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Exploring How Macroeconomic Factors Affect REITs and Evaluating Its Downside Risk – Empirical Evidence From China and the US

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Abstract

Real Estate Investment Trust (REIT) is considered as a financial instrument operated and managed by professional management teams based on a range of income-producing real estate. The focus of this thesis is on publicly traded equity REITs. There are four research questions that this thesis attempts to answer. How did REITs develop in the United States (US)? What are the critical factors that incentivized the Chinese government to promote REITs, and what is the progress? Are REITs a good hedge against macroeconomic risk factors? How can the downside risk of REITs be evaluated? To begin, the first two questions have been answered using the literature review methodology. The VAR model is constructed to evaluate the relation between the REIT market and macroeconomic factors. Ultimately, downside risk of REIT market is assessed by the GARCH(1,1)-VaR model based on the student's t-distribution.

Keywords: Equity REITs; Macroeconomic risks; VAR; VaR; GARCH(1,1).

1. Introduction

This chapter describes the general research background and motivation. Research questions will also be mentioned and proposed. Related literature will be summarised. Afterwards, methodologies are briefly described. Finally, an overview of the thesis structure is provided.

1.1. Research Background and Motivation

Real Estate Investment Trust (REIT) is an alternative to direct physical real estate investment. REITs are typically publicly listed on exchanges, so they are easier to buy and sell. Block (2011) stated that there are two types of REITs. One is mortgage REITs, which is a debt investment based on real estate related collateral. On the other hand, equity REITs is much more common, enabling investors to own real estate shares and usually providing a source of income/cash flow for investors through dividends. Compared with mortgage REITs, equity REITs are less affected by the interest rate change and have better returns historically (Block, 2011). The focus of this thesis is on equity REITs. The REIT-related concepts in the thesis, if not specified, refer to publicly traded equity REITs.

The US was the first country to introduce REIT products to the market in 1960. Since then, approximately 40 countries/regions have adopted the US-based REIT approach according to the National Association of Real Estate Investment Trusts (NAREIT) (*Nareit Global real estate investment*, 2021). [1] In comparison, in China in 2008, an official report published by the State Council of China first discussed the concept of REIT. As part of the development of the financial system, complex products such as REITs are introduced slowly in China.

On 30th January 2021, the Shanghai and Shenzhen stock exchanges in China finalized the official rules for REITs listing in China. On 17th May 2021, 9 infrastructure REITs as a pilot program obtained the Initial Public Offering (IPO) permission in mainland China. Although REITs have begun a new phase in China, there is still not sufficient research on the risks of this asset class domestically.

This thesis seeks to review the framework and system of REITs in the US market in order to draw lessons for China. In addition, empirical methods would be applied to evaluate REITs performance in relation to various macroeconomic risks and measure REITs' downside risk.

How did REITs develop in the US? What are the critical factors that incentivized the Chinese government to promote REITs, and what is the progress? Are REITs a good hedge

[1]NAREIT is a trade association that represents US REITs and listed real estate companies. The association provides comprehensive industry data on the performance of the industries respectively.

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against macroeconomic risk factors? How can the downside risk of REITs be evaluated? This thesis attempts to answer these questions by literature review and building empirical models based on data from the US and China to evaluate the risks of REITs.

1.2. Literature Review

Several studies have been done to research further on REITs as an asset class. Goddard and Marcum (2012) systematically introduced a variety of real estate related financial instruments, such as the history, types and investment strategy of REITs (Goddard & Marcum, 2012). Yin (2019) focused on residential REITs and used development history in the US market as implications for analyzing the opportunities and obstacles for REITs in China (Yin, 2019).

There have been some studies that evaluated the risk-return performance of REITs in relation to macroeconomic factors. Early examples of research include Liu and Mei (1992) as well as Peterson and Hsieh (1997), both of which suggested that the expected excess returns of REITs investment are similar to stocks. The studies indicated that REITs are also dependent on business cycles as well as the broader macroeconomy (Liu & Mei, 1992; Peterson & Hsieh, 1997). Brooks and Tsolacos (1999) used the VAR model to evaluate the degree of influence that macroeconomic factors have on real estate. The factors considered were unemployment, inflation, dividend yield and nominal interest rates. Among these factors, the interest rate term structure and unexpected inflation were suggested to have contemporaneous effects (Brooks & Tsolacos, 1999). Park, Mullineaux, and Chew (1990) and Simpson, Ramchander, and Webb (2007) have made an extensive study on the relation between inflation and REIT returns. US data were used and the suggested result was that REITs could partially hedge inflation risk (Park et al., 1990; Simpson et al., 2007). However, Wong et al. (2017), who engaged in the use of the multi-factor asset pricing model using 20 years of data in Australia, indicated different results. Several macroeconomic variables have been used, which included stock market return, unexpected inflation, expected inflation, risk premium and term structure. In the research, REITs were found to have a negative relation to unexpected inflation (Wong et al., 2017). West and Worthington (2006) also performed similar studies using data from Australia based on the GARCH-M model, and suggested a significant relationship between commercial REITs return and the combined factors of interest rate, unexpected inflation and construction index (West & Worthington, 2006).

The factor interest rate has appeared in multiple studies with regards to its influence on REIT returns. Allen, Madura, and Springer (2000) explored the influence of stock-market returns, long-term and short-term interest rate on publicly traded REITs using seemingly unrelated regression. Afterwards, the study explored how REITs can alter their risk exposure by considering some characteristics, such as asset structure and category. The result suggested that those factors significantly impact REITs, although there are some slight sensitivity differences between equity and non-equity REITs (Allen et al., 2000). Such findings are consistent with the research of Swanson, Theis, and Casey (2002), where the result based on the Cobb-Douglas regression model suggested that interest rate impacts REITs returns and REITs are more sensitive to treaty bills than commercial bonds (Swanson et al., 2002).

The relationship between REITs and the macroeconomy has also been investigated for some Asian markets. Fang, Chang, Lee, and Chen (2016) had used the Autoregressive distributed lag model and Granger causality test, which found that a long-run equilibrium exists between the REIT index and the interest rate, inflation rate, and stock index in Japan, Singapore and China (Fang et al., 2016). The research of Loo, Anuar, and Ramakrishnan (2016) utilized data from seven Asian markets based on the Johansen cointegration test and Granger causality test and pointed out that the emerging markets are more sensitive to the change of macroeconomic environment (Loo et al., 2016).

Liow, Ibrahim, and Huang (2006) utilized principal components analysis, GARCH(1,1) model and Gaussian mixture model to investigate how macroeconomic risk variables impact excess returns of REIT using data from three Asian markets as well as the UK market. It was suggested that across different markets, the significance and impact of macroeconomic risk factors varies (Liow et al., 2006). The research of Kola (2016) used a similar three-step approach to evaluate the influences of the business cycle, price stability, exchange rates and interest rates on REIT pricing in the US, Bulgaria and South Africa. The idea was put forward that industrial production and inflation are significant factors in developed markets unlike the developing market (Kola, 2016).

1.3. Methodology Overview

Literature review method will be used to illustrate the history and development of REITs to answer the first two research questions.

To explore the relationship between macroeconomic factors and REIT returns, this study will use the Vector Autoregression (VAR) model, consistent with that from Brooks and Tsolacos (1999) (Brooks & Tsolacos, 1999). As an overview, the VAR model will attempt to capture the relationship between multiple time-series data with the end goal of highlighting the interaction between all variables. As the time series variables would need to be stationary, the Augmented Dickey Fuller (ADF) test would first be applied. Afterwards, the Granger causality test, impulse response analysis and variance decomposition analysis are applied as a supplement to unravel the relationship between variables (Lütkepohl, 2005). [2]

To evaluate the downside risk, Value at Risk (VaR), a measure of the risk of loss, has been used. In this thesis, the underlying research object is daily REIT logarithmic return. The

[2] See Lütkepohl (2005) pp. 13-66.

underlying assumption of directly calculating VaR requires normal distribution of returns. However, most financial time series data are usually characterized by the heavier tail and volatility clustering. Therefore, the Generalised Autoregressive Conditional Heteroskedasticity (GARCH) family model, which takes the special properties of financial series data into account, is widely used for an accurate VaR estimation. Miletic and Miletic (2015) had evaluated the performance of GARCH-VaR models based on data of five selected European capital markets. The result showed that GARCH models with the t-distribution in most analyzed cases provide better VaR estimation (Miletic & Miletic, 2015). This finding is consistent with Cerović Smolović, Lipovina-Božović, and Vujošević (2017), whose research indicated that GARCH(1,1) with the t distribution of residual is appropriate for capturing volatility clustering
(Cerović Smolović et al., 2017). Therefore, the classical GARCH(1,1)-VaR would be applied in this thesis to evaluate the downside risk of REITs.

1.4. Research Structure

This thesis consists of five chapters to provide a structured approach to answer the research questions. The detailed research flow chart is shown in Figure 1.

Chapter one describes the general research background and proposes the research questions. Literature review, including discussion of previous related studies and the methodologies, are also found in this chapter.

Chapter two focuses on the general concept and history of REITs and attempts to answer the first two research questions mentioned in section 1.1. Theories of REITs are also discussed in this chapter, with a focus on the US and China market. An initial summary will be made at the end of this chapter.

Chapter three discusses the relationship between various macroeconomic factors and REIT returns. Context to the data is first explained for both macroeconomic factors and REITs. The five macroeconomic factors used in this thesis are inflation, interest rate, growth in money supply, growth in industrial production, and the returns of the stock market. The VAR model would be constructed and results would be analyzed. A short summary at the end of the chapter will follow.

Chapter four examines the downside risk of REITs. First, the VaR, as well as the GARCH model will be discussed. Afterwards, training data and validation data will be specified. The Autoregressive Conditional Heteroskedasticity (ARCH) effect would be tested. Afterwards, the Kupiec test would be applied to validate the GARCH(1,1)-VaR model.

Chapter five draws the conclusion for this thesis and provides recommendations for further studies on this topic.

2. REIT Overview

This chapter introduces the basic concept and characteristics of REITs. The development of REITs in the US and the exploration of China will be specified.

2.1. Characteristics of REITs

REITs are financial instruments operated and managed by professional management teams based on a range of income-producing real estate. There are two main characteristics of REITs. First, its underlying assets are mainly real estate, and the primary source of income is rental income. Often, there is also the capital appreciation of the underlying real estate. Second, REITs typically distribute the majority of the annual net income to investors as dividends. REITs can be first traced back to the US by activities and discussion in Congress in 1960. The original idea of a REIT was to provide real estate investment opportunities to small private investors (or retail investors), which was previously only open to high-net-worth individuals or institutional investors. Meanwhile, REITs would broaden the traditional financing channel of the real estate industry and also improve capital allocation and efficiency. There are some fundamental legal requirements for a REIT in the US (Goddard & Marcum, 2012; Block, 2011): [3]

- Asset allocation requirement: At least 75% of its assets must be invested in real estate properties or equivalent
- Shareholder requirement: Must be 100 shareholders at a minimum and no more than 50% of the shares held by five or fewer individuals
- Income requirement: At least 95% of gross income must be received from real estate related activities
- Dividend requirement: Must distribute at least 90% of its annual taxable income to investors

In the years that follow, forty countries, including several emerging markets, have adopted the REIT framework learned from the experience of the US. Although REITs issued by different countries may differ slightly in terms of policy and management strategy, the definition of REITs in various countries worldwide is consistent. REITs can be thought of as a collection of funds through the issuance of shares, which are managed by a particular custodian. A professional institution is entrusted to carry out real estate related investment management, and the net profit of the investment is typically directly distributed to investors as dividends.

2.2. The Development of REITs in the US

The US has the longest history of publicly traded REITs and has one of the most mature REIT markets in the world. Figure 2 shows the historical development of US equity REITs market capitalization. Its development can be divided into the following four phases (Block, 2011; Yin, 2019).

Phase one: Emerging (1960s-1980s) The US Congress passed the Real Estate Investment Trust Act in 1960, which paved the way and developed the REITs which

[3] See Block (2011) Section 3.1.

