Diversification benefits of domestic and international REITs for SET Index before and during Covid-19 crisis

Mr. Korn Kongkittiwong

An Independent Study Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Science in Finance
Department of Banking and Finance
FACULTY OF COMMERCE AND ACCOUNTANCY
Chulalongkorn University
Academic Year 2021

ผลประโยชน์จากการกระจายความเสี่ยงด้วยการลงทุนระหว่างทรัสต์เพื่อการลงทุนในอสังหาริมทรัพย์ภายในประเทศและต่างประเทศและดัชนีตลาดหลักทรัพย์แห่งประเทศไทย

นายกรณ์ ก้องกิตติวงศ์

สารนิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
สาขาวิชาการเงิน ภาควิชาการธนาคารและการเงิน
คณะพาณิชยศาสตร์และการบัญชี จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2564

Independent Study Title	Diversification benefits of domestic and international REITs for SET Index before and during Covid-19 crisis
By	Mr. Korn Kongkittiwong
Field of Study	Finance
Thesis Advisor	Associate Professor BOONLERT JITMANEEROJ, Ph.D.

Accepted by the FACULTY OF COMMERCE AND ACCOUNTANCY, Chulalongkorn University in Partial Fulfillment of the Requirement for the Master of Science

INDEPENDENT STUDY COMMITTEE

..... Chairman
()

..... Advisor
(Associate Professor BOONLERT JITMANEEROJ, Ph.D.)

..... Examiner
(Assistant Professor RUTTACHAI SEELAJAROEN, Ph.D.)

..... Examiner
(Tanawit Sae-Sue, Ph.D.)

กรณ์ ก้องกิตติวงศ์ : ผลประโยชน์จากการกระจายความเสี่ยงด้วยการลงทุนระหว่างทรัสต์เพื่อการลงทุนในอสังหาริมทรัพย์ภายในประเทศและต่างประเทศและดัชนีตลาดหลักทรัพย์แห่งประเทศไทย. (Diversification benefits of domestic and international REITs for SET Index before and during Covid-19 crisis) อ.ที่ปรึกษาหลัก : รศ. ดร.บุญเลิศ จิตรมณีโรจน์

สารนิพนธ์ฉบับนี้จัดทำขึ้นเพื่อศึกษาผลประโยชน์ที่ได้รับจากการกระจ่ายความเสี่ยงในการลงทุนในดัชนีหุ้นในตลาดหลักทรัพย์แห่งประเทศไทย (SET Index) โดยการลงทุนในดัชนีกองทรัสต์เพื่อการลงทุนในอสังหาริมทรัพย์ (REIT Indices) ของประเทศไทย สหรัฐอเมริกา สิงคโปร์ ญี่ปุ่น และทวีปยุโรป และสารนิพนธ์ฉบับนี้ยังมีการศึกษาเพิ่มเต็มในประเด็นของการเปรียบเทียบระดับผลประโยชน์ของการกระจ่ายความเสี่ยงข้างต้นระหว่างช่วงเวลาปกติและช่วงเวลาวิกฤตการระบาดของโรคติดเชื้อโควิด-19 ซึ่งทั้งสองช่วงเวลาดังกล่าวครอบคลุมตั้งแต่วันที่ 1 มกราคม 2554 ถึง วันที่ 31 มกราคม 2565 โดยสารนิพนธ์ฉบับนี้นำแบบจำลอง DCC-GARCH มาใช้เป็นแบบจำลองหลักในการศึกษาผลประโยชน์ที่ได้รับจากการกระจ่ายความเสี่ยงดังกล่าว และในท้ายที่สุดผลการศึกษาได้ค้นพบประเด็นหลัก 3 ประเด็นคือ 1. การลงทุนใน REIT Indices ของทุกประเทศและทวีปภายใต้ขอบเขตการศึกษานี้มีผลประโยชน์ในการใช้กระจ่ายความเสี่ยงในการลงทุนใน SET Index 2.ระดับผลประโยชน์ในการใช้กระจ่ายความเสี่ยงในการลงทุนใน SET Index ของการลงทุนใน REIT Indices ของประเทศสหรัฐอเมริกา ญี่ปุ่น และทวีปยุโรป ลดลงในช่วงเวลาวิกฤตการระบาดของโรคติดเชื้อโควิด-19 3.ระดับผลประโยชน์ในการใช้กระจ่ายความเสี่ยงในการลงทุนใน SET Index ของการลงทุนใน REIT index ของประเทศสหรัฐอเมริกามีมากที่สุดเมื่อเทียบกับพื้นที่อื่นๆ ในขอบเขตของการศึกษาครั้งนี้

