A multivariate GARCH Model of real estate and investment trusts: Evidence from South Africa and global markets

Lintle Balone[a]

[a]*Department of Economics, Stellenbosch University, Cape Town, South Africa*

Abstract

Using the high frequency data for five periods we examine the correlations between South Africa REITs and selected global countries. We study the various Reits companies of the Morgan Stanly Capital International (MSCI). Our analysis shows that South African reits are the least volatile stocks in relation to other stocks. Finally there is strong evidence that South African reits and global reits have a low correlation, possibly increasing th benefits to portfolio diversification when the market is most volatile. This is a very signifcant result and has not been reported so far in South African context. These results will be useful in model building for prediction of price movement and portfolio management.

Keywords: Multivariate GARCH

JEL classification L250, L100

1. Introduction

Recently, the linkage between real estate investment and trusts (REITs) and finance has been a crucial field of interest, due to the increasing importance of property as a significant asset class in investment. This has been further enhanced by the economic condition of the United States relating to the systematic defaulting of subprime borrowers. Consequently, this has influenced how investors diversify their portfolios. Portfolio diversification means holding equities across various sectors (Stephens and Tiddens 2017). However; this paper will specifically analyses REITs returns between different countries. Real estate investment and trusts (REITs) returns have been significantly examined in the literature, however; reviews that have examined the REITs return comovements between South Africa and different countries are have not been explored in greater depth. Relatively, little research has been performed in the South African REITs compared to other REITs markets (Nurick et al. 2018; Anderson 2016).

The purpose of this paper is to analyze the co-movements and the portfolio diversification the REITs of South Africa and its trading partners. Furthermore, the Multivariate (MV) GARCH modelling is used to examine the conditional correlations between REITs in different countries. The rationale for multivariate (MV) GARCH modelling technique is for investors to include time-varying correlations

Email address: lintlebalone25@gmail.com (Lintle Balone)

in their portfolio selection, hence this paper explores their properties. The results offer valuable insights into which the South African REITs appear to provide better diversification. Secondly, the volatility plot indicates that South Africa has very low volatility compared to Indonesia, Thailand and Israel and reits.

The paper is structured as follows: Section 2 presents the relevant literature. Section 3 discusses the data used in the paper and section **??** provides a comprehensive methodology employed in this paper. Section 5 presents the results of the estimated models. Section **??** concludes. Lastly, section **??** presents the appendix.

2. Literature Review

The literature significant to this study focuses on South African and international Reits in the light of portfolio management. The driving factors cited in the literature for international investment are diversification and risk-adjusted-performance (Worzala 1994; Austin and Geurts 1995; Worzala and Sirmans 2003). This trade-off between risk and return is based on a conventional portfolio theory that prudent investors choose portfolios with the lowest risk for a specific level of return. In other words, diversification of portfolios creates incentives for risk reduction, such as diversification of real estate portfolios to include offshore investments without reducing returns (Austin and Geurts 1995). It is also worth noting that, in portfolio theory, low correlations between dissimilar stocks will increase diversification potential and decrease portfolio risk (Stephens and Tiddens 2017). Put differently, the various types of investments should not follow the same pattern in the market. Therefore, the rewards of portfolio diversification weigh heavily on the correlation framework of the stock markets examined.

Bruin et al. (2009) stated that in real estate investment, portfolio diversification benefits can be accomplished by diversifying across property types and geographical regions. It has been found that various forms of international real estate have weak correlations with other types of investment, hence contribute to a well-diversified portfolio. Moreover, the literature has well-documented evidence that there is a weak correlation between emerging markets and developed markets resulting in diversification benefits (Basu and Gupta 2005; Barry, Peavy Jr, and Rodriguez 1998; Magas 2007). However; the perception that there is a weak correlation between emerging markets and developed markets is deteriorating. For instance Wong et al. (2004) examined the co-movement between stock markets in Asian emerging markets and developed countries using cointegration analysis. They found that there is an increasing correlation between most emerging and developed markets. Chancharat and Valadkhani (2007) employed cointegration and causality tests between major international stock markets and Thailand and found a high correlation between Thailand and other international markets.