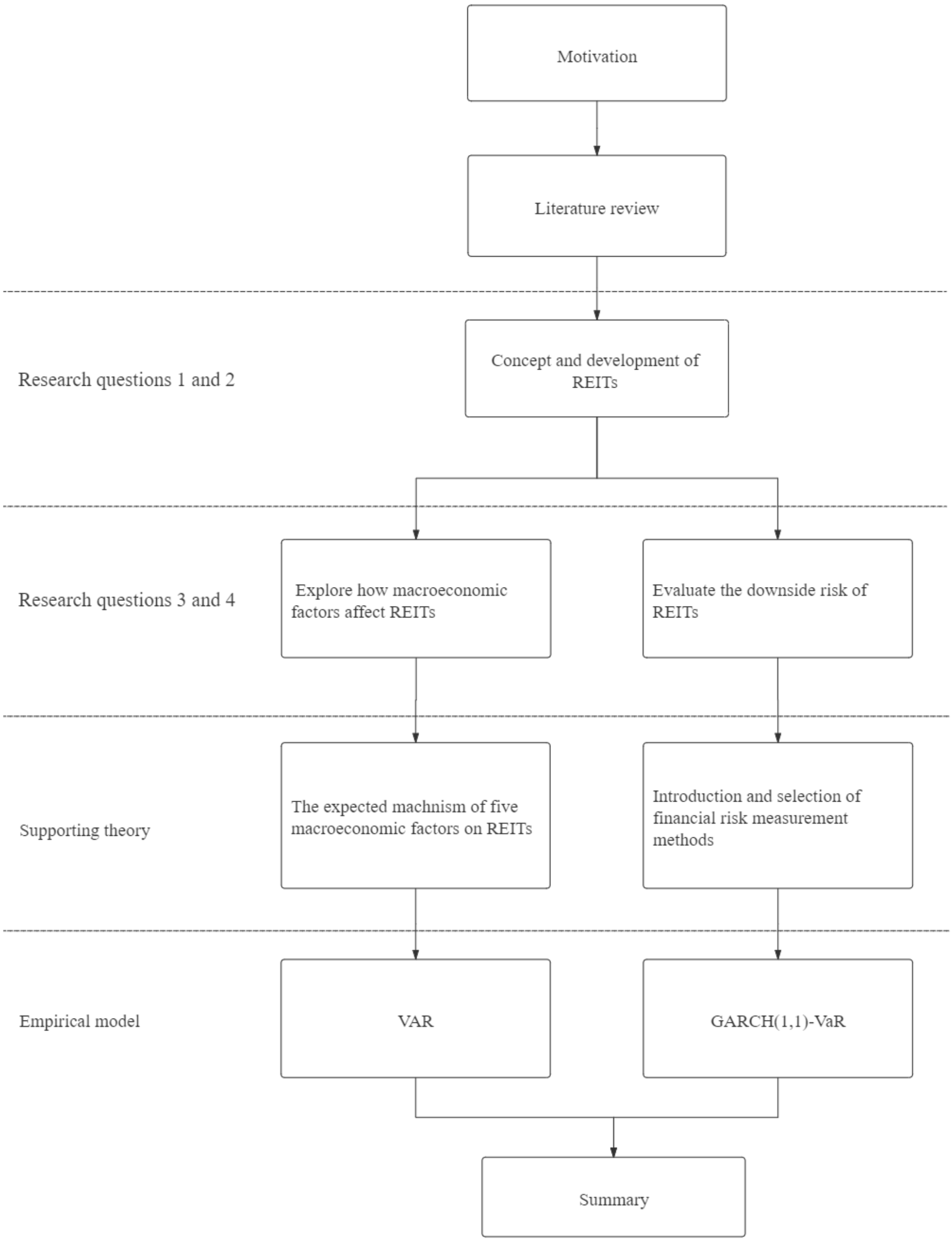

Figure 1: Research Flow Chart

Source: Author's representation

are known today. The main goal of the act was to authorize the mechanisms to provide for a real estate ownership structure and to have similar tax properties as that of a mutual fund. This way, the problem of double-taxation can be managed as the mechanisms of REITs were engineered such that they would distribute most of its earnings and capital gains. The problem of double-taxation was crucial as it would not be attractive to have an entity paying taxes at the corporate level in addition to investors (often private individuals) facing additional individual taxes on the dividends received. By mimicking elements of mutual funds, the REITs would not be subject to corporate taxes as most earnings (or almost all of its income) are passed to

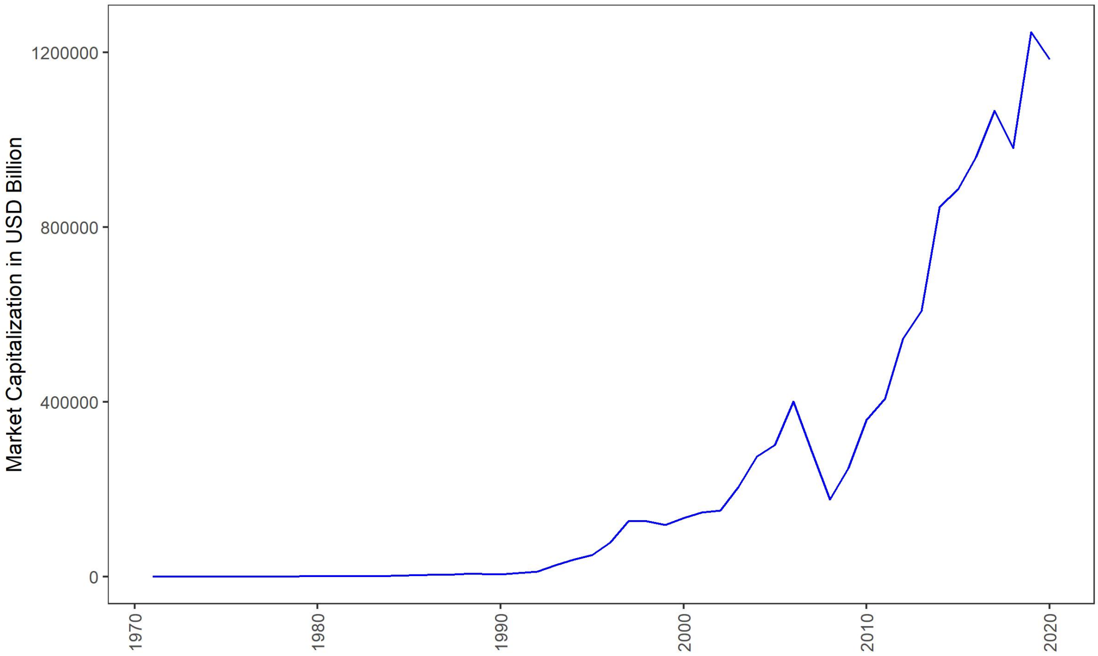

Figure 2: The US Equity REITs Market Capitalization From 1971 to 2020

Source: NAREIT (*Nareit US REIT industry equity market cap*, 2021)

investors as dividends, where they then pay individual taxes on these dividend income.

Although comparisons between REITs and mutual funds were made, there is a distinct difference that should be noted. Mutual funds typically purchase equities of companies, and they do not usually need to manage the operations of these companies. On the other hand, REITs hold properties that require active professional management, including operation (cleaning, repair work) and administration (tenant management, rental negotiation). As such, REITs would need to have a structure (or rather, a management team) in place to manage the properties. In the early years, REITs contributed little to the overall real estate investment market, and the need for professionally active and operational management could be one of the factors.

Phase two: Booming (1990s) Market awareness about REITs grew over the decades. The REITs market capitalization, number of REIT listings and investor interest skyrocketed in the 1990s. A number of reasons played a role on this topic, which will be discussed below.

First, there were significant changes to legislation. The Omnibus Budget Reconciliation Act of 1993 tweaked the ownership structure of REITs for pension funds. Due to this tweak, all investors in a pension fund could be counted as individuals for REIT investment purposes.[4] Ultimately, this helped to encourage and improve accessibility to REITs for the small private investors.

Second, the REIT Modernization Act of 1999 provided two significant points to support the REIT market. Mandatory income distribution of REITs was reduced from 95% to 90%.[5] Next, management of REITs were given more considerable independent flexibility on the topic of operational controls. REIT management could provide a variety of services to tenants without independent contractors and they also had a more extensive scope over investment decisions.

Next, financial innovation such as the umbrella partnership REITs also contributed to this skyrocketing growth of the REIT market. In such a structure, there is the standard REIT entity as well as an operating partnership. In this context, properties are owned by the REITs indirectly through the operating partnership. Owners of these operating partnerships can convert their units into shares of the REITs, thus deferring capital gain taxes until the actual transaction/conversion. This innovation increased the attractiveness of REITs as investors can better perform tax and financial planning.

[4]Specifically the shareholder requirements for REITs mentioned in Section 2.1

[5]Specifically the dividend requirements for REITs mentioned in Section 2.1

Phase three: Consolidating (1997-2008) Cycles happen in the market, and in this case, the REIT market was in a "correction" from 1997 to 1999, where the total market capitalization decreased from United States Dollar (USD) 127 billion to 118 billion (*Nareit US REIT industry equity market cap*, 2021). Various factors played a part, including overheating in the REIT market with too high a competition between lenders, which created unrealistic spreads and expected returns. Furthermore, there was the Asian financial crisis in 1997 as well as the Brazil financial crisis in 1999 - both of which had trickled impacts into the US market.

Afterwards, consolidation in the REIT market occurred. To remain competitive, companies were merging and the consolidation happened until 2008. Specialization of REITs also became a standard feature, as it became apparent that unique skill sets would be necessary to tailor for different types of REITs such as those involved in shopping centers, logistics, data centers or healthcare. This was an important discovery and development phase for the REIT market as a whole.

In 2007 the subprime mortgage crisis happened, and REITs had a significant crash in percentage terms. Kawaguchi, Sa-Aadu, and Shilling (2017) argued that the declining commercial mortgage 10 year Treasury yield spread during the Greenspan era (1994-2006) allowed the managers of REITs to be over leveraged with debt and had too much risk (Kawaguchi et al., 2017). Yin (2019) stated that such a crash did not result from overbuilding but rather due to excessive external debt to fund aggressive development activities (Yin, 2019).

Phase four: Mature (2008-present) Following the subprime mortgage crisis, REITs had the chance to acquire many undervalued properties to grow their portfolio. This was further supported by the easy monetary policies adopted by policymakers in response to the crisis. Significant capital inflow continued to flow into REITs as an asset class in the years that followed. According to Levy, Giano, and Jones (2015), there were two other reasons which contributed to the growth of the REIT market - the idea of renting and specialization (Levy et al., 2015).

An idea was put forward in the market that some industries can achieve higher efficiency by renting rather than owning the properties as part of their value chain. As a result, investors with capital can acquire properties and rent them to businesses who would prefer to rent it.

Next, there was to an extent wide belief that firms should specialize and have separate asset ownership. Thus, firms who previously owned real estate apart from their main operating business would have a tendency to dispose of or spin-off their real estate and turn to the market to fulfil this need. This contributed to the growth of REITs both from a supply and demand perspective.

2.3. The Exploration of REITs in China

The early development of REITs in China can be traced back to 2005 when the first REIT with underlying mainland Chinese properties called Yuexiu REIT was listed in the Hong Kong stock exchange. Subsequently, a few more REITs with underlying mainland China properties have been listed in markets overseas. Until May 2021, there are a total of 9 REITs with purely mainland China properties listed in the stock exchanges of Hong Kong and Singapore. Detailed information is specified in Section 3.2.2.

In the context of the REIT market in mainland China, the concept of REIT was first proposed by the State Council of China in 2008, which suggested that REITs could be an innovative financing mechanism to promote the healthy development of the real estate industry. During the time between 2008 to 2018, there was barely any substantial progress. However, over this period, China has launched various financial products that have relationships with real estates, such as commercial mortgage-backed securities, which is a type of fixed-income security collateralized by commercial real estate loans. The two most significant features of these products are privately traded and are a type of fixed income asset. Until May 2021, financial products underlying real estate have a total market value of approximately USD 62.8 billion (Deloitte China, 2021).

During the past three years, REITs have drawn much attention. According to Deloitte China, there are subsequently favorable policies for domestic REITs. These policies have provided strong political support from two aspects: by defining which type of REITs should be in the first trial and by setting up the specific IPO steps and regulations of REITs. In April 2018, the China Securities Regulatory Commission, together with the Ministry of Housing and Urban-Rural Development, advocated the secularization of the rental housing market and pushed the establishment of REITs. In April 2020, the China Securities Regulatory Commission confirmed infrastructure associated with technology as a pilot program of public REITs. This indicated the official launch of such a pilot program. Afterwards, there were various policy modifications as preparation for the development of the domestic REIT market (Deloitte China, 2021). In May 2021, the first batch of 9 publicly-traded REITs gained approvals. These 9 REITs were infrastructure REITs with underlying assets in highways, industrial parks, logistic warehouses and sewage treatment facilities, with a total capitalization of approximately USD 4.7 billion. The issuance of the pilot program of infrastructure REITs indicated that China is moving forward to develop REITs as an asset class (The Balance, 2021).

There are more listings of infrastructure REITs in the months that follow. The infrastructure REITs pilot targets five sectors. They are warehousing & logistics, transportation infrastructure, environmental protection, urban utilities and new infrastructure. Standard and Poor's (S&P) (2021) concluded the incentive of China to push the establishment of infrastructure REITs as "big infrastructure goals, limited financing options". The report suggested that REITs are part of an infrastructure financing framework with the aim to relieve the debt burden for infrastructure developers in China, since REITs generally work with the context of equity instead of debt. This can be crucial to help send the message to developers to focus on profitability so as to align and be consistent with the demands of the REIT market. The issuance of pilot infrastructure REITs would bring new opportunities. Such REITs provide investors with great investment opportunities in the context of the fast development of the Chinese economy. Additionally, REITs can be traded easily in the secondary market. As a result, this increases the liquidity as compared to traditional real estate. It is a great way to improve the asset turnover rate, remove debt burden and speed up the reinvestment for infrastructure developers through selling off operating assets and accompanying project debt, while optimizing the resources and boosting economic growth (Standard and Poor's (S&P), 2021).