สาขาวิชา	การเงิน	ลายมือชื่อนิสิต .....
ปีการศึกษา	2564	ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

6384002026 : MAJOR FINANCE

KEYWORD: Diversification Benefit, Real Estate Investment Trust Indices, REIT Indices, DCC GARCH model, Dynamic Conditional Correlation, Covid-19

Korn Kongkittiwong : Diversification benefits of domestic and international REITs for SET Index before and during Covid-19 crisis. Advisor: Assoc. Prof. BOONLERT JITMANEEROJ, Ph.D.

This study examines the diversification benefit of Thailand, the US, Europe, Singapore, and Japan REIT indices for the SET index. The time scope for this study starts from 1st January 2011 to 31th January 2022. It also compares the diversification benefit degree between pre and during Covid-19 periods. The DCC-GARCH model is used for the diversification benefit examination. The results posit 3 main points. First, all the REIT indices provide diversification benefit for the SET index. Second, the Covid-19 pandemic reduces diversification benefit generated by the US, Europe, and Japan REIT indices. Finally, the US provides the highest diversification benefit to the SET index among the others.

Field of Study:	Finance	Student's Signature .....
Academic Year:	2021	Advisor's Signature .....

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude toward my advisor, Associate Professor Boonlert Jitmaneeroj, Ph.D. I appreciate his constant support from the start to the completion of my special project. His guidance did not only help me to overcome all the challenges but also push my academical and personal ability to improve beyond my limit that I could never imagine. Lastly, I was very honored and grateful that I was one of the advisees under his supervision.

Korn Kongkittiwong

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

Chapter 1
Introduction

Background

Real Estate Investment Trusts (REITs) are publicly traded financial assets that has real estates as the underlying. The REITs were initially introduced by the congress of the United State of America (the US) in 1960 (SEC, 2011), and many countries have adopted them in their domestic markets since then. Major characteristics that make the REITs become popular are the stable and strong dividend payment and the less sensitivity to the general economy cycle (Chiang et al., 2008). This may motivate investors to perceive the asset as a stock diversifier as well and many papers are published accordingly. However, scholars generally use domestic property funds, real estate stocks, and REITs together as the samples and compare it against domestic stocks to prove the diversification benefit academically. To the author best knowledge, only a few of them are found to make the comparison from cross-countries/regionals perspective. Mull and Soenen (1997) are some of the first initiators for that. Their experiment is started by adding the US REITs to stock and bond portfolios in G-7 countries from 1985 – 1994 to find the optimal weight. The correlation coefficient between the REITs and the stocks are then found to be high. Also, the portfolios are only improved marginally for the full sample period. The US REITs are not selected to be in the optimal portfolios for most of the countries, except for United Kingdom and Canada. The monthly currency fluctuations have already been adjusted for this. The authors then further their research by separating the period into two sub-periods (1985 - 1990 and 1990 - 1994). During the first sub-period, the portfolios result remains the

same. However, it is enhanced during 1990 – 1994. This concludes that the inconsistency of time makes the portfolio construction to be problematic and uncertain.