The results of various studies on diversification of real estate are based on modern portfolio theory (MPT) (Paul, Robert, and Carl 1991; Seiler, Webb, and Myer 1999; Wilson and Zurbruegg 2003). However; Theron and Van Vuuren (2018) stated that the Modern portfolio approach is rather flawed because it assumes all parameters are known accurately. These parameters (covariances, variances and expected returns) are estimated not necessarily known with certainty. As a result, this uncertainty in parameters leads to estimation risk, which in turn also leads to suboptimal investor financial choices. Modern portfolio theorem was also criticized for the inefficient performance of many institutional portfolios during the financial crisis of 2008/2009 because most portfolios were focused on Markowitz's optimization of portfolios, a mechanism that was widely assumed would provide the necessary diversification to prevent seriously negative portfolios (Choueifaty, Froidure, and Reynier 2013). Modern portfolio models also introduced assets with weak equity correlations, but most asset class correlations increased during the crisis and expected diversification benefits were negligible. Therefore, there is a need for alternative investment ideas.

In addition to these studies, some focus primarily on developed markets in the US, Canada, Europe and Japan, for instance (Bond and Glascock 2006; Basse, Friedrich, and Bea 2009; Moss and Prima 2014). Bond and Glascock (2006) found that real estate has contributed substantially to the overall portfolio outcomes in terms of higher returns and decreases risk. Secondly, the authors are consistent with other researchers that real estate investment performs well during periods of market change. Basse, Friedrich, and Bea (2009) found that investing in US REITs was riskier compared to investment in utility stocks. Further analysis linked this result to the economic state and financial crisis in the US. Moss and Prima (2014) examined the correlation between developed Asian REITs and other developed countries and found that there are interdependent linkages among the REITs market of developed countries.

Certain literature studies analyze stock price linkages between emerging stock markets only, without capturing major stock influences in developed countries (Sharma and Wongbangpo 2002; San Ong et al. 2012; Yang, Kolari, and Min 2003). Their findings suggest that Reits provided a better diversification post-financial crisis. Sharma and Wongbangpo (2002) and Yang, Kolari, and Min (2003) found low evidence of the correlation among Asian stock markets. Also, some studies analyses the interrelationships between developed and emerging markets. For instance, Pham (2012) examined the dynamics of returns and volatility in emerging and developed markets and found that correlations among emerging Reits are lower than those among developed countries.

In investment of real estate, the advantages of portfolio diversification can be accomplished by introducing international real estate into the portfolio. Worzala and Sirmans (2003) found that with the introduction of international real estate to the portfolio, portfolio performance improves significantly. Worzala and Sirmans (2003) discovered that investment in securities linked to international real estate offers additional diversification advantages. Similarly, Niskanen and Falkenbach (2010) claimed that international diversification of REITs investment is suggested to reduce exposure due

to economic uncertainties within countries. Nonetheless, the question asked in this research is "are there any types of interdependence or dynamic correlation between South Africa and international markets?

3. Data

The aim of this study is to investigate the correlation of the Reits market of South Africa and its trading partner countries to access the diversification benefits. The return series are time-varying, intradays as well as over days. In the light of this, it is undesirable to apply models assuming time-invariant conditional variances.

We picked a sample of 10 best performing stocks and 10 worst performing stocks,includsive of South Africa. This selection was made because an investor can reduce the overall risk of his or her portfolio by owning multiple Reits which perform differently. All data is obtained from Morgan Stanely Capital International (MSCI) and encompasses of high frequency data of different 2000 to 2020 f0r some observations and 2016 to 2020 for other.

The stock value indexes are expressed in US dollars to avoid exchange rates fluctuations. For further analysis, the continuously compounded daily returns are calculated by taking the log difference of each listed company as follows:

$$r_{ki,t} = \ln(\frac{P_{k,t}}{P_{k,t-7}}) \tag{3.1}$$

Table 7.1 shows all the tickers that have been used in this analysis. In Table 7.2 it is reported that, daily mean returns were highest for the MXEU0RE index and lowest for the MXZA0RL with values of 9.872380 and -9.023962. During the period, daily returns for most indices are negatively skewed. The MMXWD0RE was the most negatively skewed with a skewness value of -0.611994373 indicating an etreme left tale. In addition to this, MXTHORL was the most positively skewed. Similarly, the daily returns for all indices exhibit excess positive kurtosis with MXMY0RL having the highest kurtosis. The distinct charecteristic of financial data and suggests that the series is not normally distributed.