However, there are also some uncertainties. Deloitte China (2021) suggested that the REITs with infrastructure as the underlying assets should have the advantages of higher transparency and better liquidity. Although the first batch of REITs had such advantages, most infrastructure projects with financing needs in China may lack such characteristics. Some quality projects might not choose REIT as a financing channel. Therefore, it is questionable for the feasibility of financing through REIT in the long run (Deloitte China, 2021). Additionally, China REIT adopted a transaction structure of public fund plus Asset Backed Securities (ABS), which are relatively complex, as shown in Figure 3. There is an ABS in between which acts as a conduit for passing through the cash flows from the underlying assets to the public fund. There are several concerns regarding this framework. One of them is that such a structure may lead to duplicate or excessive taxation. The other concern is that under this multi-layer principal-agent relationship structure, the problem of information asymmetry and conflict of interest may be more serious. This may result in cash leakage and returns being diluted (Standard and Poor's (S&P), 2021).

The guideline of the pilot program is rigorous, with higher payouts and tighter caps on leverage than global norms. Such strict regulations indicate that China has a solid commitment to the development of the domestic REIT market. The pilot REITs program is an exploration that helps to test the market appetite and learn from challenges. It would provide great experiences and lessons for China to further scale up the REIT market in the future. According to the prediction of Standard and Poor's (S&P) (2021), infrastructure REITs in China could grow to a market size between USD 300 billion and 735 billion within a decade (Standard and Poor's (S&P), 2021).

3. Explore How Macroeconomic Factors Affect REITs

This chapter introduces the choice of data, with an emphasis on independent variables and dependent variables. The stationarity of the data will be tested before the construction of the VAR model. Afterwards, an additional three analysis will be applied to perform validity checks.

3.1. Choice of Macroeconomic Factors

According to the literature review discussed in Section 1.2, frequently considered macroeconomic variables are inflation risk, interest rate risk, money supply risk, industrial production risk and stock market risk. On this basis, this thesis applies these five factors as independent variables. Table 1 shows the macroeconomic variables and their selected proxies.

$$\gamma_t = \ln p_t - \ln p_{t-1} \tag{1}$$

Data for these five variables are obtained from Refinitiv with a time frame from February 2006 to March 2021. Consideration has been given to indicate the real economy and business cycles (182 months in total). It should also be noted that the data frequency applied is monthly. Among these variables, $GIND$, $GCPI$ and $GM2$ are MoM change data, which have been downloaded from Refinitiv (Refinitiv, 2021). The logarithmic return has been calculated for the stock market with the Formula 1, which is represented by R_S.

3.2. Choice of Target REITs

3.2.1. US REIT Data

In this thesis, the US REIT index created by Morgan Stanley Capital International (MSCI) is chosen to represent the US REIT market.[6] "The MSCI US REIT index is a free float-adjusted market capitalization weighted index. With 136 constituents, it represents about 99% of the US REIT universe and securities that are classified under the equity REIT industry (under the Real Estate Sector) according to the global industry classification standard" (MSCI, 2021a). The MSCI US REIT index is very comprehensive. Around 23.69% of components are specialized REITs, followed by residential REITs, industrial REITs, and retail REITs. The specific percentage of each category is shown in Figure 4 below.

The selected sample span is the same as that of macroeconomic factors. The monthly logarithmic return of MSCI US REIT index can be then calculated by the Formula 1. Symbol R_T represents the REIT variable in this thesis, and such variable of US is represented by US_R_T.

3.2.2. China REIT Data

As the REIT market in China is still relatively new, there is no existing REIT index (or equivalent) for mainland China, and one would have to self construct. Till date, there are 9 REITs (with underlying properties based in mainland China) listed in Hong Kong and Singapore. The detailed information of each of these REITs is shown in Table 2.

Compared with the MSCI US REIT index components, these 9 Chinese REITs are less diversified, with the main focus on commercial properties. Among them, the REITs with

[6] MSCI is an investment research firm that provides stock indexes, portfolio risk and performance analytic, and governance tools to institutional investors and hedge funds.

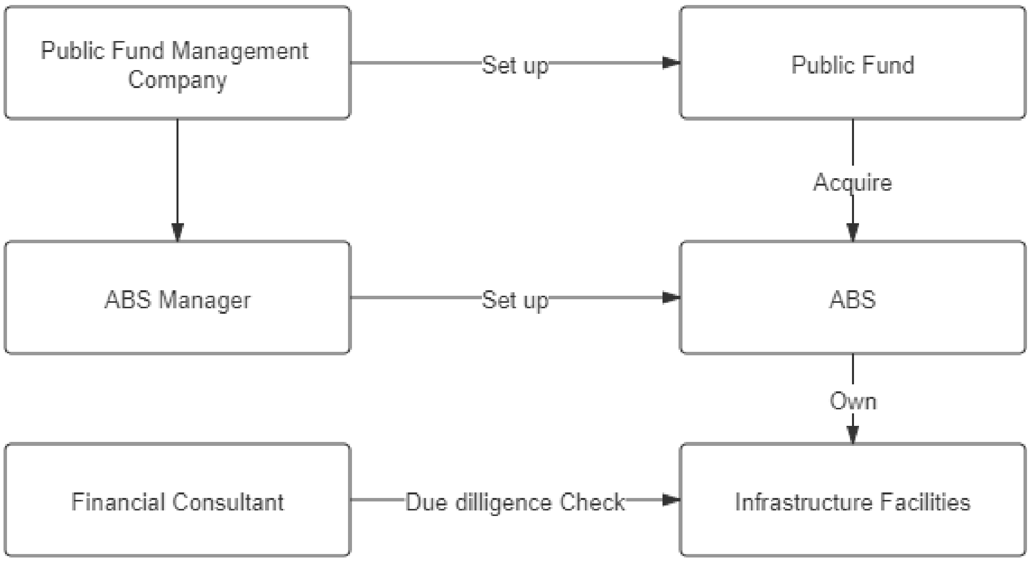

Figure 3: Public Fund Plus ABS Structure of China Infrastructure REITs

Source: Deloitte China (Deloitte China, 2021)

Table 1: Macroeconomic Variables and Proxies

Note: S&P 1500 Composite Index covers approximately 90% of US market capitalization (Standard and Poors (S&P), 2021); SSE Composite Index covers all stocks traded in SSE; MoM

Variables	Macroeconomic Factors	Proxy
R_0	Interest rate risk	10-year government bonds yields as interest free rate
$GIND$	Fluctuation of industrial production	Industrial production MoM change
$GCPI$	Fluctuation of inflation	CPI MoM change
$GM2$	Fluctuation of money supply	M2 money supply MoM change
R_S	Fluctuation of stock market	S&P 1500 Composite Index for US ; SSE Composite Index for China

a larger market capitalization are Yuexiu, Hui Xian and Capitaland. According to the financial report of New Century REIT, the tourism industry has suffered a significant financial loss due to the COVID-19 pandemic. Revenue of hotels has decreased 16% year over year due to travel restrictions and lock-downs. As a result, the New Century REIT was liquidated on the 14th of April 2021 (New Century, 2021). In this thesis, the index based on the 9 REITs mentioned before is used as a reference. The methodology to construct this REIT index is consistent with that of the MSCI US REIT index (Market free float-adjusted market capitalization weighted) (MSCI, 2021b). The formula is shown in 2.

$$p_t \& = \frac{\sum_{t=1}^{n} p_t x_t}{\sum_{t=1}^{n} x_t} \tag{2}$$

There are two key steps to be performed before the final index is calculated and constructed.

First, to maintain consistency with the MSCI US REIT index, dividends of REITs are to be considered and added (MSCI, 2021b). Often, after a stock goes ex-dividend, the share price drops by approximately the amount of the dividend paid. Therefore, the original close price downloaded from Refinitiv should be modified to add the equivalent cash dividend. Furthermore, since REITs have various IPO dates, the price and weights of unlisted REITs at time t would be set to 0. These 9 REITs are listed in Hong Kong and Singapore. As these two markets have different workdays, the workdays of Hong Kong are chosen for REIT index calculation. If the time t in Singapore is a bank holiday, the price and shares of that particular REIT would be adjusted to the previous work-

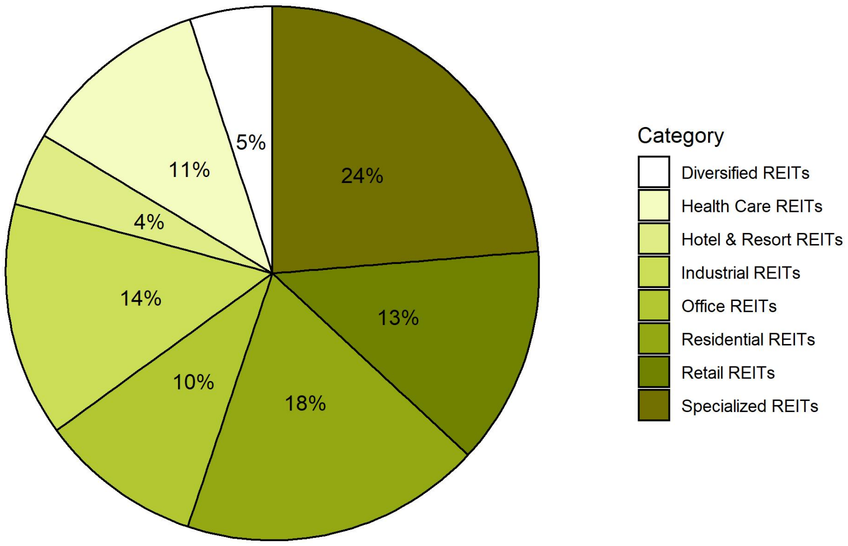

Figure 4: The Pie Chart of REITs Category of MSCI US REIT Index

Source: MSCI (MSCI, 2021a)

Note: Diversified REITs refer to REITs that own more than one category of properties; Specialized REITs refer to REITs that own properties which do not fit within the other category, such as casinos and farmland

ing day's value. Afterwards, the weighted average index can be calculated using Formula 2 and its logarithm return can be obtained by Formula 1.

As this index only has 9 components, the distribution of daily data should be checked to ensure that there is no outlier. The selected sample span is for a period from 1st February 2006 to 31st March 2021. There is a total of 3725 days of validated data and a box plot is constructed. As shown in Figure 5, there is a rate of return slightly above 30%. This data point is on the 08th December 2006, which is the IPO date of Capitaland China REIT. Before 08th December 2006, the index only consists of Yuexiu REIT. Thus, this resulted in an imbalanced calculation for the new addition to the index. To minimize this impact, this outlier is ignored.

To be consistent with the monthly macroeconomic factor data, a total of 182 months of data is used in this chapter. The REIT variable of China is represented by CN_R_T.

3.3. The Effect of Macroeconomic Factors on REITs

3.3.1. Descriptive Analysis

As mentioned in section 3.1, there are five independent variables, which are R_0, $GIND$, $GCPI$, $GM2$ and R_S. The dependent variable is R_T. The time series line plot of each variable and brief descriptions are provided.

Two distinctions are illustrated in Figure 6. First, yields on the 10-year bonds in both countries react in a similar fashion during times of crises, as they typically are expected to act as "safe-havens". For example, during the subprime mortgage crisis of 2008, yields on the 10-year bonds in both countries decreased sharply, indicating a "risk-off" event as prices on these bonds increased. From 2015 to 2016, the stock market bubble in China had burst, leading to a similar sharp decrease in yields on the 10-year bonds. In the most recent COVID-19 crisis, a similar sharp decrease in yields for both countries happened as well. Second, yields on the Chinese 10-year government bonds are within a band of approximately 0.04 and 0.019 throughout the period from 2006 until 2021. In comparison, yields on the US 10-year government bonds were in a downward trend for the same time period. A number of factors can help explain this divergence in trends, such as the reserve status of the USD and the growing trade deficit of the US with its trading partners.

Two interesting points can be noted in Figure 7, which illustrates the MoM change of industrial production. Using the same context of the two crises in the US from 2006 to 2021, the data highlights sharp volatility during the 2008 subprime crisis, where the financial system had a shock as well as a severe liquidity event that affected a large number of businesses. However, the impact looks minor compared to the COVID-19 crisis, where many businesses had to stop operations due to the uncertainty of COVID-19. Only in Q3 2020 were strategies employed to keep workers safe and to resume operations. There is, unfortunately, no publicly available information for the same MoM data set for China.

