estate; to which they found that securitized real estate leads real property assets. The issue of the appraisal methods used for securitized real estate versus unsecuritized real estate has been brought up several times in past literature. Seiler et al. (1999) differentiated the two by pointing out that the returns on REITs are derived from transaction data and those of the real estate asset are derived from appraisal data. They make the argument that transaction data obtained from the capital market where trades are more orderly thus valuations of REITs are conducted more frequently. Nevertheless, unsecuritized real estate valuations can only be captured on average on a yearly basis and not all properties are valued at the same each year which raises other concerns. This problem has often been countered by conducting a process known as appraisal smoothing. The effectiveness of this process has been a matter of debate in past literature. With several authors pointing out the distortion it may cause to the variation and volatility measures of the real estate index, Edelstein and Quan (2006) and Seiler et al. (1999) observed how the process of appraisal smoothing can, in fact, underestimate the measured volatility in real estate returns. The appraisal smoothing phenomenon is observed by investors who rely on information obtained from real estate performance indexes, where the movements of real estate prices are displayed. The inefficiencies of these indexes are unavoidable due to the nature of real estate valuations. This is due to the subjectivity of the real estate appraisers known as heterogeneity in appraiser behaviour; as well as the time varying aspect of real estate valuation where appraisals are conducted at any time of the year.

The lead-lag concept in real estate has been attributed to the perceived inaccuracy of the valuation of unsecuritized real estate versus the accuracy of REIT appraisals. This is due to the likely occurrence of subjectivity and bias when conducting property valuations, for instance, any two valuers are not likely to use the same set of comparable properties to value a particular property due to differing opinions on the perceived relevance that these may have on the valuation. More so, the illiquidity of real estate physical assets has been associated with the lead-lag effect stating that the fact that property is illiquid and less frequently traded than securitized real estate causes a disconnect among the two.

When testing for the lagging effect, according to Abdul et al. (2010), there is robust evidence in literature that proves that there is a strong concurrent correlation that is positive, along with the lead/lag linkages between the indirect and direct real estate markets. The paper goes on to further elaborate on how the Causality analysis, which points out that the real estate market, is led to a short term by the wider economy and negative future returns may be pointed at through the positive real estate returns in the rest of the economy. This is a good demonstration of the significance of first being able to establish the relationship between the variables and how changes in them can manipulate the real estate markets over short-run and long-run horizons.

3 Methodology

Discrete volatilities models first emerged back in 1982 (see Engle 1982). Initially the first model was Autoregressive Conditional Heteroskedasticity (ARCH) model. Subsequently, an extension to the ARCH model was later modelled by Tim Bollerslev, which led to Generalised Autoregressive Conditional Heteroskedasticity GARCH model (see Bollerslev 1986a, b). GARCH is a robust method that can model return variation through time in a way that allows that variation to change based on the variable's history and even when some conditions, such as price level, have not changed. Therefore, this article adopts ARCH and GARCH family models.

The formula for the ARCH (1) is as follows:

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2, \tag{1}$$

where for the conditional variance to non-negative and the model well-defined ω must be positive and all the i's non-negative. Ding (2011) made the conclusion that ARCH models are widely used in time series analysis due to its ability to reflect the changes in variance, past econometric models often ignored this quality. Extending the ARCH model, this article chose the Asymmetric Power Autoregressive Conditional Heteroskedasticity (APARCH) and Threshold Autoregressive Conditional Heteroskedasticity (TARCH) models which are explained subsequently.

$$\sigma_t^2 = \omega + \sum\nolimits_{j=1}^{q} \beta_i \sigma_{t-j}^2 + \sum\nolimits_{i=1}^{p} \alpha_i \varepsilon_{t-1}^2 + \sum\nolimits_{k=1}^{r} \gamma_k \varepsilon_{t-k}^2 \mathrm{I}_{t-k}. \tag{2}$$

The TARCH model is preferred since it considers the allowance of asymmetric shocks to volatility. The introduction of the TARCH, by Glosten et al. (1993) and Zakoian (1994), was in response to the observance of varying effects of volatility due to positive and negative shocks in the financial markets. This was after it was found by Engle and Ng (1993) that when comparing positive and negative shocks of the same size, the negative shocks result in higher volatilities. Note that Eq. (1) will be lagged all the way to 1 because lagging effect has a significant role in real estate including REITs (Bowes and Ihlanfeldt 2001). Further, Ding (2011) went on to state that the PARCH model offers the best results within the ARCH type models due to its ability to express the "fat tails, excess kurtosis and leverage effect"; which are necessary to capture the conditional volatility in a time series analysis. The power ARCH (PARCH) which was designed by Ding et al. (1993) nests several of the most popular univariate parameterizations. More specifically APGARCH (p,q) model as expressed as follows:

$$\sigma_t^\delta = \omega + \sum\nolimits_{i=1}^{q} \alpha_i (|\varepsilon_{t-i}| - \gamma_i \varepsilon_{t-i})^\delta + \sum\nolimits_{i=1}^{p} \beta_i \sigma_{t-i}^\delta. \tag{3}$$

And it reduces to the standard linear GARCH (p,q) model and GJR-GARCH model (Bollerslev 1986b). The major challenge at ARCH is that it cannot be generalised; therefore, one needs a model that can be generalised. Tim Bollerslev generalised ARCH to come up with GARCH 1986. Another challenge arises in the need to have a long lag length in the ARCH models as well as the fact that its parameters are required to be of a non-negative nature (Jorge 2004).