According to the normality test both daily returns and absolute returns are non normal for all

indices. The null hypothesis of normality test was rejected for all indices..[1] In Figure 7.1 we note that the return series appears to be nearly stable with an average return of approximately zero, however the variability of the data changes over time.

4. Methodology

The empirical analysis is undertaken using an MGARCH framework considering a stochastic process y_t, of a continuously compounded weekely returns. The first step in this analysis is to obtain the GARCH estimates for the univirate volatility estimates fo each series. The study employs the GARCH(1,1) univariate specification. The standard GARCH(1,1) specification model is written in equation 4.1 as follows:

$$\begin{aligned} y_t &= \mu_t + \varepsilon_t \\ varepsilon_t &= \sigma_t . z_t \\ sigma_t^2 &= \alpha + \beta_1 e_{t-1}^2 + \beta_1 sigma_{t-1}^2 \\ z_t &\sim N(0, I) \end{aligned} \tag{4.1}$$

The paper also employs the parsimonious DCC MV GARCH modelling techniques of [engle2002dynamic]. The DCC model provides an easy and parsimonious way of modeling multivariate volatility. The DCC model can be described as follows:

$$H_t = D_t . R_t . D_t .$$

The equation 4.2 splits the variance covarience matrix into identical diagonal matrices and an estimate of time varying correlation. R_t refers to time varying conditional correlations.

The diagonal matrices are defined as:

$$D_t = diag(h_t^{1/2}, h_t^{1/2}). \tag{4.2}$$

Then we define the dynamic conditional correlation structure. This is show in 4.3 below:

[1] We tested for normality using the Jarque-Bera normality test and the results indicate that the returns are not normally distributed.

$$
\begin{aligned}
Q_{ij,t} &= \bar{Q} + a\left(z_{t-1}z'_{t-1} - \bar{Q}\right) + b\left(Q_{ij,t-1} - \bar{Q}\right) \\
&= (1-a-b)\bar{Q} + az_{t-1}z'_{t-1} + b.Q_{ij,t-1}
\end{aligned} \tag{4.3}
$$

$Q_{ij,t}$ is the unconditional variance between series i and j. $\bar{Q}$ is the unconditional covarience between univariate series estimated in step 1. The non-negative parameters are represented by a and b and they must satisfy a + b $<$ 1.

Equation 4.3 is employed in order to estimate R_t as:

$$
R_t = diag(Q_t)^{-1/2} Q_t . diag(Q_t)^{-1/2}. \tag{4.4}
$$

Equation 4.4 has bivariate elements that can be shown in the equation below.

$$
R_t = \rho_{ij,t} = \frac{q_{i,j,t}}{\sqrt{q_{ii,t} \cdot q_{jj,t}}} \tag{4.5}
$$

Writing out a complete DCC model is then constructed as shown in 4.6 below:

$$
\begin{aligned}
\varepsilon_t &\sim N(0, D_t.R_t.D_t) \\
D_t^2 &\sim \text{Univariate GARCH(1,1) processes } \forall \text{ (i,j), i} \neq \text{j} \\
z_t &= D_t^{-1}.\varepsilon_t \\
R_t &= Diag(Q_t^{-1}).Q_t.Diag({Q_t}^{-1}) \\
Q(1-a-b) + a(z'_t z_t) + b(Q_{t-1})
\end{aligned} \tag{4.6}
$$

5. Results

Section 5.1 discusses the results the standard univariate GARCH(1,1) model. Section 5.2 presents the results of the DCC model.

5.1. Standard Univariate GARCH(1,1) Model

The graph below report Reits conditional volatility of the respective GARCH model. Volatility is the degree to which the trade price series varies over time. Even though volatility patterns look almost similar for all indices, differences between the volatility levels of indices can be seen. It is is evident from the graph that other stocks are highly volatile throughout the periods. Indonesia, Thailand and Israel real estate are all amongst the higly volatile stocks. Indonesia real estate have the highest spikes upward compared to other reits. This is unsurprising because these are emerging coutries where returns are classified to be higly volatile in such regions. The graph also shows that South African reits are less volatily, therefore it results in lower expected losses.

```
## Q(m) of squared series(LM test):
## Test statistic:  567.646  p-value:  0
## Rank-based Test:
## Test statistic:  532.7781  p-value:  0
## Q_k(m) of squared series:
## Test statistic:  6829.119  p-value:  0
## Robust Test(5%) :  5863.004  p-value:  0
```

The findings in Table 7.1 also show the volatality output of the reits indices measured by the standard deviation. Indonesia reits display the highest volatility amongst all the indices, however with one of the lowest daily returns. The MXWD0RE reits exhibits the lowest volatility amongst all the indiced. Moreover, it is apparent that one of the least volatile indices is the South Afican reit index whoch can offer valuable insights intp diversification potential. Summing up, higher average returns are connected with larger risk exposure in Chinese real estate which coincides with the traditional asset pricing theory.