Table 2: Detailed Information for 9 REITs Which Have Purely Mainland China Properties

Note: HK refers to Hong Kong stock exchange and SG refers to Singapore stock exchange; The sector information of each REIT comes from the financial reports; The market capitalization data is downloaded from Refinitiv (Refinitiv, 2021), which is the data on 31.03.2021 shown in USD

Name	Listed	IPO Date	Category	Market Cap
Yuexiu	HK	21.12.2005	Office and Retail	$1,691,093,580
Hui Xian	HK	28.04.2011	Office, Retail,Hotels & Resort	$1,619,991,179
New Century	HK	09.07.2013	Hotels & Resort	$254,186,222
China Merchants	HK	10.12.2019	Office and Retail	$356,430,723
CapitaLand China	SG	08.12.2006	Office and Retail	$1,540,351,500
Dasin Retail	SG	20.01.2017	Retail	$422,312,494
BHG Retail	SG	11.12.2015	Retail	$209,315,134
EC World	SG	27.07.2016	Industrial	$436,201,412
Sasseur	SG	27.03.2018	Retail	$749,005,526

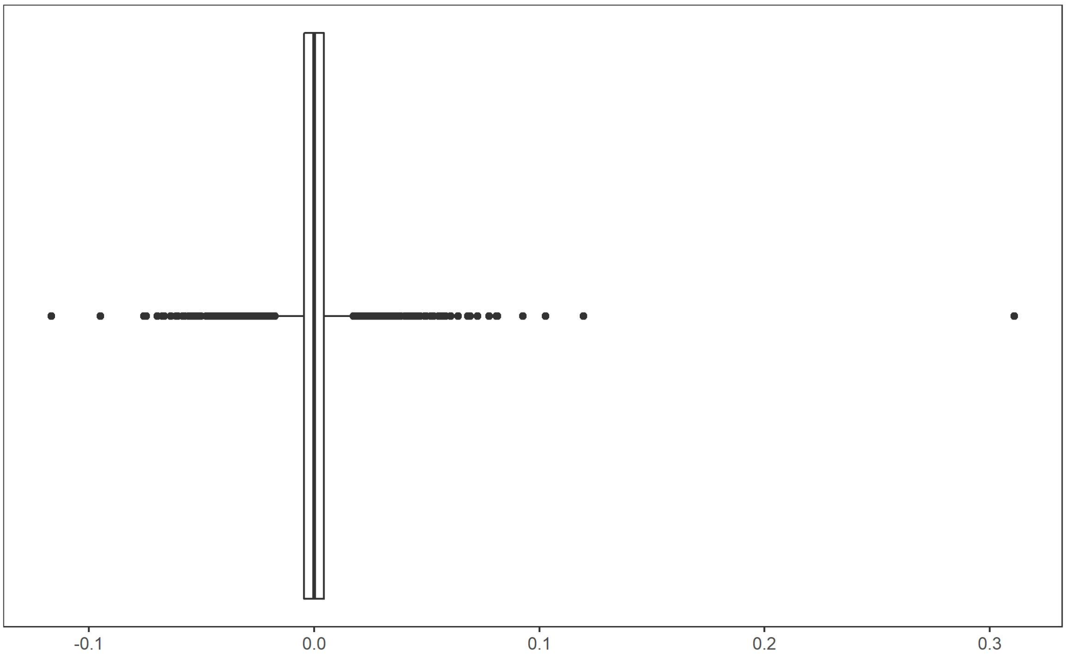

Figure 5: The Box Plot of Daily Logarithm Return of China REIT Index

Source: Author's representation

Thus, this independent variable will be ignored in the VAR model of China in later sections.

MoM change of CPI in China and the US is illustrated in Figure 8. The first takeaway is that CPI change in China is at a much larger magnitude compared to that of the US. Part of the reason is that as China is considered an emerging economy, a much more significant price change can happen due to the low base effect.[7] The second takeaway is that the MoM change in CPI in China did not appear to have any significant fall in the 2008 subprime mortgage crisis. On the other hand, it can be seen that the CPI MoM change in the US had a significant fall during the subprime mortgage crisis. One reason could be that China and its businesses had less exposure to the US economy during that time period, and China were still effectively increasing the number of the middle class, with rising wages which reduces any deflationary pressure and vice versa for the US.

Figure 9 illustrates the $M2$ money supply MoM change in China and the US. In China, the $M2$ money supply had generally been increasing MoM from 2006 until 2017 and had been in a rather consistent manner apart from a sharp spike in 2011 and 2015. From 2017 onwards, $M2$ money supply MoM change in China had higher volatility, which

[7]Low base effect refers to the tendency of a small absolute change from a low initial amount to be translated into a large percentage change

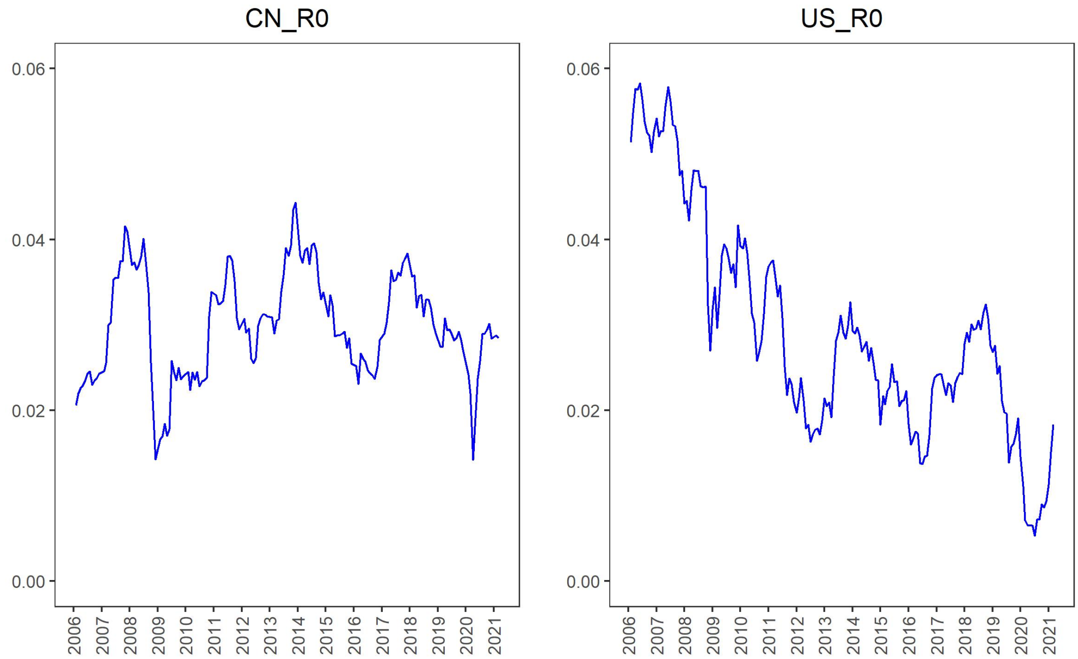

Figure 6: The Time Series Line Plots of CN_R_0 and US_R_0

Source: Refinitiv (Refinitiv, 2021)

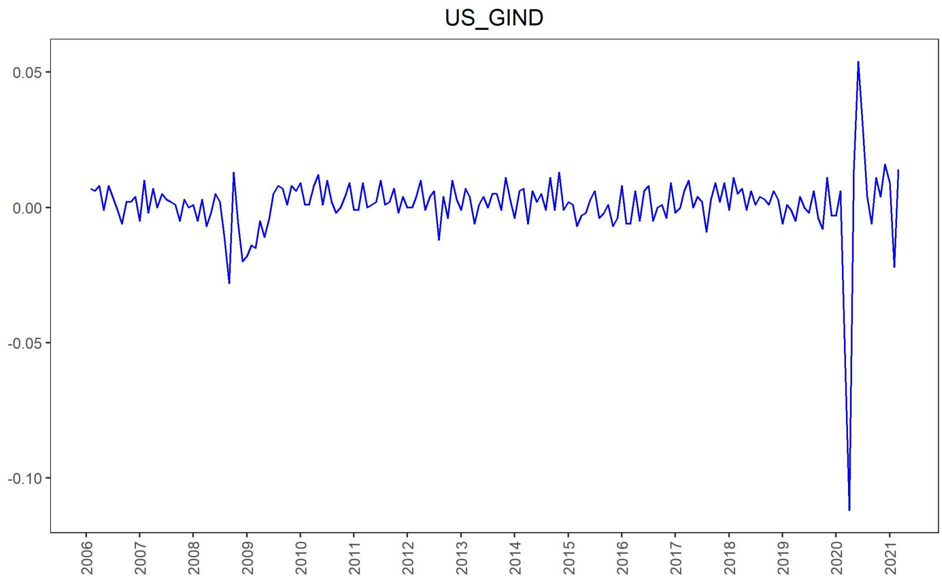

Figure 7: The Time Series Line Plot of US_GIND

Source: Refinitiv (Refinitiv, 2021)

could partly be attributed to a combined factor of a broadening definition of the $M2$ money supply as well as to react to the burst of the 2016 stock market bubble. In comparison, the $M2$ money supply in the US has been growing very consistently, except for the large liquidity injection in 2020 to combat the COVID-19 crisis. It is noteworthy that in the US in 2008, the money supply was mainly increased to recapitalize banks to combat the subprime mortgage crisis. However, in 2020, money was additionally handed out directly to individuals, which drastically increased the $M2$ money supply.

Figure 10 provides context to daily logarithmic returns of the SSE composite index and the S&P 1500 composite

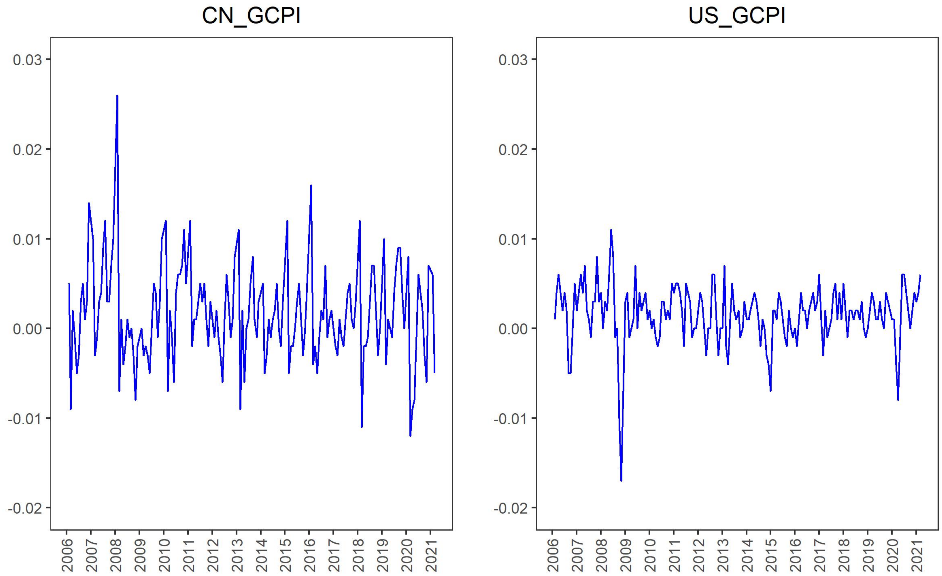

Figure 8: The Time Series Line Plots of CN_GCPI and US_GCPI

Source: Refinitiv (Refinitiv, 2021)

index in China and the US respectively. In China, three critical points of volatility can be identified. First, there was the subprime mortgage crisis in 2008-2009. Second, there was the burst of the stock market bubble in China in 2016. Third, there was the COVID-19 outbreak which affected businesses in China towards the end of 2019. In the US, two key points of volatility can be identified. First, and similarly, there was the subprime mortgage crisis in 2008. In 2020, the US reacted to the COVID-19 crisis where many businesses had to shut down, causing extreme volatility in the stock market. It can be seen that the magnitude of volatility during crises are consistent, which the use of tools such as circuit breakers in the stock market might have played a role. Another exciting finding is that the overall CN_R_S had higher volatility than US_R_S. This phenomenon can be explained by the characteristics of emerging markets, such as lower liquidity, which caused the market to be more volatile.

The daily logarithmic returns of the self-constructed China REIT index and MSCI US REIT index can be seen in Figure 11. Three key points can be taken away from both China and the US. First, R_T had much more volatility in the year 2006 leading to 2008. Volatility was due to the growing interest in real estate, as well as the speculative mindset on real estate which was evident throughout many countries in that period of time. Second, the period after the 2008 subprime mortgage crisis until 2019 has less volatile price action compared to the years before due to higher emphasis by policymakers on price stability, as well as deleveraging in many businesses. Third, like most other asset classes, REITs were also highly affected during the COVID-19 crisis, whereby an amalgamation of factors including low liquidity and uncertainty over the economic outlook affected the prices.

3.3.2. Detecting Stationary

A critical assumption of the primary, stationary finite order VAR model is that the variables should be Gaussian white noise. It should be a stationary and ergodic random process with zero mean (Lütkepohl, 2005). [8] A unit test could be used to test the stationary of time series data. In this thesis, Augmented Dickey Fuller (ADF) test would be applied, with the null hypothesis that a unit root is present or non-stationary.

As shown in Table 3 Panel A, only variable R_0 in both counties are non-stationary. Therefore, the first difference of R_0 is taken, represented by ΔUS_R_0 and ΔCN_R_0. ADF test has been used again for these two modified variables. Table 3 Panel B shows that both modified variables are significant at the 1 percent level, which indicates that they meet the stationary requirement. R_0 would be replaced by ΔR_0 to be used in the following sections.