The formula for GARCH (1) is as follows:

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2, \tag{4}$$

where ω > 0, α, β and λ ≥ 0. And ω-constant variance coefficient, α-reaction of the volatility to market events, β determines the persistence in volatility, λ captures the leverage effect, α + β determines the degree of convergence of the conditional volatility to the long-run average level. Further, α + β = 1 otherwise the model "explodes" and σ_{t-1}^2 is the spot variance. Note that Eq. (1) does not account for (i) correlation coefficients of debt and equity, (ii) equity parameter, (iii) risk premium, (iv) interest rates and (v) shocks-stock markets. In their analysis of various volatility models including the GARCH, EGARCH and TGARCH models, McMillan et al. (2000) found that the GARCH model offers the best results in terms of consistently forecasting prices. This notion is further confirmed by discussions held by Bollerslev et al. (1992); they contend that the GARCH model effectively represents an extensive selection of volatility processes.

According to Bollerslev (1986a), ω is a product of the long run variance and the parameter representing the weight, for example, gamma, alpha or beta. Furthermore, the author states that when estimating the expected volatility, then α + β represent the persistence and the greater the value the more persistence to today's variance than to decay to the long run variance. Bollerslev (1986a) further states that α + β ≠ 1 because the two parameters represent two weights out of three. Further to the GARCH model, we chose the integrated GARCH (IGARCH) extended model and the exponential GARCH (EGARCH) which we explain subsequently.

$$\sigma_t^2 = \sum\nolimits_{i=1}^{P} \alpha \varepsilon_{t-i}^2 + \sum\nolimits_{j=1}^{Q} \beta \sigma_{t-j}^2. \tag{5}$$

The IGARCH Model as proposed by Engle and Bollerslev (1986) is an extension of the GARCH model which, unlike the original GARCH model, incorporates the permanent effect on volatility caused by shocks due to its infinite memory. That is, the most important characteristic of the IGARCH model is its ability to capture long memory which is said to enable the predictability of returns in the long run as well as act against the effects of the market efficiency hypothesis often disregarded by other models (Ding 2011). However, Engle and Bollerslev (1986) do point out that the disadvantage of using this model is that it generates a phenomenon known as temporal aggregation which in turn reduces the model's credibility.

The EGARCH model was developed by Daniel Nelson in 1991. This model explicitly also allows for asymmetries. However, it allows for asymmetries in the relationship between return in contrast to the AGARCH model. And $z_t \equiv \varepsilon_t \sigma_t^{-1}$ which denotes the standardized innovations. The EGARCH (1) model is expressed as follows:

$$log\ log\left(\sigma_t^2\right) = \omega + \alpha(|z_{t-1}| - E(|z_{t-1}|)) + \gamma z_{t-1} + \beta log\left(\sigma_{t-1}^2\right). \tag{6}$$

Negative shocks will have a bigger impact on future volatility than positive shocks of the same magnitude. This effect is normally observed with returns on stock index, and it is referred to as a "leverage effect", Bollerslev (1986b). Moreover, Bollerslev

(1986b) stated that the leverage effect is “the tendency for volatility to rise more following a large price fall than following a price rise of the same magnitude”.

4 Data

4.1 Population and Sampling

There are 33 listed REITs on the Johannesburg Securities Exchange (JSE), and all REITs are of equity nature. This article analyses the top ten South African REITs based on their market capitalisation because they represent at least 80% of the South African REIT index. Note that the REIT legislation only became legal in South African in May 2013. Before then, listed real estate funds were either property unit trusts (PUTs) or property loan stocks (PLSs). The convention to REIT status occurred over time. The last fund to convert to REIT status is Texton Property Fund in the second half of 2019. The weekly data is from IRESS Expert database from February 2006 to December 2018. The prices are converted to log returns for consistency with ARCH and GARCH family models. The data is stratified by dates which are as follows:

- In-Sample dates from 2006 to 2018, and it is basically estimating the parameters (Akinsomi et al. 2016).
- Out-Sampling dates from 2014 to 2018, and this is for forecasting (Akinsomi et al. 2016).

Below, this article gives an overview of listed real estate funds used for the analysis.

Consisting of 454 properties within its property portfolio in South Africa that are directly owned, Growthpoint Properties Ltd is a real investment trust that also has 57 properties in Australia, a 50% interest in the properties of the V&A Waterfront, and a 26.9% interest in AIM-listed Globalworth Real Estate Investments (GWI). The combined value of these property assets was R121.3bn as of 30 June 2018. Redefine Properties Ltd is a REIT focusing on obtaining a geographically diverse portfolio of properties, as well as a portfolio of investments in listed property securities. As of 31 August 2018, the group’s property assets were valued at R91.3bn, including a South African portfolio of 315 properties with a combined value of R68.5bn.

Resilient REIT Ltd is a REIT which invests directly and indirectly in regional malls and shopping centres in South Africa, Nigeria, and Portugal, and in locally listed and offshore property-related assets. All asset management functions are housed within the company and its subsidiaries with the day-to-day management of retail centres outsourced to the property managers, namely Broll Property Group (Pty) Ltd and JHI Retail (Pty) Ltd. As of 30 June 2018, the group’s property portfolio comprised: South Africa—35 properties with a gross lettable area of 1,096,890 square metres and valued at R21, 980 m Nigeria—4 properties with a gross lettable area of 30,427 square metres and valued at R662m Portugal—2 properties valued at R1, 884 m. Hyprop Investments Ltd is a REIT status with a portfolio of properties in major metropolitan areas across South Africa, sub-Saharan Africa, and South-eastern Europe. The group's South African property portfolio was valued at R29.7bn on 30 June 2018.

Vukile Property Fund Ltd is a REIT that holds a portfolio of direct property assets as well as strategic shareholdings in listed and unlisted REITs. A group's portfolio was valued at R19.1bn on 31 March 2018. The group's property management services are currently outsourced to Broll Property Group (Pty) Ltd, JHI Properties (Pty) Ltd, Spire Property Management (Pty) Ltd, Trafalgar Property Management (Pty) Ltd, and McCormick Property Development (Pty) Ltd. SA Corporate Real Estate Ltd comprises retail, industrial, and office properties in its portfolio covering a total of 1.5 million square metres in GLA; primarily in the major metropolitan centres of South Africa, with a secondary node in Zambia. The company was valued at R16.8bn as of 31 December 2017 with a total portfolio of 196 properties. The property management function for the traditional portfolio is outsourced to Broll Property Group (Pty) Ltd, while the property management for the AFHCO portfolio is performed in-house either directly or through AFHCO Property Management.