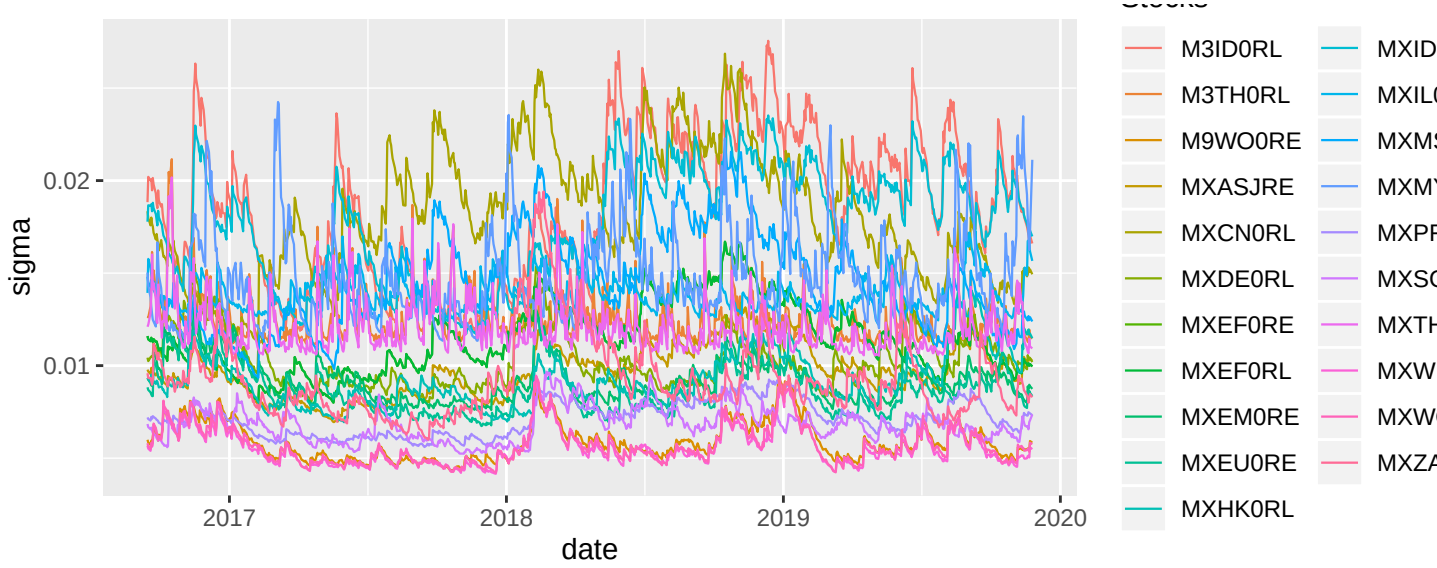

Figure 5.1: Volatility of each asset

The next step is to fit our DCC model utilizing the residuals that we have obtained when fitting thr GARCH model. The dynamic conditional correlations are shown in figure 5.2 below:

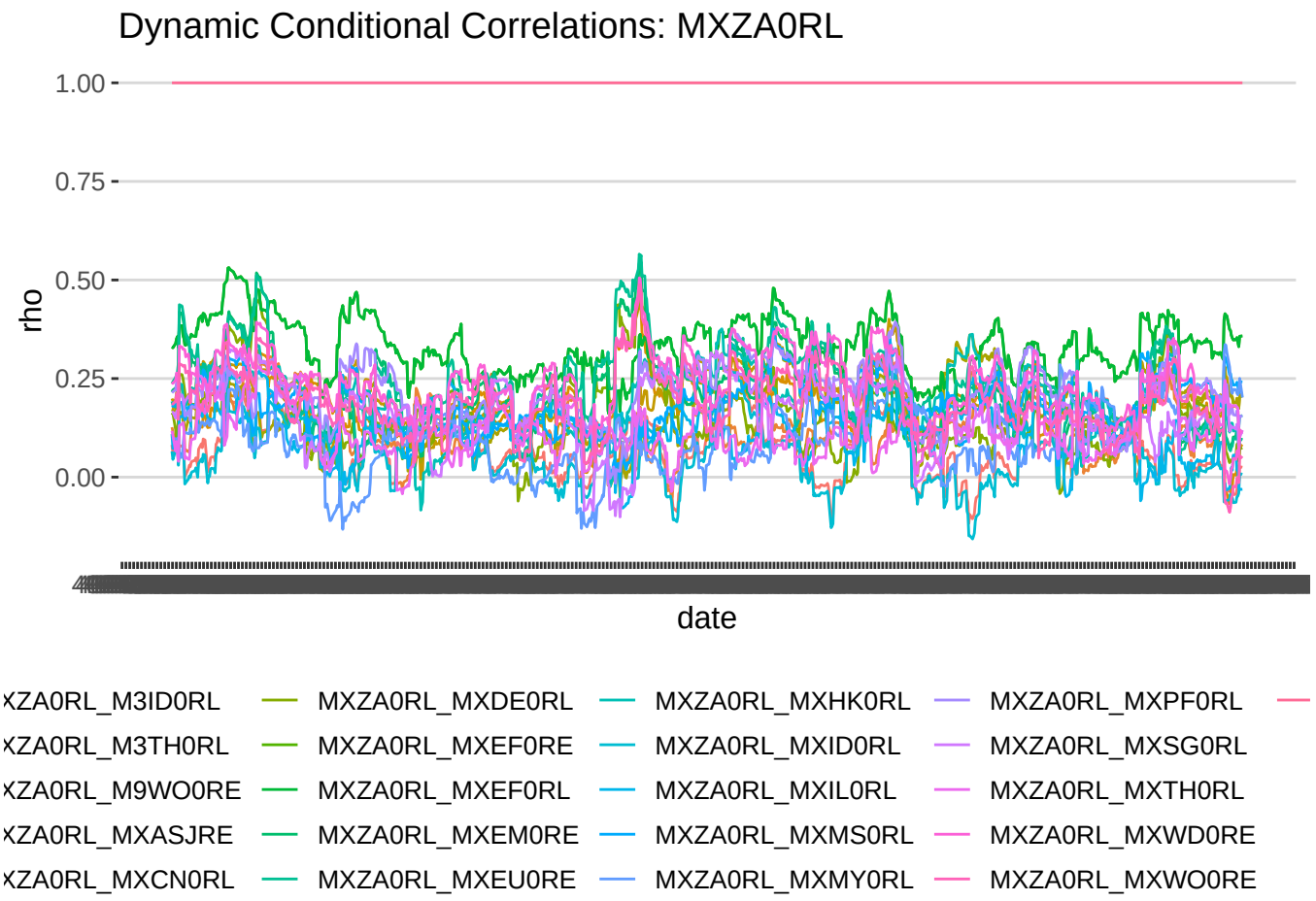

Figure 5.2: Dynamic Conditional Correlations for Each Asset Relative to the SA Reits

The time-varying correlation offers a insight into the underlying comovement structires of a portfolio (Katzke 2019).Basically the DCC-GARCH model estimates conditional volatilities and correlations in two steps (Saleem 2011). It should be noted that the comovements between stocks is fundamental to investors and investment managers, as it provides valuable insights into proper diversification. If there is a high correlation between two stocks, then an investor is faced with low diversification.

In terms of the interpretation, the lower the dynamic correlations, the higher the diversification. This is because low correlation reduces the volatility of the portfolioas a whole. The results in 5.2 confirm that the conditional correlations of South Africa and global reits returns are highly dynamic and time varying. Moreover, it seems that the volatilities of SA reits and global reits comove together. From Figure 5.2 it is apparent that the correlations between MXZA0RL_MXEU0RE and MXZA0RL_MXEM0RE are relatively low. The correlation between

MXZA0RL_M9WO0RE AND MXZA0RL_MXWO0RE reits display the highest correlation. The results of MXZA0RL_MXEU0RE AND MXZA0RL_MXEM0RE are consistent with Worzala and Sirmans (2003), who found that with the introduction of international real estate to the portfolio, portfolio performance improves significantly.