Moving across the world to Thailand, Saengchote and Charoenpanich (2021) have explained a good and concise setting for the REITs within this country. This study mainly adopted their words as the proceeding. Property funds were there in the Thai financial market long before, since 2003. It played a role as recovery tools for distressed properties, which was inherited from the Asian Financial Crisis 1997. The Security and Exchange Commission of Thailand (SET) then launched the REITs to the Thai market, under the Trusts for Transaction in the Capital Market Act of 2007, in 2012 to reduce some restrictions related to leverage and investment opportunity of the property fund as well as to align with the international standard. 2 years later, the first REITs was established and listed in the SET (Jiamchoatpatanakul, 2019). Nowadays as the REITs have become more popular among the Thai investors and researchers like in the other countries, still only a few related academic papers appeared to be found within the nation. One of them focuses on examining real estate funds' (property funds and REITs) diversification benefit, hedging, and safe-haven abilities against equity domestically (Tangjitprom et al., 2016). The result turnouts that the funds do not have the mentioned abilities, but it is still attractive enough to be used for diversification. The average beta of these funds is comparatively low, and the risk-return performance is higher than the overall Thai equity market. Another paper is conducted by Chaisrichawla (2017), to testify behavior of residential REITs return in Thailand. In a long run period, the REITs return performs similarly to their underlying assets. Though during a short run period, the REITs return acts more closely to common stocks. These behaviors indicate that the

residential REITs in Thailand can be the diversifier if it is held only for a long period of time.

Motivation

According to the international and Thailand REITs background, Chaisrichawla (2017); Mull and Soenen (1997); Tangjitprom et al. (2016) prove that it is possible to use the REITs as the diversifiers against the stocks. Furthermore, in practice there are 66 Thai mutual funds that manage investment portfolios constructing by both international and domestic REITs (DekFinance, 2021). However, there are only 27 of them focusing on individual countries/regions. Besides, apart from the Asia region, out of the 27, there are 7 funds that invest only in Thailand, 2 only in the US, 1 only in Japan, 1 only in Singapore, and another one in Europe (mainly in developed Europe) REITs. It is then interesting to understand how investment in foreign and domestic REITs indices, especially within these specific countries and the region, support fund managers and investors to diversify their investment against Thai equity index, since these countries and region are the only chosen ones to be invested in individually.

Contribution

Many of the diversification studies of REITs against stocks are conducted using samples within their countries. Only a few of them are found to do it base on cross-countries perspective. Those papers are written by Mull and Soenen (1997) as mentioned previously and Granath and Carlsson (2019); Niskanen and Falkenbach (2010), which will be referred to in the literature review. However, none of them use the sample in Thailand. The closest location is in Asia (Granath & Carlsson, 2019; Niskanen & Falkenbach, 2010). Besides, only one of these papers incorporates the global financial crisis period into the scope to see the differences in the result relative

to the normal time (Granath & Carlsson, 2019) and no one covers the coronavirus disease, 2019 (Covid-19) crisis period in the analysis. Consequently, the author aims to fill up these research gaps by comparing the degree of diversification benefit of international REITs indices, collected from the individual target markets of the Thai fund managers, which are the US, developed Europe, Japan, and Singapore, against the Thai stock index during pre and Covid-19 crisis periods. Additionally, the author also further provides the optimal minimum variance portfolio weight for the readers to see the diversification picture more vividly.

Objective and research questions

Taking from the motivation and contribution, the purpose of this research is to support the fund managers and investors during both normal and Covid-19 crisis periods to diversify the Thai equity by using domestic and international REITs samples from Thailand, the US, developed Europe, Japan, and Singapore. Therefore, it intends to answer these following research questions.

1. Do the domestic and international REITs provide diversification benefit against the Thai stock index?
2. How does the Covid-19 crisis period impact on the result from the first question?
3. Which country among the target ones provide the lowest degree of condition correlation (highest diversification benefit) between their REITs and Thai equity index?

The structure of the rest of this research is designed as follow. Chapter 2 presents literatures review on a related theory, financial integration among the target countries, international REITs and the equity portfolio relationship. and the. Chapter 3

develops hypothesis base on the literatures review section. Chapter 4 reveals the data with its sources. Chapter 5 explains the detail methodological framework. Chapter 6 illustrates the empirical result and disclose practical implication accordingly. Finally, Chapter 7 represents the highlighted conclusion and ending massage from the study.