Emira Property Fund Ltd has a property portfolio valued at R12.5bn consisting of predominantly South African assets with a growing component of offshore assets in Australia and the USA. Its sectoral profile of about 104 properties is spread across office, retail, industrial and a recent residential component. Property management services are outsourced to Eris Property Group (Pty) Ltd, Broll Property Group (Pty) Ltd and Feenstra Group. Hospitality Property Fund Ltd is a specialised REIT focusing on property investments in the hospitality and leisure sectors in South Africa. As of 31 March 2018, the Funds property portfolio comprised 53 hotels with 9,001 rooms and was independently valued at a fair market value of R12.6bn.

Octodec Investments Ltd is focused primarily on a portfolio of 306 properties located in Tshwane CBD and Gauteng. As of 31 August 2018, the group's property portfolio includes properties owned in joint ventures at a total portfolio value of R12.9bn. Octodec has an asset and property management services agreement with City Property Administration (Pty) Ltd. Fairvest Property Holdings Ltd focuses on non-metropolitan and rural shopping centres, as well as convenience and community shopping centres across South Africa. As of 30 June 2018, Fairvest's property portfolio comprises 44 properties with a GLA of 237,965 square metres and valued at R2.99bn. Property management services are outsourced to JHI Properties, Broll Property Group, Axis Property Fund, Spire Property Management, Mainstream Group, Bara Property Management and Abreal Property Management.

4.2 Descriptive Data

Table 1a, b exhibit each company's publicly preliminary and financial information.

Table 1a, b represent preliminary information of ten chosen companies. In this table are the variables of interest which are as follows: market cap, share price, net

Table 1 **a** Preliminary information. **b** Preliminary information

a

REIT	Market cap (ZAR Billions)	Share price (ZAR Cents)	Net asset value/share (ZAR Cents)	Sector focus (GLA in m^2)						Total
				Residential	Retail	Office	Industrial	Hotel	Specialized	
GRT	84.4	2841	2843.03	0	1,390,878	1,791,626	2,254,812	0	0	5,437,316
RDF	66.3	1159	1004.05	0	1,334,433	1,096,941	1,786,642	0	28,699	4,246,715
RES	21.3	5000	6180.38	0	1,096,890	0	0	0	0	1,096,890
HYP	26.9	10,822	10,487.9	0	663,505	58,956	0	0	0	722,461
VKE	17.2	2188	2029.49	0	972,911	42,966	74,891	0	25,953	1,116,721
SAC	12.4	488	527.08	381,907	364,801	55,241	684,478	0	0	1,486,427
EMI	8.1	1555	1733.01	0	322,065	318,524	348,699	0	0	989,288
HPB	6.8	1175	1931.48	0		0	0	9,003	0	9,003
OCT	5.4	2040	2978.6	393,643	444,642	413,581	253,396	13,458	125,713	1,644,433
FVT	2.1	210	239.9	0	223,216	11,748	0	0	0	234,964
Mean	25.1	2747.8	2995.49	387,775	757,038	473,698	900,486	11,231	60,122	1,698,422
Median	14.8	1797.5	1980.48	387,775	663,505	188,740	516,589	11,231	28,699	1,106,806
STD Dev	27.9	3145.65	3120.09	8,299	451,608	643,551	902,323	3,150	56,820	1,753,486
Skewness	1.6	2.2	1.9	0	0.3	1.6	0.9	0	1.7	1.5
Kurtosis	1.4	5.4	3.4	0	−1.7	1.7	−1.3	0	0	1.5

(continued)

Table 1 (continued)

b

REIT	Geographical spread (GLA in m^2)											International spread	Total portfolio
	Eastern cape	Free state	Gauteng	KwaZulu Natal	Limpopo	Mpumalanga	Northern Cape	North West	Western Cape	Other parts of SA	Total		
GRT	163,119	0	3,371,136	598,105	0	0	0	54,373	1,196,209	54,373	5,437,315	1,234,615	6,671,930
RDF	0	0	3,207,406	293,066	0	0	0	0	680,408	0	4,180,880	0	4,180,880
RES	34,489	0	251,024	214,905	278,799	191,599	66,621	59,453	0	0	1,096,890	0	1,096,890
HYP	0	0	431,254	0	0	0	0	0	0	0	431,254	0	431,254
VKE	24,312	56,728	332,263	145,872	64,832	40,520	0	40,520	48,624	0	753,670	237,805	991,475
SAC	0	0	944,705	433,635	15,487	0	0	0	77,435	0	1,471,262	62,269	1,533,531
EMI	0	32,647	729,105	91,014	0	0	0	0	136,522	0	989,288	0	989,288
HPB	0	0	3,018	0	0	0	0	0	2,381	3,604	9,003	0	9,003
OCT	0	0	1,644,433	0	0	0	0	0	0	0	1,644,433	0	1,644,433
FVT	16,172	26,626	59,499	56,700	11,483	4,692	17,462	0	42,330	0	234,964	0	234,964
Mean	59,523	38,667	1,097,384	261,900	92,650	78,937	42,042	51,449	311,987	28,989	1,624,896	511,563	1,778,365
Median	29,400	32,647	580,180	214,905	40,159	40,520	42,042	54,373	77,435	28,989	1,043,089	237,805	1,044,182
STD Dev	69,469	15,928	1,251,694	195,992	126,448	99,199	34,761	9,799	454,847	35,899	1,779,551	632,302	2,077,141
Skewness	1.9	1.5	1.2	0.9	1.8	1.5	0	0	1.6	0	1.5	1.6	1.8
Kurtosis	0	0	0.1	−0.2	3.2	0	0	0	1.7	0	1.5	0	3

asset value per share (NAV, hereafter), sectoral focus, geographical and international spread. Table 1a shows the corresponding market capitalization amounts for the top ten REITs which ranges from a value of R2,112 billion of Fairvest Property Holdings Limited to the value of R84,406 billion of Growthpoint Properties Limited; the average, in terms of market capitalization is R25,085 Bn. According to a paper by Muller (1998) which classifies REIT sizes according to their market capitalization values in US dollars, from the data on Table 1a the top 5 REITs are either large-caps \$1.1–\$4 billion and mega-caps are +\$4 billion. And between \$0 and \$0.5 billion are small-caps and \$0.501–\$1 billion are mid-caps.