It is worth noting that the dynamic correlations make it clear that the diversifaction opportunities of the included REITS are not entirely constant over time. In conclusion the results in figure 5.2 confirm that the conditional correlations of South African reits and global reits are dynamic and time varying.

6. Conclusion

In this study we address one of the most important questions concerning conventional and morden portfolio management, i.e., the dynanmic conditional correlation between South African reits and global reits. Correlation of reits plays a fundamental role in asset allocation risk management and portfolio managed. Despite its significance this phenomena has been significantly neglected in ermeging markets regardless of their high returns and attractive potential for diversification. We have carried out an analysis of the Multivariate modelling for a period of five years. This time frame contains periods of small and large fluctuations and therefore provides a good example for understanding and examining the reits market behaviour. As expected, the financial data is not normally distributed and exhibit excess kurtios and skeweness.

The empirical results support the assumption of dynamic conditional correlations and there was evident evidence of time varying correlations between South Africa and global reits. Moreover, these correlation are very low, therefore, we believe our results can offer a comprehensive understanding of the dynamic correlations between South African reits and global reits in an emerging market setting which is valuable for financial researchers, international investors, investment managers and risk analysts. In a nutshell, South Africa can offer diversification opportunities to investors during high periods of volatility when stocks are extremely risky. Therefore, investors should invest in stocks that do not comove such as South Africa and .

7. Appendix

	Ticker	Description
1	M3TH0RL	Thailand
2	MXCN0RL	China
3	MXDE0RL	Germany
4	MXEF0RL	EM Real Estate
5	MXHK0RL	Hong Kong
6	MXIL0RL	Israel
7	MXMS0RL	EM Asia
8	MXPF0RL	AC Pacific
9	MXSG0RL	Singapore
10	MXTH0RL	Thailand
11	M3ID0RL	Indonesia
12	M9WO0RE	World
13	MXASJRE	AC Asia ex Japan
14	MXEF0RE	EM Real Estate
15	MXEM0RE	EMU Real Estate
16	MXEU0RE	Europe
17	MXID0RL	Indonesia
18	MXMY0RL	Malaysia
19	MXWD0RE	ACWI Index
20	MXWO0RE	World
21	MXZA0RL	South Africa

Table 7.1: Descriptive Statistics Table

	group1	vars	mean	sd	median	trimmed	min	max	skew	kurtosis	se
X11	M3ID0RL	1.00	-0.00	0.02	0.00	-0.00	-0.08	0.08	0.20	1.53	0.00
X12	M3TH0RL	1.00	0.00	0.01	0.00	0.00	-0.06	0.08	0.31	2.54	0.00
X13	M9WO0RE	1.00	0.00	0.01	0.00	0.00	-0.03	0.02	-0.54	1.37	0.00
X14	MXASJRE	1.00	0.00	0.01	0.00	0.00	-0.04	0.05	-0.20	1.90	0.00
X15	MXCN0RL	1.00	0.00	0.02	0.00	0.00	-0.08	0.07	0.01	1.61	0.00
X16	MXDE0RL	1.00	0.00	0.01	0.00	0.00	-0.06	0.06	-0.29	3.29	0.00
X17	MXEF0RE	1.00	0.00	0.01	0.00	0.00	-0.05	0.05	-0.17	1.47	0.00
X18	MXEF0RL	1.00	0.00	0.01	0.00	0.00	-0.05	0.05	-0.17	1.47	0.00
X19	MXEM0RE	1.00	0.00	0.01	0.00	0.00	-0.05	0.03	-0.33	1.42	0.00
X110	MXEU0RE	1.00	0.00	0.01	0.00	0.00	-0.04	0.03	-0.25	0.93	0.00
X111	MXHK0RL	1.00	0.00	0.01	0.00	0.00	-0.06	0.08	0.25	6.21	0.00
X112	MXID0RL	1.00	-0.00	0.02	0.00	-0.00	-0.06	0.07	0.27	1.36	0.00
X113	MXIL0RL	1.00	0.00	0.01	0.00	0.00	-0.05	0.05	0.07	1.17	0.00
X114	MXMS0RL	1.00	0.00	0.02	0.00	0.00	-0.07	0.06	-0.06	1.45	0.00
X115	MXMY0RL	1.00	-0.00	0.02	0.00	-0.00	-0.14	0.14	-0.12	11.95	0.00
X116	MXPF0RL	1.00	0.00	0.01	0.00	0.00	-0.04	0.03	-0.47	1.74	0.00
X117	MXSG0RL	1.00	0.00	0.01	0.00	0.00	-0.04	0.04	-0.11	3.47	0.00
X118	MXTH0RL	1.00	0.00	0.01	0.00	-0.00	-0.05	0.07	0.40	2.21	0.00
X119	MXWD0RE	1.00	0.00	0.01	0.00	0.00	-0.03	0.02	-0.61	1.70	0.00
X120	MXWO0RE	1.00	0.00	0.01	0.00	0.00	-0.02	0.02	-0.57	1.55	0.00
X121	MXZA0RL	1.00	-0.00	0.01	0.00	-0.00	-0.06	0.09	0.16	8.92	0.00