Chapter 2
Literature Review

Related Theory

Modern Portfolio Theory (MPT) was first introduced by Markowitz (1952) to help investors make their decision on risky assets. A simple conclusion of his creation can be stated as when adding more stocks which are not posit the perfect correlation (correlation value equal to 1) with an existing portfolio into itself, the portfolio overall risk drops. Besides, there can be many combinations of these correlated stocks in the portfolio. Continuing with this pattern, practitioners can form optimal portfolios where the maximum return and lowest risk are achieved. Nowadays the diversification implication of the MPT is widely applied, although it is practiced with different academic methods. In this study the author also tweaks the diversification definition slightly to capture relationship with the equity market volatility and compare the diversification benefit among the target assets against the SET index. This method is adopted from Chong et al. (2009). They measure the REITs-Stock correlation against the equity market volatility. The stronger the relationship, the less benefit the investors get from using the REITs as the stock diversifier.

Financial integration and its diversification implication

When international diversification discussion take place, most of the scholars will immediately think about financial integration among their focused countries as it is one of the key matter topics around this theme. Increasing homogeneity of financial

legislation around the world describe higher level global financial integration (Granath & Carlsson, 2019). This leads the financial market to be increasingly distracted by the global risk rather than the country specific one (Malliaropulos et al., 2006). Donadelli and Paradiso (2014) also say that the connection among the markets imply reduction in the international diversification. Moreover, the financial connectedness level rise during financial crisis due to volatility spillover among countries (Ahmad et al., 2015; Zheng & Zuo, 2013). Taking example of the 2008 global financial crisis, the US spreads the volatility from its markets to others, for both securitized real estate (K. Liow & Q. Ye, 2018; K. H. Liow & Q. Ye, 2018) and stocks (Zheng & Zuo, 2013). In addition, K. Liow and Q. Ye (2018); K. H. Liow and Q. Ye (2018) add that the globalization is another cause for this spillover, and it surges the correlation among international securitized real estate return.

Scoping down to Asian region as this research particularly concentrate on diversifying the Thailand market, Caporale et al. (2021) explores financial integration in emerging Asia to see whether it relates more to the global or regional. They find that neither the entire sample period (January 2001 – August 2016) nor the sub-periods (pre- and post-crisis) show any evidence of integration between the growing Asian economies (including Thailand and Singapore) and Japan. However, regional (represented by Morgan Stanley Capital International (MSCI) Asia, excluding Japan) dominates the correlation with Asian countries during the full period and Thailand is one of the most regionally integrated country. Focusing on the pre-crisis period (January 2001 – December 2007), the global region (represented by the US market) has higher integration degree with the Asian countries than the regional. On the other hand, the opposite is true during the post-crisis period (January 2009 – December 2016), when

no global integration degree occurs but stronger integration is seen within the region. Apart from these connections, not many scholars study the relationship between Asia and Europe, but Loh (2013) find a long-term co-movement between the region and Europe as well as the US. Another paper written by Hyde et al. (2007), argues that the Asia has higher level of connection to the US than the Europe.

As Thailand is one of the emerging countries (Duttagupta & Pazarbasioglu, 2021), differences between developed and emerging market during the financial crisis are considered. Emerging markets are less influenced by global recessions in terms of deeper integration since they lack global market characteristics (Donadelli & Paradiso, 2014). On this matter, Li and Majerowska (2008) use European evidence to discover that country-specific risk is a better description of emerging markets than global or regional risk. If financial integration does not have the same impact on developing markets as it does on developed markets, emerging markets can be a useful risk diversification option for individual investors (Granath & Carlsson, 2019).

Speaking of the recent Covid-19 pandemic crisis additionally, there are many studies conducted to investigate its financial contagion effect over countries around the world. Based on listed financial and non-financial enterprises, Akhtaruzzaman et al. (2021) investigate how financial contagion occur between China and G7 countries during Covid-19. Their findings suggest that conditional correlations between these firms' stock returns increase dramatically across the G7, and the intensity of this surge is much higher for financial firms during the Covid-19 epidemic. This indicates the vital role these companies play in financial contagion transmission. Guo et al. (2021) initiate another study on the tail risk contagion during the pandemic. They say that the risk transmits to the global financial markets during the crisis period, implying that the