Further, Table 1a indicates that the mean NAV is higher than the mean share price, this is an interesting observation because REITs usually trade at a premium to the NAV (where share price > NAV). Therefore, we can say that the top 10 SA REIT share price is trading at a discount to the NAV. Clayton and MacKinnon (2000) argued that discounts from the NAV in REITs could be because of mispricing REIT shares due to pessimistic investor sentiment, or otherwise a result of the correct use of information on the underlying property market (information efficiency). Also on the table is the sectorial spread of the difference; one finds that most properties in the combined portfolio are retail properties, followed by industrial and then office. With regards to the geographical spread on Table 1b, one distinguishes that many of the properties are in Gauteng, followed by the Western Cape and then the Kwazulu-Natal, which is unsurprising as these provinces house South Africa's largest property markets in terms of value. It is also interesting to note that a significant portion of the portfolio of properties is located internationally, which aids for the company's diversification strategies.

Table 2 represents each company's financial information for the year ended 2018. The following are the variables of interest: revenue; total cost; profit after tax and owners' equity. The revenue is recorded in South African currency (ZAR). The same descriptive statistics measures in Table 2 will be applied to analyse the information of each company with the mean being assumed as the benchmark, standard deviation representing the risk associated within the portfolio, the skewness and kurtosis representing represent the distribution of the variables of interest representing the magnitude of the tails of the distribution, respectively. The skewness as reflected in Table 2 for both the revenue and the total cost, which is an indication of a lack of symmetry, is positive which also indicates that the possibility of diversification for both variables is paying off.

4.3 Synthesis and Conclusion

The preliminary and financial variables of interest from the ten companies analysed reveals positive results. Most companies have a portfolio mix of traditional commercial property types namely, retail, office and industrial. Amongst all, only Hospitality Property Fund specializes in hotels. However, it outperformed companies that have

Table 2 Financial information

REIT	Revenue (ZAR millions)	Total cost (ZAR thousands)	Profit after tax (ZAR millions)	Owners' equity (ZAR millions)
GRT	10,9	182	7,9	83,2
RDF	8,1	146,5	6,6	58,1
RES	2,7	46,7	−3,3	22,9
HYP	3,1	61,9	2,6	26,4
VKE	2,0	45,1	2,4	15,9
SAC	2,3	50,2	0,8	12,9
EMI	1,8	45,9	0,8	9,0
HPB	0,9	13,4	0,1	11,1
OCT	1,9	18,4	0,5	7,8
FVT	0,4	9,6	0,3	2,4
Mean	3,4	62,0	1,9	25
Median	2,2	46,3	0,8	14
STD Dev	3,4	57,2	3,3	26
Skewness	1,7	1,5	0,7	1,7
Kurtosis	2,0	1,3	0,6	2,2

a diversified portfolio. As a result, this shows that the variables of interest are independent of each other. For example, low revenue will not result in a low share price as evidenced in Table 2 when comparing Hospitality Property Fund, South Africa Corporate Real Estate Ltd and Fairvest Property Holdings Ltd. Also, the size of the gross lettable area does not determine the amount of revenue the company will yield as evidenced under Table 2.

5 Data Analysis

5.1 Data Analysis

Table 3 is on historical volatilities, and it illustrates that the calculated mean is positive for most of the REITs, both for the in-sample and out-sample data. This suggests that the companies are moving with the market and that there are no benefits in diversification in most of them. Hospitality Property Fund in its nature is unique, considering that it offers organic growth, and has diversification benefits, hence the negative mean (Sebehela et al. 2019). Resilient and SA Corporate Real Estate Ltd also have negative means.

The minimum volatilities for almost all the companies are negative and positive for nearly all the maximum ones. This reflects net zero effect on the companies.

Table 3 Historical volatilities

Parameter	Growth point	Emira	Fairvest	Hospitality property fund	Hyprop	Octodec	Redefine	Resilient	SA Corporate Real Estate Ltd	Vukile
Panel A: In-Sample										
Mean	0.00091	0.00042	0.00245	−0.00227	0.00136	0.00085	0.00071	−0.00133	−0.00007	0.00119
Median	0.00254	0.00218	0.00000	0.00000	0.00285	0.00000	0.00099	−0.00078	0.00000	0.00188
Min	−0.16569	−0.19479	−0.21441	−0.40213	−0.19481	−0.49470	−0.20045	−0.12464	−0.13618	−0.21806
Max	0.14552	0.16012	0.23639	0.26826	0.10764	0.51282	0.14848	0.11048	0.13976	0.13239
Std Dev	0.02990	0.03158	0.05373	0.05103	0.03082	0.04572	0.03157	0.02097	0.03284	0.03015
Kurt	2.64129	5.05598	3.31964	9.17666	3.77212	43.73591	4.00090	7.49110	2.62721	5.46518
Skew	−0.24160	−0.34457	0.39739	−0.70654	−0.54098	0.21355	−0.25108	−0.64244	−0.29579	−0.65916
Panel B: Out-Sample										
Mean	−0.00014	0.00010	0.00151	−0.00255	0.00029	−0.00041	0.00001	−0.00365	−0.00043	0.00055
Median	−0.00073	0.00344	0.00000	0.00000	0.00143	−0.00166	−0.00192	−0.00258	0.00000	0.00276
Min	−0.16569	−0.19479	−0.14310	−0.40213	−0.19481	−0.13238	−0.20045	−0.12464	−0.12883	−0.21806
Max	0.11840	0.11545	0.14603	0.26826	0.10088	0.09087	0.13231	0.11048	0.13976	0.13239
Std Dev	0.02881	0.03193	0.03821	0.05759	0.03299	0.03618	0.03078	0.02939	0.02783	0.02963
Kurt	4.42332	8.12851	1.39615	11.06051	5.20299	0.95767	7.37711	3.66016	4.19044	12.26624
Skew	−0.52671	−0.95146	0.35225	−0.93361	−0.85659	−0.17590	−0.76250	−0.40402	−0.03180	−1.38521