Table 7.2: Descriptive Statistics Table

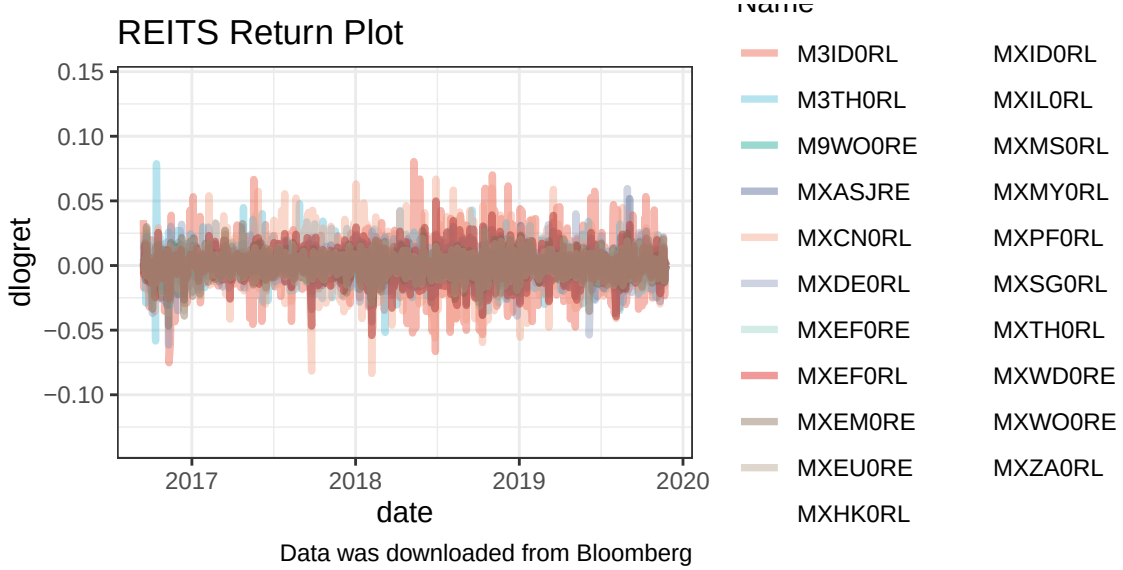

Figure 7.1: Daily log Reits Returns

References

Anderson, Lloyd. 2016. "A Place for Residential Reits in the South African Reit Market." PhD thesis, University of Pretoria.

Austin, Jaffe, and Tom G. Geurts. 1995. "Risk and Real Estate Investment: An International Perspective." *Journal of Real Estate Research* 11 (2): 117–30.

Barry, Christopher B, John W Peavy Jr, and Mauricio Rodriguez. 1998. "Performance Characteristics of Emerging Capital Markets." *Financial Analysts Journal* 54 (1): 72–80.

Basse, Tobias, Meik Friedrich, and E Vazquez Bea. 2009. "REITs and the Financial Crisis: Empirical Evidence from the Us." *International Journal of Business and Management* 4 (11): 3–10.

Basu, P, and R Gupta. 2005. "Benefits of Diversification into Emerging Equity Markets with Changing Correlations: An Australian Perspective." In *18th Australian Finance and Banking Conference*, 14–16.

Bond, Shaun A, and John L Glascock. 2006. "The Performance and Diversification Benefits of European Public Real Estate Securities." *Available at SSRN 896524*.