3.3.3. VAR Model

The Vector Autoregression (VAR) model was first proposed by Christopher Sims in 1980. As Stock and Watson (2001) stated, "A VAR is an n-equation, variable linear model in which each variable is in turn explained by its own lagged values, plus current and past values of the remaining n-1 variables. This simple framework provides a systematic way to capture rich dynamics in multiple time series, and the statistical toolkit that came with VARs was easy to use and interpret" (Stock & Watson, 2001). The definition of VAR with p

[8] See Lütkepohl (2005), pp. 13-18.

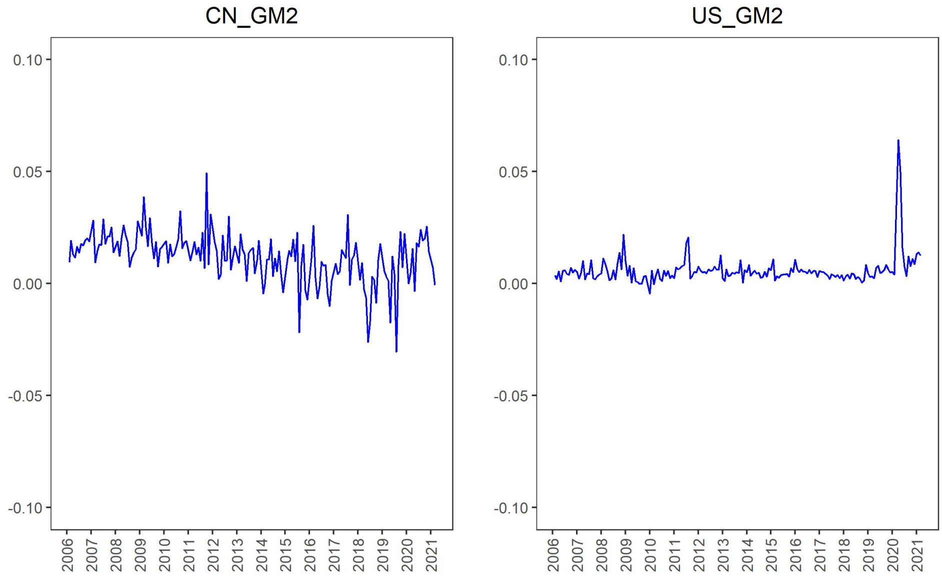

Figure 9: The Time Series Line Plots of CN_GM2 and US_GM2

Source: Refinitiv (Refinitiv, 2021)

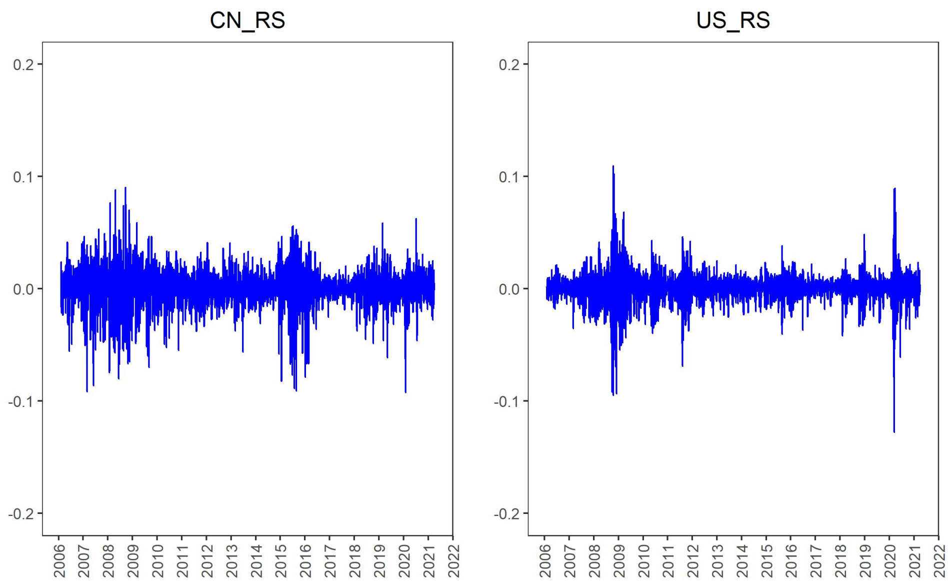

Figure 10: The Time Series Line Plots of Daily CN_R_S and US_R_S

Source: Refinitiv (Refinitiv, 2021)

lags can be represented in Formula 3, where v is a fixed (K x 1) vector of intercept terms, A_i is (K x K) coefficient matrices, y_t is (K x 1) dimensional random vectors, and u_t is K-dimensional white noise (Lütkepohl, 2005).[9]

$$y_t = v + A_1 y_{t-1} + ... + A_p y_{t-p} + u_t,\ t = 1, 2, ..., T \quad (3)$$

Choice of lags is crucial in terms of VAR model construction. A very often used criterion in selecting lags is the Akaike Information Criterion (AIC), which is based on approximate 1-step ahead forecast mean squared error (Lütkepohl, 2005).[10] The optimized lags according to AIC for the US and China are 3 and 2 respectively.

[9]See Lütkepohl (2005), pp. 13-18.; p represents the lags; T represents the total sample size; K represents the total variable amount

[10]See Lütkepohl (2005), p. 146.

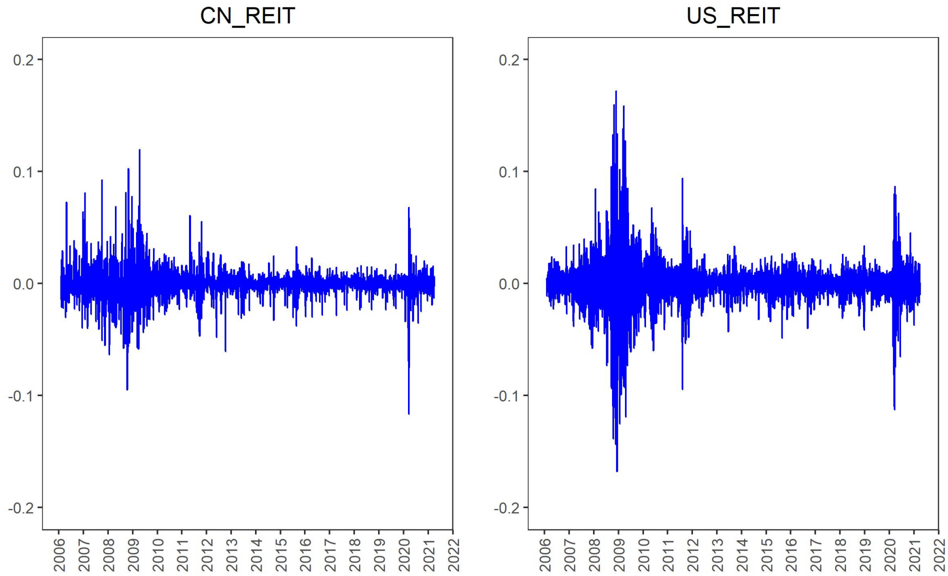

Figure 11: The Time Series Line Plots of Daily CN_R_T and US_R_T

Source: Refinitiv (Refinitiv, 2021)

The results are shown in the following Table 4 and 5. As the model involves too many variables, only the variables with statistically significant relationships would be analyzed in this thesis. The results of both VAR models are summarized as follows:

1) For REIT returns based on US model, US_R_T(-3), US_R_S(-1), US_R_S(-3), ΔUS_R_0(-3) and US_GIND (-2) are significant. Among these, the impacts of US_R_T(-3), US_R_S(-1) and US_R_S(-3) have stronger evidences. However, in the model of China, only CN_R_S(-2) is significant at the 5 percent level, which means only the stock market fluctuation of two months earlier can positively affect REIT. Other factors do not help to explain the changes in REIT return.
2) Looking at the fluctuation of 10-year government bonds yields, the US_R_T(-3), US_GIND(-1), US_GCPI (-1), US_R_S(-1) and US_R_S(-3) are significant. In the context of China, only CN_R_T(-1) and CN_R_T(-2) are significant at the 1 percent level. This indicates that ΔR_0 is significantly affected by factor of the the stock market, REIT market, industrial production and CPI in the US, but only observe the significant effect of REIT market in China.
3) In the analysis of MoM change in industrial production, US_R_T(-1), US_R_T(-3), ΔUS_R_0(-2), US_GIND (-1), US_GIND(-2), US_GIND(-3), US_GM2(-1) and US_GM2(-2) are significant. This indicates industrial production is significant correlated with $M2$ money supply, 10-year government bonds, REIT market and especially limited by its own growth level in the early period.
4) For the MoM change in CPI, US_R_T(-3), US_GM2 (-2) and US_GCPI(-2) are significant at 10 percent level, US_R_S(-1) is significant at 5 percent level and only US_GCPI(-1) is significant at 1 percent level. The results of the US are consistent with the results of China, which shows the significance of CN_GM2(-1), CN_GM2(-2), CN_GCPI(-1) and CN_R_S(-2).
5) For the the MoM change in $M2$, US_R_T(-1), US_GIND (-1), US_GM2(-1) and US_GCPI(-3) are significant. However, in the context of China, only US_GM2(-1) and US_GM2(-2) have significant observations.
6) Looking at the fluctuation of S&P 1500 composite index returns, only US_R_T(-3) is significant at the 5 percent level. Similarly, for the fluctuation of SSE composite index returns, only two variables are significant. They are CN_R_S(-1) and CN_R_T(-2), which are statistically significant at the 5 percent level.

The formulas of both models are shown in Formula 5 and 4.

$$\begin{aligned} CN\_R_T = {} & 0.051 * CN\_R_T(-1) + 0.044 * \\ & CN\_R_T(-2) - 0.725 * \Delta CN\_R_0(-1) \\ & - 3.240 * \Delta CN\_R_0(-2) - 1.222 * \\ & CN\_GCPI(-1) + 0.265 * CN\_GCPI(-2) \\ & + 0.534 * CN\_GM2(-1) - 0.040 * \\ & CN\_GM2(-2) + 0.064 * CN\_R_S(-1) \\ & + 0.151 * CN\_R_S(-2) - 0.006 \end{aligned} \quad (4)$$

Table 3: The Results of ADF Test of Time Series Variables

*Note: ***Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.*

Panel A: ADF Test Results of 11 Initial Variables

Variables	ADF Value	P Value	Result
US_R_0	-2.711	0.279	Non-Stationary
US_GIND	-8.044	0.010***	Stationary
US_GCPI	-7.723	0.010***	Stationary
US_GM2	-6.308	0.010***	Stationary
US_R_S	-7.247	0.010***	Stationary
US_R_T	-6.842	0.010***	Stationary
CN_R_0	-3.403	0.056*	Non-Stationary
CN_GCPI	-8.428	0.010***	Stationary
CN_GM2	-6.394	0.010***	Stationary
CN_R_S	-6.705	0.010***	Stationary
CN_R_T	-7.284	0.010***	Stationary

Panel B: ADF Test Results of ΔUS_R_0 and ΔCN_R_0

Variables	ADF Value	P Value	Result
ΔUS_R_0	-7.124	0.010***	Stationary
ΔCN_R_0	-6.909	0.010***	Stationary

$$\begin{aligned} US\_R_T = & -0.105*US\_R_T(-1)-0.141*US\_R_T(-2) \\ & +0.305*US\_R_T(-3)-2.346*\Delta US\_R_0(-1) \\ & +3.395*\Delta US\_R_0(-2)+4.425*\Delta US\_R_0(-3) \\ & +0.582*US\_GIND(-1)+1.023US\_GIND(-2) \\ & -0.819*US\_GIND(-3)-1.280*US\_GCPI(-1) \\ & +1.522*US\_GCPI(-2)+0.476*US\_GCPI(-3) \\ & +0.391*US\_GM2(-1)+1.509*US\_GM2(-2) \\ & -1.670*US\_GM2(-3)+0.499*US\_R_S(-1) \\ & +0.001*US\_R_S(-2)-0.422*US\_R_S(-3) \\ & -0.001 \end{aligned} \tag{5}$$

3.3.4. Granger Causality Test

The Granger causality test, first proposed by Clive Granger in 1969, is a hypothesis test for determining whether one time series is useful in forecasting another. According to Lütkepohl (2005), the Granger Causality test is an essential part of structured analysis with the VAR model. "The idea is that a cause cannot come after the effect. Thus, if a variable x affects a variable z, the former should help to improve the predictions of the latter variable" (Lütkepohl, 2005). [11] The Null hypothesis of Granger causality test is that X does not Granger Cause (GC) Y.

The results of the Granger causality test can be seen in Table 6 Panel A and B.

1) For the results of the US model, ΔUS_R_0 and US_R_S are the significant Granger causality of US_R_T at 10 percent level. Meanwhile, ΔUS_R_0 and US_R_T are Granger causality of each other, same as US_R_T and US_R_S.
2) Similarly, the results of the China model shows the CN_R_T and CN_R_S are Granger causality of each other at 10 percent level. Other than that, there is no other significant Granger causality for CN_R_T.