Practically, all the companies are skewed to the left, for both in-sample and out-sample. This explains that these companies can be used as investment vehicles and that a minimization of risk can occur by purely investing in them. Focusing on the skewness of in-sampling data, the overall skewness of numbers is low, meaning that risk is inherently low, and that risk can also be minimized. The out-sample numbers are more on the fringe than those of the in-sample data. The overall conclusion for the historical volatilities data from Table 3 is that there is evidence of investment conundrum-some parameters suggest investing in them while other parameters do not support investing in those REITs. However, to further continue with the getting to the objective of this research, discrete volatilities models will be used to run the in-sample and the out-sample data of the REITs (Tables 4 and 5).

All parameters of the six models are statically significant. The salient point is parameters decrease as one starts to lag them. Thus, parameters are found to be convex in shape in terms of their distribution with time. This illustrates that volatilities decrease with time, which means that risk decreases over time. This could be possibly due to diversification benefits that by nature REITs have or also perchance be due to having companies being in one portfolio as a hedging strategy. The adjusted R^2 of the six models for the REITs is negative. This is acceptable in the case of real estate because there is a lot of heterogeneity in it.

ARCH (1) model well captured the market reaction of the REITs. Durbin Watson below 1.3 reflects autocorrelation. Akaike info, Schwarz and Hannan–Quinn criterion all fall outside of the range (1.6–2.7), which illustrates that there is negative skewness for all the REITs. This means that extra money can be generated from all these REITs. TARCH (1) model shows a change in delta which is an illustration of a change in spot price. The change in delta decreases with time, which is an indication of a decrease in risk over time with changes in the market. All alphas (α) and betas (β) summed up for each REIT, equal to one. It shows that this model is fine. The adjusted R^2, Durbin–Watson stat, and Akaike info, Schwarz and Hannan–Quinn criterion all show similar results of ARCH (1) model. This is also seen in other models—panel C to panel F. Moreover, panel C to panel F illustrate that same patterns as ones in panels A and B. All the models confirm the same thing, which is that risk decreases over time.

All the parameters in all the six models are statistically significant. Volatilities decrease over time, which illustrate that risk decreases with time. The results obtained from out-sample show the same pattern as in the in-sample. Discrete volatilities are appropriate for risk management and risk hedging (Carr and Wu 2014).

6 Conclusion

The findings from this article are as follows. REITs by nature have information asymmetry, heterogeneity and lagging effects. Those three traits are confirmed by both literature review and the data analysis. Therefore, firstly, systematic risk is inherently higher in REITs. Secondly, diagnostic tests confirmed that REIT behaviour

Table 4 Discrete volatilities: In-Sample

Parameter	Emira	GrowthPoint	Fairvest	Hospitality	Hyprop	Octodec	Redefine	Resilient	SA Corp	Vukile
Panel A: ARCH (1)										
ω	0.000(0.000) ***	0.000 (0.000) ***	0.000 (0.000) ***	0.000 (0.000) ***	0.000 (0.000) ***	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***
α	0.895 (0.000***)	0.858 (0.000)***	0.746 (0.000)***	0.832 (0.000)***	0.867 (0.000)***	0.697 (0.000)***	0.850 (0.000)***	0.918 (0.000)***	0.868 (0.000)***	0.933 (0.000)***
Adj R^2	−0.005	−0.002	0.000	−0.005	−0.003	−0.001	0.000	−0.013	−0.001	−0.010
Durbin–Watson	0.452	0.432	0.500	0.416	0.432	0.047	0.449	0.334	0.468	0.442
Akaike	−4.850	−4.829	−3.854	−3.992	−4.863	−4.217	−4.766	−5.894	−4.686	−4.952
Schawrz	−4.850	−4.823	−3.849	−3.986	−4.858	−4.211	−4.760	−5.888	−4.681	−4.946
Hannan	−4.850	−4.827	−3.852	−3.990	−4.861	−4.215	−4.764	−5.892	−4.685	−4.950
Panel B: TARCH (1)										
ω	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.001 (0.000)***	0.000 (0.000)***	0.002 (0.000)***	0.000 (0.000)***	4.75E-05 (0.000)***	0.000 (0.000)***	0.000 (0.000)***
α	0.799 (0.000)***	0.886 (0.000)***	0.667 (0.000)***	0.854 (0.000)***	0.851 (0.000)***	0.339 (0.000)***	0.642 (0.000)***	0.802 (0.000)***	0.896 (0.000)***	0.804 (0.000)***
β	0.171 (0.0523)**	−0.012 (0.886)	0.100 (0.888)	0.128 (0.087)**	0.044 (0.651)	0.058 (0.612)	0.159 (0.060)**	0.237 (0.004)***	−0.022 (0.647)	0.180 (0.035)***
γ	−0.007 (0.226)	−0.021 (0.000)***	−0.012 (0.000)***	−0.016 (0.000)***	−0.013 (0.271)	−0.017 (0.000)***	−0.033 (0.000)***	−0.005 (0.129)	−0.025 (0.000)***	−0.014 (0.000)***
Adj R^2	−0.004	−0.002	−0.002	−0.016	−0.003	−0.001	0.000	−0.013	0.000	−0.006
Durbin–Watson	0.452	0.432	0.499	0.412	0.432	0.5	0.449	0.334	0.468	0.443
Akaike	−4.853	−4.832	−3.844	−3.944	−4.865	−3.898	−4.754	−5.897	−4.689	−4.955
Schawrz	−4.843	−4.823	−3.835	−3.935	−4.856	−3.889	−4.745	−5.888	−4.680	−4.945