Bruin, Thomas, Rebecca Porterfield, Edward Graham, and Joseph Farinella. 2009. "Real Estate Investment Trusts and Market Sentiment in the United States & Europe." *Annals of the International Masters of Business Administration at UNC Wilmington* 2 (1).

Chancharat, Surachai, and Abbas Valadkhani. 2007. "An Empirical Analysis of the Thai and Major International Stock Markets."

Choueifaty, Yves, Tristan Froidure, and Julien Reynier. 2013. "Properties of the Most Diversified Portfolio." *Journal of Investment Strategies* 2 (2): 49–70.

Katzke, N. F. 2019. "Financial Econometrics Course: Multivariate Volatility Modeling." https://www.fmx.nfkatzke.com/posts/2019-09-06-practical-multivariate-volatility-modeling/.

Magas, I. 2007. "The Changing Benefits of Global Equity Investing: Developed and Emerging Markets, 1997–2007." *Acta Oeconomica* 57 (4): 343–62.

Moss, Alex, and AD Prima. 2014. "Asia Pacific Listed Real Estate: A Contextual Performance Analysis."

Niskanen, Jaakko, and Heidi Falkenbach. 2010. "REITs and Correlations with Other Asset Classes: A European Perspective." *Journal of Real Estate Portfolio Management* 16 (3): 227–39.

Nurick, Saul, Luke Boyle, Greg Morris, Jacques Potgieter, and Oliver Allen. 2018. "An Investigation into the Relatively Low Uptake of Residential Stock Within South African Real Estate Investment Trusts." *Journal of African Real Estate Research* 3 (1): 61–80.

Paul, Asabere, Kleiman Robert, and McGowan Carl. 1991. "The Risk-Return Attributes of International Real Estate Equities." *Journal of Real Estate Research* 6 (2): 143–51.

Pham, Anh Khoi. 2012. "The Dynamics of Returns and Volatility in the Emerging and Developed Asian Reit Markets." *Journal of Real Estate Literature* 20 (1): 79–96.

Saleem, Kashif. 2011. "Time Varying Correlations Between Stock and Bond Returns: Empirical Evidence from Russia." *Asian Journal of Finance & Accounting* 3 (1): 1.

San Ong, Tze, Boon Heng Teh, Chin Hooi Soh, and Yat Liang Yan. 2012. "Malaysian Real Estate Investment Trusts: A Performance and Comparative Analysis." *International Journal of Economics and Finance* 4 (5): p73.

Seiler, Michael, James Webb, and Neil Myer. 1999. "Diversification Issues in Real Estate Investment." *Journal of Real Estate Literature* 7 (2): 163–79.

Sharma, Subhash C, and Praphan Wongbangpo. 2002. "Long-Term Trends and Cycles in Asean Stock Markets." *Review of Financial Economics* 11 (4): 299–315.

Stephens, David, and Charlotte van Tiddens. 2017. "Inter-Sector Return Correlations Between

South Africa, the United States, the United Kingdom and Europe: Evidence from the Dcc Multivariate Garch Model."

Theron, Ludan, and Gary Van Vuuren. 2018. "The Maximum Diversification Investment Strategy: A Portfolio Performance Comparison." *Cogent Economics & Finance* 6 (1): 1427533.

Wilson, Patrick, and Ralf Zurbruegg. 2003. "International Diversification of Real Estate Assets: Is It Worth It? Evidence from the Literature." *Journal of Real Estate Literature* 11 (3): 257–78.

Wong, Wing-Keung, Jack Penm, Richard Deane Terrell, and Karen Yann Ching. 2004. "The Relationship Between Stock Markets of Major Developed Countries and Asian Emerging Markets." *Journal of Applied Mathematics & Decision Sciences* 8 (4): 201–18.

Worzala, Elaine. 1994. "Overseas Property Investments: How Are They Perceived by the Institutional Investor?" *Journal of Property Valuation and Investment* 12 (3): 31–47.

Worzala, Elaine, and CF Sirmans. 2003. "Investing in International Real Estate Stocks: A Review of the Literature." *Urban Studies* 40 (5-6): 1115–49.

Yang, Jian, James W Kolari, and Insik Min. 2003. "Stock Market Integration and Financial Crises: The Case of Asia." *Applied Financial Economics* 13 (7): 477–86.