3.3.5. Impulse Response Analysis

Impulse response analysis is an important tool to interpret the results of the VAR model. This analysis helps to quantify the response of one variable to the dynamic impulse in another variable. This tool investigates the inter-ration and causality of the model, and also provides information about the positive and negative directions of the response to exogenous shocks (Lütkepohl, 2005). [12]

Figure 12 and 13 show the responses of R_T to six variables based on US and China VAR models. The horizontal axis represents the number of retrospective periods in the impulse response, which is defined as 10 months. The vertical axis represents the response size of the dependent variable to the independent variable. It is noteworthy that the solid blue line refers to the actual value, and the red dot line represents the value at the 95% confidence interval. There are six findings as follows.

1) R_T is greatly influenced by itself. The evidence of the US model shows that when a positive impact is given

[11] See Lütkepohl (2005), pp. 41-51.

[12] See Lütkepohl (2005), pp. 51-63.

Table 4: The Results of VAR model Based on China Data

*Note: ***Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level. [] is t-value.*

	CN_R_T	ΔCN_R_0	CN_GCPI	CN_GM2	CN_R_S
CN_R_T(-1)	0.051	0.006***	0.003	-0.006	-0.142
	[0.593]	[2.698]	[0.521]	[-0.427]	[-1.461]
CN_R_T(-2)	0.044	0.007***	0.005	-0.013	0.230**
	[0.497]	[2.703]	[0.813]	[-0.928]	[2.308]
ΔCN_R_0(-1)	-0.725	0.094	0.127	0.425	-0.502
	[-0.279]	[1.256]	[0.668]	[1.034]	[-0.171]
ΔCN_R_0(-2)	-3.240	0.049	0.210	0.187	-1.342
	[-1.293]	[0.686]	[1.140]	[0.472]	[-0.475]
CN_GCPI(-1)	-1.222	-0.019	0.277***	-0.025	-0.471
	[-1.216]	[-0.639]	[3.759]	[-0.157]	[-0.416]
CN_GCPI(-2)	0.265	-0.023	-0.098	0.082	0.071
	[0.272]	[-0.817]	[-1.367]	[0.533]	[0.064]
CN_GM2(-1)	0.534	-0.008	0.113***	0.244***	0.740
	[1.086]	[-0.612]	[3.140]	[3.130]	[1.333]
CN_GM2(-2)	-0.040	0.007	-0.113***	0.207***	-0.614
	[-0.080]	[0.496]	[-3.078]	[2.624]	[-1.090]
CN_R_S(-1)	0.064	0.002	-0.008	-0.004	0.174**
	[0.856]	[1.129]	[-1.367]	[-0.357]	[2.064]
CN_R_S(-2)	0.151**	0.001	0.013**	0.001	0.045
	[2.009]	[0.356]	[2.365]	[0.078]	[0.527]
Constant	-0.006	1.450e-04	0.002***	0.007***	0.003
	[-0.672]	[0.546]	[2.582]	[4.498]	[0.321]

to US_R_T, the corresponding US_R_T will have at least eight phases of impact, of which the first phase is positive and the impact is more significant. The subsequent phase is negative and gradually followed by another two phases of positive impact. Afterwards, there are some minor fluctuations around 0. Similar evidence is shown in the China model, but with a short period of impact, which has only four phases of impact and afterwards, the influence gradually weakened to 0.

2) R_S also shows a great impact on R_T in both models. When R_S is given a positive shock, R_T would initially have a positive response, indicating that a booming stock market would benefit the REIT market. The US_R_S has a stronger impact than CN_R_S with the evidence that US_R_S has at least eight phases of impact, whereas CN_R_S shows three stages of effects.
3) The impact of CN_GM2 is relatively significant. When CN_GM2 is given a positive shock, CN_R_T would have a positive response, and such impact would last for four phases with a decreasing trend. However, when US_GM2 is given a positive shock, US_R_T would have an initial small negative response, followed by two stages of positive response and one phase of negative response.
4) US_GIND has lagged and lasting impact on US_R_T. The initial negative response is relatively small but becomes most vital in the fourth phase. Afterwards, the fluctuation hovers around 0 and ends until the eighth phase.
5) ΔR_0 also has lagged impact in both models. It can be seen that when a positive impact is given to ΔUS_R_0, it would cause an initial small negative impact response and gradually reach maximum positive repose at the fourth phase. The impact of ΔCN_R_0 is also very small initially and reaches a maximum negative response at the third phase. Afterwards, it comes to 0.
6) The impact of variable $GCPI$ is the weakest. In both models, the magnitude of the response is no more than 1%, which indicates that the impact on the REIT index is the smallest.

To sum up, both models produces consistent results. The R_T and R_S have the strongest impact. CN_GM2, US_GIND and US_R_0 are relatively significant. The impact of remaining variables can be ignored.

3.3.6. Variance Decomposition Analysis

The variance decomposition is an additional tool used for VAR model interpretation to simplify structures. In general, it indicates the amount of forecast error variance of the dependent variable that can be explained by shocks of other variables (Lütkepohl, 2005). [13]

[13] See Lütkepohl (2005), pp. 63-66.

Table 5: The Results of VAR Model Based on US Data

*Note: ***Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level. [] is t-value.*

	US_R_T	Δ US_R_0	US_GIND	US_GCPI	US_GM2	US_R_S
US_R_T(-1)	-0.105	0.003	0.048**	0.002	-0.015*	0.033
	[-0.859]	[0.745]	[2.598]	[0.524]	[-1.747]	[0.397]
US_R_T(-2)	-0.141	-0.004	-0.011	0.003	-0.005	-0.012
	[-1.143]	[-0.951]	[-0.615]	[0.629]	[-0.549]	[-0.143]
US_R_T(-3)	0.305**	-0.012***	0.030*	-0.008*	0.016	0.018**
	[2.579]	[-2.966]	[0.092]	[-1.665]	[1.150]	[2.266]
ΔUS_R_0(-1)	-2.346	-0.072	0.571	0.034	-0.288	-0.432
	[-0.932]	[-0.809]	[1.497]	[0.328]	[-1.601]	[-0.250]
ΔUS_R_0(-2)	3.395	0.003	0.702*	0.092	-0.103	2.698
	[1.339]	[0.034]	[1.828]	[0.887]	[-0.568]	[1.553]
ΔUS_R_0(-3)	4.425*	0.005	0.593	-0.023	-0.195	1.596
	[1.777]	[0.054]	[1.573]	[-0.222]	[-1.097]	[0.936]
US_GIND(-1)	0.582	-0.046**	0.206**	-0.004	-0.172***	-0.076
	[0.943]	[-2.105]	[2.205]	[-0.149]	[-3.901]	[0.181]
US_GIND(-2)	1.023*	0.014	-0.260***	0.016	0.063	0.509
	[1.743]	[0.692]	[-2.938]	[0.676]	[1.498]	[1.266]
US_GIND(-3)	-0.819	0.029	0.170**	0.014	0.097	-0.023
	[-1.518]	[1.512]	[2.088]	[0.681]	[1.123]	[-0.627]
US_GCPI(-1)	-1.280	0.179**	-0.054	0.479***	-0.034	0.258
	[-0.638]	[2.523]	[-0.178]	[5.867]	[-0.234]	[0.187]
US_GCPI(-2)	1.522	-0.115	-0.353	-0.149*	[-0.181]	-0.079
	[0.699]	[-1.495]	[-1.071]	[-1.677]	[-1.159]	[-0.053]
US_GCPI(-3)	0.476	-0.026	0.276	-0.095	0.437***	-0.489
	[0.246]	[-0.376]	[0.942]	[-1.211]	[3.154]	[-0.369]
US_GM2(-1)	0.391	-0.061	-0.390**	-0.031	0.544***	0.725
	[0.300]	[-1.315]	[-1.977]	[-0.601]	[5.828]	[0.812]
US_GM2(-2)	1.509	0.071	0.919***	0.096*	-0.065	0.977
	[1.071]	[1.415]	[4.312]	[1.667]	[-0.645]	[1.013]
US_GM2(-3)	-1.670	-0.013	[-0.046]	-0.017	0.097	-0.324
	[-1.386]	[-0.316]	[-0.251]	[-0.346]	[1.123]	[-0.392]
US_R_S(-1)	0.499***	0.012*	0.020	0.018**	-0.009	0.100
	[2.611]	[1.772]	[0.687]	[2.377]	[-0.674]	[0.764]
US_R_S(-2)	0.001	0.010	0.022	-0.002	0.006	-0.106
	[0.004]	[1.418]	[0.717]	[0.629]	[0.441]	[-0.779]
US_R_S(-3)	-0.422**	0.015**	0.004	-0.008	0.016	-0.171
	[-2.127]	[2.236]	[0.120]	[-1.665]	[1.150]	[-1.257]
Constant	-0.001	-4.843e-05	-0.002	0.001*	0.002***	8.588e-05
	[-0.069]	[-1.393]	[-1.194]	[1.791]	[3.104]	[0.013]

The results of variance decomposition can be seen in Table 7 and 8.

1) In both models, R_T is affected most by itself but shows a decreasing trend. The CN_R_T has higher explanatory power than US_R_T for its own forecast error variance. In the last period, the value is standing at around 38.4% and 71.3% respectively.
2) R_S also has very strong explanatory power that is consistent with the results of impulse response analysis in the previous section. However, US_R_S explains around half the variance of the US model, which is higher than the portion explained by CN_R_S.
3) As R_T together with R_S can explain the variance at least 85.8% and 91.7% of US_R_T and CN_R_T respectively. The remaining macroeconomic variables can be ignored.

3.4. Chapter Summary

This chapter first introduces the choice of data and then uses the VAR methodology to conduct an econometric analysis of the macroeconomic risk of REIT. On the basis of the stationary test, the data was processed, and then the VAR model

Table 6: The Results of Granger Causality Test

*Note: ***Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.*

Panel A: The Results of Granger Causality Test Based on US Data			
Null Hypothesis	Sample Size	F Value	P Value
US_R_T does not GC ΔUS_R_0	174	8.095	4.501e-05***
ΔUS_R_0 does not GC US_R_T	174	2.195	0.091*
US_R_T does not GC US_GIND	175	11.428	7.169e-07***
US_GIND does not GC US_R_T	175	1.628	0.185
US_R_T does not GC US_GCPI	175	6.500	3.426e-04***
US_GCPI does not GC US_R_T	175	0.625	0.600
US_R_T does not GC US_GM2	175	6.048	6.136e-04***
US_GM2 does not GC US_R_T	175	0.610	0.610
US_R_T does not GC US_R_S	175	2.211	0.089*
US_R_S does not GC US_R_T	175	2.201	0.090*
Panel B: The Results of Granger Causality Test Based on China Data			
Null Hypothesis	Sample Size	F Value	P Value
CN_R_T does not GC ΔCN_R_0	176	12.889	6.028e-06***
ΔCN_R_0 does not GC CN_R_T	176	0.835	0.436
CN_R_T does not GC CN_GCPI	177	2.000	0.138
CN_GCPI does not GC CN_R_T	177	0.928	0.397
CN_R_T does not GC CN_GM2	177	0.430	0.651
CN_GM2 does not GC CN_R_T	177	0.472	0.624
CN_R_T does not GC CN_R_S	177	2.780	0.064*
CN_R_S does not GC CN_R_T	177	2.556	0.081*

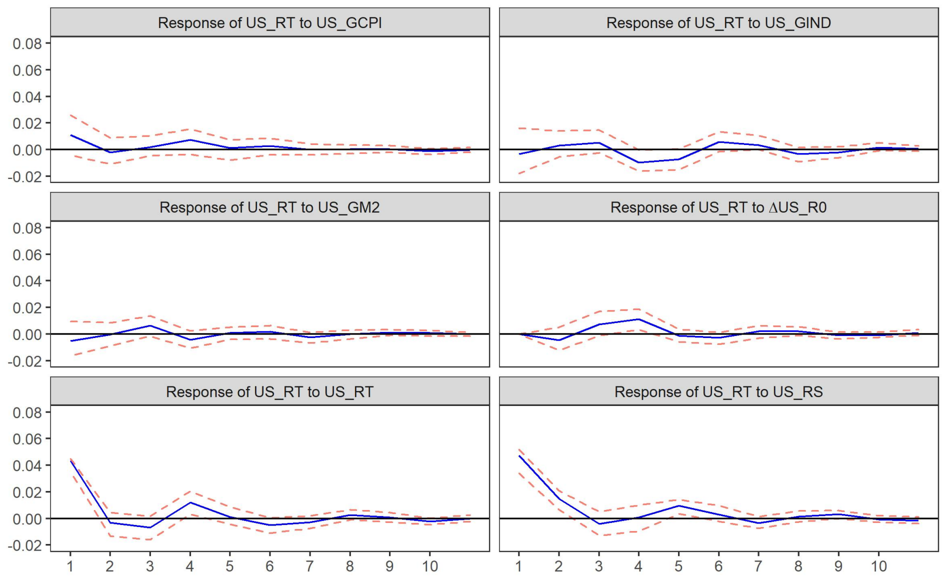

Figure 12: The Impulse Response Plots of US_R_T as Response

was constructed. To perform a structured VAR analysis, the Granger causality test was further carried out together with impulse response analysis and variance decomposition analysis.