(continued)

Table 4 (continued)

Parameter	Emira	GrowthPoint	Fairvest	Hospitality	Hyprop	Octodec	Redefine	Resilient	SA Corp	Vukile
Hannan	−4.849	−4.829	−3.841	−3.941	−4.862	−3.895	−4.751	−5.894	−4.686	−4.951
Panel C: APARCH (1)										
ω	0.010 (0.000)***	0.011 (0.000)***	0.024 (0.000)***	0.018 (0.000)***	0.010 (0.000)***	0.019 (0.000)***	0.012 (0.000)***	0.006 (0.000)***	0.012 (0.000)***	0.100 (0.000)***
α	0.781 (0.000)***	0.824 (0.000)***	0.690 (0.000)***	0.800 (0.000)***	0.786 (0.000)***	0.595 (0.000)***	0.786 (0.000)***	0.819 (0.000)***	0.801 (0.000)***	0.812 (0.000)***
β	0.062 (0.011)***	0.010 (0.700)	0.024 (0.367)	0.066 (0.003)***	0.020 (0.438)	0.029 (0.474)	0.001 (0.978)	0.077 (0.001)***	0.012 (0.617)	0.051 (0.040)***
γ	−0.097 (0.000)***	−0.188 (0.000)***	−0.151 (0.000)***	−0.113 (0.000)***	−0.122 (0.000)***	−0.062 (0.000)***	−0.174 (0.000)***	−0.083 (0.000)**	−0.172 (0.000)***	−0.121 (0.000***
Adj R^2	−0.00487	−0.002121	−0.002869	−0.012055	−0.000665	−0.00482	−0.000556	−0.020789	−0.000323	−0.005182
Durbin–Watson	0.451995	0.431891	0.498324	0.4133	0.432934	0.468321	0.448549	0.330973	0.468128	0.443774
Akaike	−4.860169	−4.830839	−3.830447	−4.004408	−4.861588	−4.174667	−4.759218	−5.899227	−4.684325	−4.953432
Schawrz	−4.85104	−4.82171	−3.821318	−3.995279	−4.852459	−4.165538	−4.750089	−5.890097	−4.675195	−4.944302
Hannan	−4.856904	−4.827574	−3.827182	−4.001143	−4.858323	−4.171402	−4.755953	−5.895961	−4.681059	−4.950166
Panel D: GARCH (1)										
ω	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.001 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***
α	1.004 (0.000)***	0.980 (0.000)***	0.863 (0.000)***	0.856 (0.000)***	0.845 (0.000)***	0.425 (0.000)***	0.903 (0.000)***	0.923 (0.000)***	0.888 (0.000)***	0.947 (0.000)***
β	−0.006 (0.101)	−0.021 (0.000)***	−0.008 (0.000)***	−0.009 (0.000)***	−0.016 (0.160)	−0.010 (0.000)***	−0.022 (0.000)***	−0.005 (0.053)**	−0.024 (0.000)***	−0.013 (0.000)***
Adj R^2	−0.001	−0.002	−0.001	−0.005	−0.002	0.000	0.000	−0.013	0.000	−0.010

(continued)

Table 4 (continued)

Parameter	Emira	GrowthPoint	Fairvest	Hospitality	Hyprop	Octodec	Redefine	Resilient	SA Corp	Vukile
Durbin–Watson	0.454	0.432	0.499	0.416	0.432	0.471	0.449	0.334	0.468	0.442
Akaike	−4.841	−4.833	−3.815	−3.993	−4.863	−4.014	−4.771	−5.894	−4.691	−4.956
Schawrz	−4.834	−4.826	−3.808	−3.986	−4.856	−4.007	−4.764	−5.887	−4.683	−4.949
Hannan	−4.839	−4.830	−3.812	−3.991	−4.860	−4.011	−4.769	−5.892	−4.688	−4.953
Panel E: EGARCH (1)										
ω	−4.339 (0.000)***	−4.890 (0.000)***	−4.159 (0.000)***	−2.760 (0.000)***	−4.453 (0.000)***	−6.205 (0.000)***	−4.613 (0.000)***	−4.204 (0.000)***	−4.500 (0.000)***	−4.493 (0.000)***
α	1.052 (0.000)***	1.099 (0.000)***	0.902 (0.000)***	0.797 (0.000***)	1.066 (0.000)***	0.893 (0.000)***	1.074 (0.000)***	1.036 (0.000)***	1.034 (0.000)***	1.111 (0.000)***
β	−0.048 (0.076)*	−0.019 (0.542)	0.006 (0.863)	−0.058 (0.001)***	−0.035 (0.236)	0.100 (0.403)	−0.006 (0.852)	−0.098 (0.000)***	−0.018 (0.530)	−0.082 (0.003)***
γ	0.537 (0.000)***	0.486 (0.000)***	0.453 (0.000)***	0.673 (0.000)***	0.527 (0.000)***	0.195 (0.000)***	0.501 (0.000)***	0.607 (0.000)***	0.504 (0.000)***	0.531 (0.000)***
Adj R^2	−0.005	−0.002	−0.006	−0.012	0.000	−0.005	−0.002	−0.020	−0.003	−0.002
Durbin–Watson	0.452	0.432	0.497	0.413	0.433	0.468	0.448	0.331	0.467	0.445
Akaike	−4.770	−4.742	−3.721	−3.918	−4.776	−4.078	−4.673	−5.802	−4.600	−4.857
Schawrz	−4.761	−4.733	−3.711	−3.909	−4.767	−4.069	−4.664	−5.793	−4.591	−4.848
Hannan	−4.767	−4.739	−3.717	−3.915	−4.773	−4.074	−4.670	−5.799	−4.597	−4.854
Panel F: AGARCH (1)										
ω	0.156 (0.000)***	0.085 (0.000)***	0.152 (0.000)***	0.102 (0.000)***	0.131 (0.000)***	0.102 (0.000)***	0.133 (0.000)***	0.096 (0.000)***	0.131 (0.000)***	0.153 (0.000)***
α	0.844 (0.000)***	0.915 (0.000)***	0.848 (0.000)***	0.898 (0.000)***	0.8699 (0.000)***	0.898 (0.000)***	0.867 (0.000)***	0.904 (0.000)***	0.869 (0.000)***	0.847 (0.000)***

(continued)

Table 4 (continued)

Parameter	Emira	GrowthPoint	Fairvest	Hospitality	Hyprop	Octodec	Redefine	Resilient	SA Corp	Vukile
Adj R^2	0.000	−0.014	0.000	−0.031	−0.003	0.000	−0.008	−0.010	−0.008	0.000
Durbin–Watson	0.454	0.493	0.433	0.406	0.432	0.471	0.445	0.335	0.465	0.446
Akaike	−4.499	−3.378	−4.495	−3.624	−4.535	−3.955	−4.431	−5.560	−4.394	−4.569
Schawrz	−4.496	−3.374	−4.492	−3.621	−4.531	−3.951	−4.427	−5.556	−4.390	−4.566
Hannan	−4.498	−3.376	−4.494	−3.623	−4.533	−3.953	−4.430	−5.559	−4.392	−4.568

Note that for every model, the first value is a coefficient and the value in the brackets is a p-value. *, ** and *** represent 0%, 5% and 10% significance level, respectively

Table 5 Discrete volatilities: Out-Sample

Parameter	Emira	GrowthPoint	Fairvest	Hospitality	Hyprop	Octodec	Redefine	Resilient	SA Corp	Vukile
Panel A: ARCH (1)										
ω	0.003 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.001 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***
α	0.899 (0.000)***	0.863 (0.000)***	0.812 (0.000)***	0.8000 (0.000)***	0.832 (0.000)***	0.793 (0.000)***	0.926 (0.000)***	0.888 (0.000)***	0.723 (0.000)***	0.935 (0.000)***
Adj R^2	−0.006	0	0	−0.002	−0.002	−0.001	−0.003	−0.011	0	−0.016
Durbin–Watson	0.457	0.443	0.476	0.438	0.435	0.409	0.0452	0.307	0.467	0.455
Akaike	−4.874	−4.888	−4.311	−3.75	−4.724	−4.315	−4.886	−5.165	−4.91	−5.044
Schawrz	−4.862	−4.877	−4.299	−3.738	−4.712	−4.303	−4.874	−5.153	−4.898	−5.032
Hannan	−4.869	−4.884	−4.307	−3.745	−4.72	−4.31	−4.882	−5.161	−4.905	−5.04
Panel B: TARCH (1)										
ω	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.001 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***
α	0.823 (0.000)***	0.924 (0.000)***	0.662 (0.000)***	0.807 (0.000)***	0.788 (0.000)***	0.827 (0.000)***	0.668 (0.000)***	0.769 (0.000)***	0.747 (0.000)***	0.846 (0.000)***
β	0.216 (0.175)	−0.126 (0.320)	0.162 (0.439)	0.007 (0.963)	0.072 (0.671)	0.022 (0.903)	0.171 (0.0740)*	0.156 (0.284)	0.017 (0.934)	0.201 (0.106)
γ	−0.026 (0.000)***	−0.034 (0.000)***	−0.023 (0.314)	−0.011 (0.382)	−0.019 (0.000)***	−0.054 (0.000)***	−0.029 (0.143)	−0.012 (0.392)	−0.027 (0.001)***	−0.015 (0.002)***
Adj R^2	−0.005	0.000	0.000	−0.002	−0.003	−0.001	−0.001	−0.007	0.000	−0.014
Durbin–Watson	0.458	0.443	0.476	0.438	0.435	0.409	0.453	0.309	0.467	0.456
Akaike	−4.878	−4.885	−4.290	−3.748	−4.723	−4.322	−4.877	−5.164	−4.910	−5.047
Schawrz	−4.859	−4.865	−4.270	−3.728	−4.703	−4.302	−4.857	−5.144	−4.890	−5.027

(continued)

Table 5 (continued)

Parameter	Emira	GrowthPoint	Fairvest	Hospitality	Hyprop	Octodec	Redefine	Resilient	SA Corp	Vukile
Hannan	−4.871	−4.878	−4.283	−3.741	−4.716	−4.315	−4.870	−5.156	−4.903	−5.039
Panel C: APARCH (1)										
ω	0.010 (0.000)	0.011 (0.000)	0.016 (0.000)	0.021 (0.000)	0.011 (0.000)	0.014 (0.000)	0.008 (0.000)	0.010 (0.000)	0.013 (0.000)	0.009 (0.000)
α	0.857 (0.000)	0.831 (0.000)	0.740 (0.000)	0.823 (0.000)	0.793 (0.000)	0.729 (0.000)	0.8781 (0.000)	0.764 (0.000)	0.726 (0.000)	0.852 (0.000)
β	0.069 (0.116)	−0.002 (0.940)	−0.016 (0.755)	0.073 (0.096)	−0.001 (0.978)	−0.028 (0.458)	0.001 (0.981)	0.052 (0.211)	0.036 (0.534)	0.074 (0.025)
γ	−0.171 (0.000)	−0.195 (0.000)	−0.155 (0.000)	−0.130 (0.000)	−0.131 (0.099)	−0.247 (0.000)	−0.130 (0.000)	−0.122 (0.000)	−0.196 (0.000)	−0.155 (0.000)
Adj R^2	−0.002	0.000	−0.002	−0.012	0.000	0.000	−0.002	−0.008	−0.010	−0.001
Durbin–Watson	0.459	0.443	0.476	0.434	0.436	0.409	0.453	0.308	0.462	0.462
Akaike	−4.884	−4.893	−4.321	−3.756	−4.728	−4.255	−4.914	−5.140	−4.892	−5.035
Schawrz	−4.864	−4.873	−4.302	−3.736	−4.708	−4.235	−4.894	−5.120	−4.872	−5.015
Hannan	−4.877	−4.885	−4.314	−3.749	−4.720	−4.248	−4.907	−5.132	−4.884	−5.028
Panel D: GARCH (1)										
ω	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.001 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0000 (0.000)	0.001 (0.000)
α	0.936 (0.000)	0.894 (0.000)	0.650 (0.000)	0.812 (0.000)	0.663 (0.000)	0.841 (0.000)	0.917 (0.000)	0.887 (0.000)	0.755 (0.000)	0.958 (0.000)
β	−0.024 (0.000)	−0.032 (0.000)	−0.030 (0.000)	−0.0106 (0.363)	−0.031 (0.000)	−0.052 (0.000)	−0.025 (0.002)	−0.012 (0.171)	−0.027 (0.001)	−0.014 (0.006)
Adj R^2	−0.005	0.000	0.000	−0.002	−0.003	−0.0007	−0.003	−0.009	0.000	−0.015