The results of VAR based on US and China data lead to a consistent conclusion. In both models, the R_T and R_S are the most significant factors. This result is the same as the finding of Fang et al. (2016), who found the stock market has a significantly positive relationship with the REIT index based on evidence from Japan, Singapore, and China (Fang

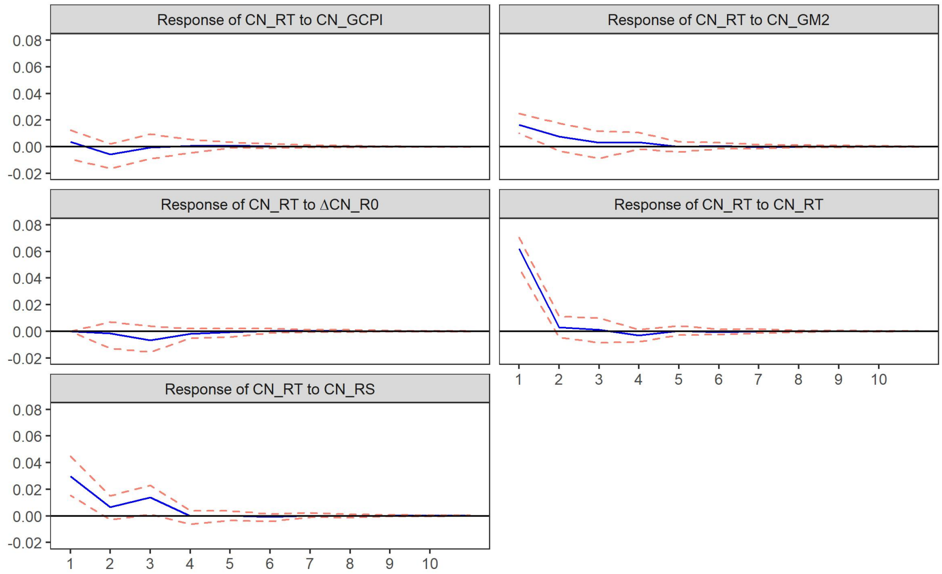

Figure 13: The Impulse Response Plots of CN_R_T as Response

Table 7: The Results of Variance Decomposition Analysis of US_R_T

Period	US_R_T	ΔUS_R_0	US_GIND	US_GCPI	US_GM2	US_R_S
1	0.436855	0.000000	0.002539	0.028611	0.006279	0.525713
2	0.413491	0.004638	0.004268	0.027903	0.005925	0.543773
3	0.406787	0.015966	0.009754	0.027541	0.014254	0.525696
4	0.399909	0.039144	0.027473	0.035942	0.016662	0.480866
5	0.389063	0.038329	0.036564	0.035278	0.016360	0.484404
6	0.387470	0.039154	0.042113	0.036037	0.016659	0.478564
7	0.385865	0.039743	0.044042	0.035752	0.017614	0.476980
8	0.385337	0.040432	0.046025	0.035593	0.017533	0.475078
9	0.384242	0.040441	0.046752	0.035502	0.017725	0.475335
10	0.384408	0.040492	0.047067	0.035698	0.017795	0.474538

Table 8: The Results of Variance Decomposition Analysis of CN_R_T

Period	CN_R_T	ΔCN_R_0	CN_GCPI	CN_GM2	CN_R_S
1	0.768411	0.000000	0.002509	0.053896	0.175183
2	0.748497	0.000422	0.008899	0.063823	0.178357
3	0.714481	0.008772	0.008549	0.062661	0.205536
4	0.712900	0.009304	0.008567	0.064630	0.204596
5	0.712670	0.009420	0.008756	0.064609	0.204542
6	0.712517	0.009435	0.008790	0.064651	0.204605
7	0.712509	0.009439	0.008792	0.064653	0.204604
8	0.712504	0.009444	0.008792	0.064654	0.204603
9	0.712503	0.009445	0.008793	0.064654	0.204603
10	0.712503	0.009445	0.008793	0.064654	0.204603

et al., 2016). This result can be explained by the research of Hoesli and Reka (2015). They found there is a demonstrated risk of contagion between REIT and stock in the US and their further study pointed out that such phenomenon is driven by behavioral and liquidity mechanisms, such as investor sentiment (Hoesli & Reka, 2015).

The second interesting finding is regarding the different explanatory power of R_S in the variance decomposition analysis. In the US model, US_R_S consists of 47.4%. In comparison, CN_R_S only consists of 20.4% in the China model. This is probably due to the different structure of the emerging market and developed market. Another possible explanation would be the proxies of REIT market. The underlying index of US_R_T is the MSCI US REIT index, and on the other hand, the CN_R_T is based on a self-constructed index. The MSCI US REIT has 136 constituents, whereas the latter only has 9. Therefore, it can be suggested that the self-constructed index might not be fully representative of the entire China REIT market.

Combining with the results of all analyses, the effects of other macroeconomic risk factors are relatively minor. Therefore, it is noteworthy to conclude that REITs are a good hedge against some macroeconomic variables, including the fluctuation of 10-year government bonds yields, industrial production, CPI, and $M2$ money supply.

4. Evaluate the Downside Risk of REITs

This chapter first introduces the concept of VaR and its combination with the GARCH model. Afterwards, the choice of data would be specified, and the characteristics of the data set would be mentioned. The ARCH effect is tested before the creation of the GARCH(1,1)-VaR model. The VaR at 95% and 99% would be evaluated, and the Kupiec test would be applied to test credibility.

4.1. Model Overview

Value at Risk (VaR) is defined as the maximum loss over a targeted horizon for a given level of confidence. It is used to estimate the tails of the empirical distribution of financial losses. The formula of VaR is shown in 6. Examining the variables, $Prob$ represents the probability of actual loss in a given period is greater than VaR at α significance level. The final VaR can be calculated using the conditional volatility of returns (σ) multiplied by the percentile of a given probability distribution at 1-α level (a) (Cerović Smolović et al., 2017).

$$\begin{aligned} Prob(\Delta P > VaR) = \alpha \\ VaR = \sigma a \end{aligned} \tag{6}$$

The aim here is to estimate VaR using an econometric approach, which is combined with the Generalised Autoregressive Conditional Heteroskedasticity (GARCH) model. This is because there are particular assumptions under the VaR model, such as normal distribution, which the financial time series data cannot fulfill in normal circumstances. Miletic and Miletic (2015) stated that "The GARCH-type model successfully captures several characteristics of the financial time series, such as thick-tailed returns and volatility clustering" (Miletic & Miletic, 2015). "In the classical GARCH models, the conditional variance is expressed as a linear function of the squared past values of the series." Tim Bollerslev proposed GARCH(p,q) in 1986, and the model can be specified as Formula 7 (Francq & Zakoian, 2019). [14] Only lower-order GARCH models are used in the most applications. Therefore, the classical GARCH(1,1) would be applied in this thesis — the formula is shown in 8 (Francq & Zakoian, 2019). [15] After getting the σ of the different periods based on the GARCH(1,1) model, the corresponding VaR can then be calculated using Formula 6.

$$\begin{aligned} \epsilon_t = \sigma_t \eta_t,\ (\eta_t)\ i.i.d\ whitenoise(0,1) \\ {\sigma_t}^2 = w + \sum_{i=1}^{q} \alpha_i {\epsilon^2}_{t-i} + \sum_{j=1}^{p} \beta_j {\sigma^2}_{t-j}, t \in Z \\ w > 0, \alpha_i >= 0, \beta_j >= 0, i = 1, ..., q, j = 1, ..., p \end{aligned} \tag{7}$$

$${\sigma_t}^2 = w + \alpha {\epsilon^2}_{t-1} + \beta {\sigma^2}_{t-1} \tag{8}$$

4.2. Descriptive Analysis

The data referenced in this chapter is the daily R_T, and specific methodologies of data preparation have been described in Section 3.2. The selected time span of data is from 1st February 2006 to 31st March 2021. The total sample size of the US and China are 3819 and 3725 respectively. To maintain data integrity and continuity of the model, the first thirteen years' data (from 1st February 2006 to 31st December 2018) are used to train the model. The remaining data would be used for model validation.

The main characteristics of US_R_T and CN_R_T have been measured. Meanwhile, the Jarque-Bera test has been applied for testing if sample data have the skewness and kurtosis matching normal distribution. The null hypothesis is that the data has a normal distribution. The histogram is also constructed to provide further evidence.

Table 9 indicates that the daily logarithm returns of both REIT markets are not normally distributed due to the fact that the skewness deviates from 0, and kurtosis is much higher than 3. These results are also supported by the Jarque-Bera tests, which are significant at the 1 percent level. The results confirm the presence of fat tails and are leptokurtic, which indicates that the R_T is not normally distributed and cannot apply methodologies with normal distribution assumption. These findings are consistent with histogram plots in Figure 14.

4.3. Test of ARCH Effect

The Autoregressive Conditional Heteroskedasticity (ARCH) effect refers to the relationship within the heteroskedasticity, often termed serial correlation of the heteroskedasticity. There are two available tests which are the Ljung–Box test and the the Lagrange multiplier test based on squared residuals of the mean. The null hypothesis of the Ljung–Box test is that there are no autocorrelations. In 1982, Engel suggested

[14] See Francq and Zakoian (2019) section 2.1.
[15] See Francq and Zakoian (2019) section 2.2.1.

Table 9: Descriptive Analysis of Daily US_R_T and CN_R_T

*Note: ***Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.*

Variable	Size	Max	Min	Mean	Jarque-Bera	Std. Dev.	Skewness	kurtosis
US_R_T	3252	0.172	-0.220	4.969e-05	35681***	0.021	-0.192	16.211
CN_R_T	3169	0.120	-0.094	-5.241e-05	16243***	0.013	0.432	11.048

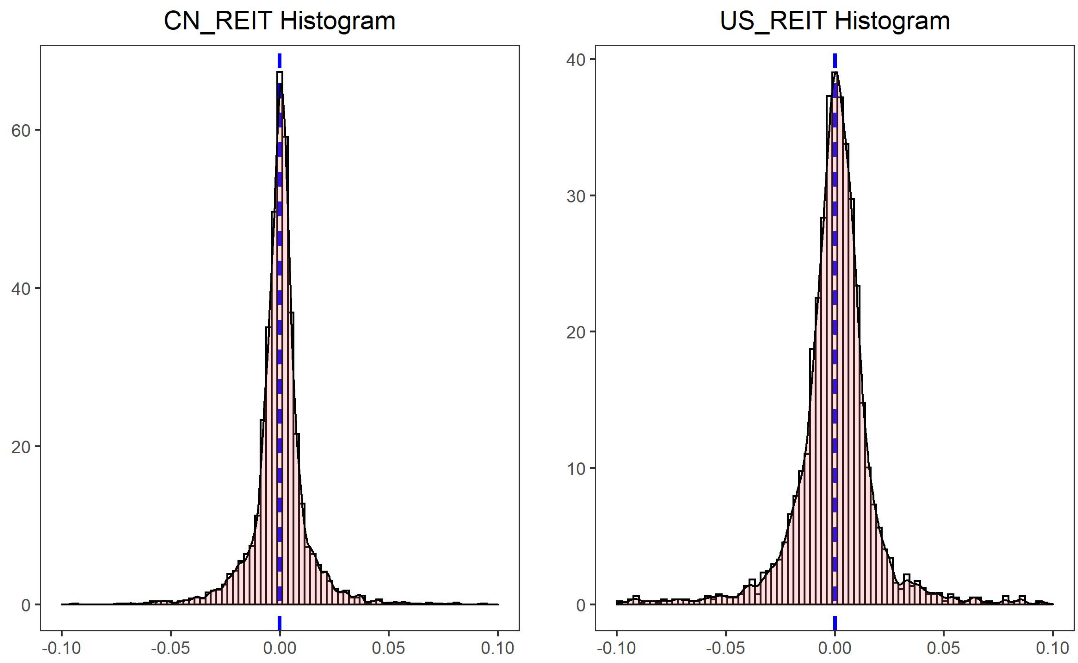

Figure 14: The Histogram Plots of US_R_T and CN_R_T

using Lagrange multiplier test to detect the ARCH effect and its null hypothesis is that there is no existing ARCH effect up to lag order q in the residuals (Tsay, 2005).[16]

The results of Table 10 indicate that the null hypothesis of both tests should be rejected. This suggests the evidence of autocorrelation and time varying volatility. This means that there are some patterns in the dataset that can be determined by other factors. In other words, the GARCH model would be appropriate to evaluate the σ and then VaR of US_R_T and CN_R_T.

4.4. GARCH(1,1)-VaR Model

As discussed earlier, the GARCH(1,1) model would be used. Evidence from previous research suggests that GARCH models based on the standardized residuals with t distribution can better capture the characteristics of financial data (Miletic & Miletic, 2015; Cerović Smolović et al., 2017).