(continued)

Table 5 (continued)

Parameter	Emira	GrowthPoint	Fairvest	Hospitality	Hyprop	Octodec	Redefine	Resilient	SA Corp	Vukile
Durbin–Watson	0.457	0.443	0.476	0.438	0.435	0.409	0.452	0.308	0.467	0.455
Akaike	−4.878	−4.899	−4.289	−3.750	−4.710	−4.324	−4.892	−5.167	−4.912	−5.046
Schawrz	−4.861	−4.883	−4.273	−3.734	−4.694	−4.308	−4.876	−5.151	−4.896	−5.030
Hannan	−4.871	−4.893	−4.283	−3.744	−4.704	−4.318	−4.886	−5.161	−4.906	−5.040
Panel E: EGARCH (1)										
ω	−4.019 (0.000)***	−4.817 (0.000)***	−4.988 (0.000)***	−3.548 (0.000)***	−4.410 (0.000)***	−4.635 (0.000)***	−4.439 (0.000)***	−4.408 (0.000)***	−5.026 (0.000)***	−4.633 (0.000)***
α	1.013 (0.000)***	1.133 (0.000)***	1.030 (0.000)***	0.866 (0.000)***	1.057 (0.000)***	1.063 (0.000)***	1.259 (0.000)***	0.975 (0.000)***	0.974 (0.000)***	1.100 (0.000)***
β	−0.065 (0.173)	−0.023 (0.679)	−0.009 (0.892)	0.002 (0.958)	−0.021 (0.688)	0.021 (0.718)	0.010 (0.861)	−0.075 (0.075)*	0.025 (0.651)	−0.106 (0.010)***
γ	0.578 (0.000)***	0.492 (0.000)***	0.402 (0.000)***	0.542 (0.000)***	0.523 (0.000)***	0.467 (0.000)***	0.557 (0.000)***	0.531 (0.000)***	0.446 (0.000)***	0.516 (0.000)***
Adj R^2	−0.002	−0.005	−0.003	−0.009	−0.004	−0.009	−0.001	−0.008	−0.009	−0.002
Durbin–Watson	0.459	0.441	0.475	0.435	0.435	0.406	0.453	0.308	0.463	0.461
Akaike	−4.792	−4.807	−4.218	−3.608	−4.644	−4.253	−4.826	−5.032	−4.825	−4.936
Schawrz	−4.772	−4.787	−4.198	−3.589	−4.624	−4.233	−4.806	−5.012	−4.805	−4.916
Hannan	−4.84	−4.8	−4.21	−3.610	−4.636	−4.246	−4.819	−5.024	−4.818	−4.929
Panel F: IGARCH (1)										
ω	0.2170 (0.000)***	0.180 (0.000)***	0.116 (0.000)***	0.049 (0.000)***	0.123 (0.000)***	0.142 (0.000)***	0.194 (0.000)***	0.078 (0.000)***	0.141 (0.000)***	0.138 (0.000)***
α	0.783 (0.000)***	0.820 (0.000)***	0.884 (0.000)***	0.951 (0.000)***	0.877 (0.000)***	0.858 (0.000)***	0.806 (0.000)***	0.922 (0.000)***	0.859 (0.000)***	0.861 (0.000)***

(continued)

Table 5 (continued)

Parameter	Emira	GrowthPoint	Fairvest	Hospitality	Hyprop	Octodec	Redefine	Resilient	SA Corp	Vukile
Adj R^2	0.000	0.000	−0.016	−0.004	−0.002	−0.007	−0.014	0	−0.033	−0.001
Durbin–Watson	0.46	0.443	0.469	437	0.435	0.406	0.447	0.311	0.452	−0.462
Akaike	−4.574	−4.556	−3.879	−3464	−4.396	−3.974	−4.484	−4.749	−4.631	−4.55
Schawrz	−4.567	−4.548	−3.87	−3.456	−4.389	−3.966	−4.476	−4.741	−4.623	−4.542
Hannan	−4.571	−4.553	−3.876	−3.461	−4.393	−3.97	−4.481	−4.746	−4.628	−4.547

Note that for every model, the first value is a coefficient and the value in the brackets is a p-value. ***, ** and * represent 0%, 5% and 10% significance level, respectively is unique—for example, low adjusted R^2 are common in listed real funds. Thirdly, in- and out-of-sample data are confirming the same results. Thus, the parameters of REITs are accurately predicted.

The implications from this article are as follows. Firstly, investors need to understand that REITs are unique products, especially in terms of their volatility risk. Intraday investors can create different volatility strategies which can earn them alpha. Finally, estimation and prediction of REITs parameters, especially volatility tends to be accurate.

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