Table 11 indicates the parameter estimates of the GARCH-(1,1) model. The AIC indicates that both models are good fits for the data. Additionally, The residuals obtained from the GARCH model show no evidence for the ARCH effect by Ljung–Box and Lagrange multiplier tests. Therefore, the models for US_R_T and CN_R_T do have appropriate statistical characteristics. The formula of GARCH(1,1) models of US_R_T and CN_R_T is shown in 9. Applying the predicted volatility and percentile of t distribution into formula 6, the VaR at a certain confidence level can be obtained.

$$\begin{aligned} US\_R_T:\ \sigma_t{}^2 &= 0.100e-05 + 0.101 * \epsilon^2{}_{t-1} + 0.896 * \sigma^2{}_{t-1} \\ CN\_R_T:\ \sigma_t{}^2 &= 0.100e-05 + 0.110 * \epsilon^2{}_{t-1} + 0.888 * \sigma^2{}_{t-1} \end{aligned} \quad (9)$$

Figure 16 and 15 shows the comparison between actual daily returns of REIT index and VaR. The blue line represents the actual R_T. The red and green lines are the expected maximum loss at 95% and 99% confidence levels respectively. Instinctively, in both models, there are only a few extreme cases in which the single-day loss of the REIT index exceeds the VaR value under the 95% confidence level. There is almost no single-day loss that exceeds the 99% VaR value. Therefore, it is reasonable to draw a preliminary conclusion that

[16]See Tsay (2005) section 3.3.1.

Table 10: The Results of Ljung–Box and Lagrange Multiplier Tests for US_R_T and CN_R_T

*Note: ***Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.*

Variable	LB[1]	LB[10]	LB[30]	LM[1]	LM[10]	LM[30]
US_R_T	131.590***	160.910***	314.530***	406.910***	1085.900***	1272.200***
CN_R_T	22.933***	73.508***	109.240***	98.637***	398.900***	568.810***

Table 11: Parameter Estimates of the GARCH(1,1) Model With t Distribution of the Standardized Residuals for US_R_T and CN_R_T

*Note: ***Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.*

Model	w	α	β	AIC	LB[1]	LM[7]
GARCH(1,1)-US_R_T	0.100e-05	0.101	0.896	-5.914	1.170	3.330
GARCH(1,1)-CN_R_T	0.100e-05	0.110	0.888	-6.642	1.960	3.552

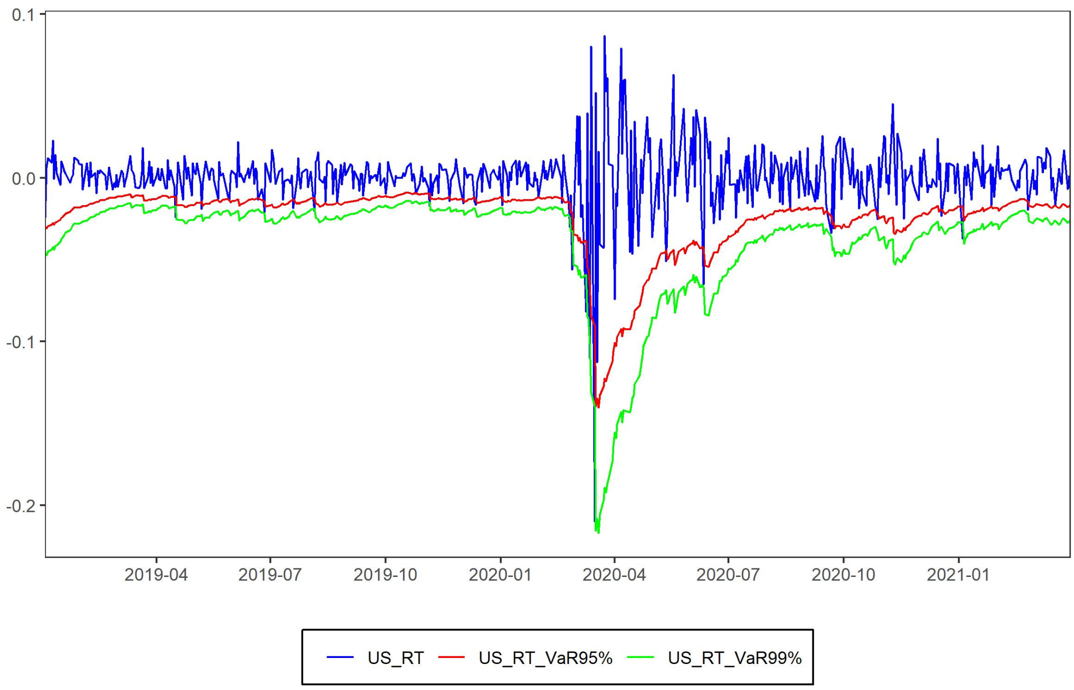

Figure 15: The Time Series Line Plot of Actual US_R_T, VaR95% and VaR99%

GARCH(1,1)-VaR model is quite effective in predicting the downside risk of R_T in both markets.

4.5. Backtesting

Backtesting refers to the statistical procedure used to estimate the reliability and accuracy of the VaR model. The main idea is to statistically examine if the frequency of exceptions is consistent with the chosen confidence level (Miletic & Miletic, 2015).

Kupiec test is most often used for backtesting. The Kupiec test has a chi-square distribution with one degree of freedom. The formula is shown in 10. It denotes the total sample size as T, and the number of exceptions as N. Thus, the failure ratio can be gotten by $\frac{N}{T}$. The null hypothesis is that the number of exemptions follows the binomial distribution, which means that the model is credible (Cerović Smolović et al., 2017).

$$LR = 2\ln[(1-\frac{N}{T})^{\mathrm{T-N}}\frac{N}{T}^{\mathrm{N}}] - 2\ln[(1-P)^{\mathrm{T-N}}P^{\mathrm{N}}] \quad (10)$$

Table 12 supports that VaR at 95% level has high reliability and accuracy for both US_R_T and CN_R_T. However, the test results of VaR at 99% level in both models reject the null hypothesis of Kupiec. This is because the Kupiec test would reject the null hypothesis for both higher and lower frequency of failures than the range at a certain significance

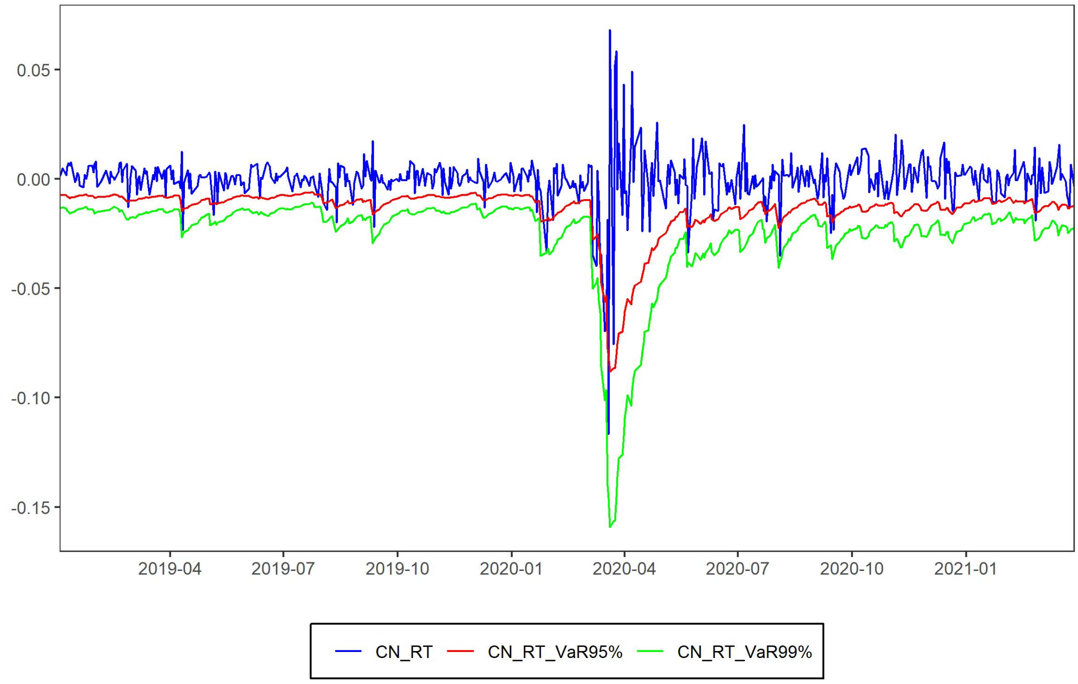

Figure 16: The Time Series Line Plot of Actual CN_R_T, VaR95% and VaR99%

Table 12: The Results of Kupiec Test

*Note: ***Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.*

Variable	Exceptions	Test statistics	P-Value
VAR95% of US_R_T	33	0.764	0.382
VAR99% of US_R_T	0	11.397	0.001***
VAR95% of CN_R_T	28	0.005	0.946
VAR99% of CN_R_T	1	5.677	0.017**

level. The number of exceptions for VaR at 99% has fewer exceptions than expected. It indicates that the predicted VaR at 99% is slightly higher than the actual, especially for the US REIT market.

4.6. Chapter Summary

There are a number of interesting findings from the training data set (from 1st February 2006 to 31st December 2018) and the GARCH(1,1)-VaR model.

From 2006 to 2018, the evidence of relatively low standard deviation indicates that the volatility of the US_R_T and CN_R_T were stable. In other words, the VaR concept can be used to predict the downside risk of REIT effectively.

The US_R_T and CN_R_T data from 2006 to 2018 have the features of fat tails and are leptokurtic, which are not matched with characteristics of normal distribution. Therefore, an econometric approach should be used to evaluate the VaR accurately.

The GARCH(1,1)-VaR is quite suitable for assessing the VaR at 95% level based on the evidence of non-significant Kupiec test results. However, it might be somewhat conservative in terms of estimating the maximum loss at the 99% level. It would be meaningful to perform further research on other econometric approaches of VaR measurement.

5. Conclusion and Outlook

This chapter provides a summary to answer the four research questions mentioned in Section 1.1. Afterwards, an outlook is provided regarding future potential research topics.

5.1. Conclusion

Research questions can be divided into three parts. To begin, the first two questions have been answered using the literature review methodology. The VAR model is constructed to evaluate the relation between the REIT market and macroeconomic factors. Ultimately, downside risk of REIT market is assessed by the GARCH(1,1)-VaR model based on the student's t-distribution.

1) REIT first originated in the US market in 1960, and its success can be attributed to four factors. One, tax benefits have played an essential role in the development of the REIT market. Next, favorable government legislation had also supported the growth of the REIT sector. Additionally, consolidation in the real estate sector helped to keep the sector healthy and growing in the long run. Lastly, REIT specialization helped managers develop specific expertise, which proved to be useful in value generation to promote growth (Parker, 2019).
2) REITs are relatively new in China. In May 2021, China officially launched a REITs pilot program, which focused on the infrastructure REITs. The motivation of the Chinese government was to relieve the debt burden and, at the same time, optimize resources to support economic growth. The issuance of the pilot infrastructure REITs was expected to uncover new opportunities. However, the feasibility of REIT is still questionable due to the transparency problems of traditional infrastructure projects and the complex REIT structure in China.
3) The VAR models using the US and Chinese data led to a consistent conclusion. The stock market is highly correlated with the REIT market. Such a relationship might be explained by investor sentiment and market liquidity (Hoesli & Reka, 2015). It is also noteworthy that the US stock market is found to have a more substantial impact on the REIT market. This could be explained by market maturity differences between the US and China and the possible flaws of the self-constructed China REIT index. The third finding is that REITs are a good hedge against some macroeconomic variables, including the fluctuation of 10-year government bonds yields, industrial production, CPI, and $M2$ money supply.
4) The logarithm returns of the REIT index between the year 2006 and 2018 in both countries have features of fat tails and are leptokurtic. As a result, an econometric approach is necessary to evaluate the accurate VaR. The results of the Kupiec test show that GARCH(1,1)-VaR assuming a t distribution is an excellent measure of the downside risk at the 95% confidence level. However, evidence indicated that it has the tendency to overestimate the maximum loss at the 99% confidence level.

5.2. Outlook

1) In this thesis, the China REIT index is self-constructed, which is based on 9 REITs with underlying mainland China properties listed in Hong Kong and Singapore. Quality of representation can be argued due to the small number of REITs used. It should be noted that with the launching of the infrastructure pilot REIT program in China, one can expect more listings of REITs in China in the future, which can lead to new REIT indexes for research purposes.
2) The target REIT data in this thesis is the equity REIT index, which is a mixture of different specializations. It might be helpful to perform similar research but categorize REITs into their different specializations, such as industrial and retail REITs. It can also be meaningful to conduct further research on mortgage REITs and hybrid REITs.[17]
3) The factors used in this thesis as representations of macroeconomic factors can be subjective. It might be useful to consider different types of factors to get new observations and findings. For example, in the context of the macroeconomic factor inflation risk, it can be helpful to consider factors such as unexpected inflation.
4) A very strong correlation between the REIT index and the stock index has been identified. Therefore, it can be meaningful to perform further research in this aspect to identify additional findings. One suggestion could be to include additional variables such as investor sentiment.
5) The results of the Kupiec test indicated that GARCH(1,1)-VaR assuming a t distribution tends to overestimate the VaR at 99% level. It can be helpful to investigate further on the VaR with different GARCH-family models or even using other econometric approaches.

[17] Hybrid REITs refer to those REITs, which are effectively a combination of equity and mortgage REITs

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