Covid-19 influences negatively on the international financial system. Besides, the spillovers of this risk among the Asia financial markets are primarily coming from the European and American situation. Chopra and Mehta (2022) further the analysis of this theme using DCC-GARCH model. They find out that there is increase spread of contagion from pre to during Covid-19 period, originating from China to many countries in Asian, including Thailand but excluding Japan and Singapore. However, this is still less than the effect spread from the US to those countries from pre to during the global financial crisis in 2008. Moreover, the fractal contagion effect of the Covid-19 crisis on the stock markets of 32 nations (including Thailand, Japan, the US, and some from Europe) is explored by Okorie and Lin (2021). The results signify that there is a considerable contagion effect in the stock markets return and volatility, but it is only temporary. Fu et al. (2021) then add on that contagion effects are ubiquitous throughout global equity markets in four regions, which are North America, Latin America, Europe and Asia and the least vulnerable territory that expose to this contagion risk boils down to the Asia.

The relationship between international REITs and the equity

After Mull and Soenen (1997), Niskanen and Falkenbach (2010) likewise argue that there is the correlation between REITs and international equities, and it shows time-varying properties. For the period 2006–2009, they study the diversification potential of European REITs against stock markets in Europe, the US, and Asia Pacific. As a result, the correlations between European REITs and the international stock markets are ranked from the highest to lowest as follow, Europe, the US, and Asia Pacific. Furthermore, the paper also studies the REITs-stocks correlation in the Europe during different equity market volatility periods. When the volatility is abnormally low, the

correlation is lower than the average. However, the opposite is true when the volatility is very high. For private investors, this means that European REITs provide the highest diversification benefit against Asia stock market in general and against European stock during the low volatility period.

Taking another 9 years, Granath and Carlsson (2019) collect international REITs samples from the US, Asia Pacific, and Europe to study its diversification against European stock markets during 2007 – 2019. The methods used for this study are Johansen's cointegration, Granger non-causality, and DCC-GARCH. The findings denote 4 main points. First, international REITs have both long- and short-term diversification potential for European stocks. The diversification of cross-regional REITs against stocks provides higher diversification potential than the within-regional during the long-term period. Still, time-varying result occur for the short-term diversification. Second, emerging REIT markets are favored over developed ones (except the US) due to reduced conditional correlations with the equity. Third, changes in stock market returns precede changes in REIT market returns, inferring that stock markets react faster to fresh market information. The fourth point is the argument of the matter during the financial crisis periods in 2008. Growing interdependence between the REITs and stock markets is seen throughout the time, affirming the abnormal market condition and less diversification potential. Though, this only impacts on the short-term investors due to undiscovered trend of this increasing interdependence over the whole sample. Consequently, it implies that the international REITs continue to be good European stocks diversifiers for the private investors after the crisis period.

Chapter 3
Hypothesis Development

In Thailand, Chaisrichawla (2017); Tangjitprom et al. (2016) imply that the REITs can diversify the stocks. For the international perspective, although Mull and Soenen (1997) mention some periods that show very high correlation between the US REITs and the international stocks, indicating that the diversification benefit for these assets may not possible, the other period in their research results in the other way around. Similarly, Granath and Carlsson (2019); Niskanen and Falkenbach (2010) also reveal some limitations of using the REITs as the stock diversifier across the regions, they still present the opportunity for the portfolio diversification by combining the investment in these assets. Additionally, there is no papers affirming a perfect correlation among the target countries in term of the financial integration or contagion, entailing that the cross-countries diversification using financial assets is generally achievable. All these papers imply the possibility of utilizing the international REITs against the Thai equity index for the portfolio diversification purpose. Thus, the author hypothesizes the first research question that

H1: The international and domestic REITs provide diversification benefit against the Thai equity portfolio.

Some scholars, Ahmad et al. (2015); Zheng and Zuo (2013) say that the financial integration rise internationally during the global financial crisis in 2008, due to the volatility spillover from the US (K. Liow & Q. Ye, 2018; K. H. Liow & Q. Ye, 2018; Zheng & Zuo, 2013). Applying this statement, the diversification benefit among all the countries may be reduced. Even though emerging market received less effect, some positive degree of correlations among countries are seen (Donadelli & Paradiso,

2014; Li & Majerowska, 2008). Moreover, existing financial contagion effect or risk spreading during the Covid-19 imply significantly higher correlation between counter parties (Fu et al., 2021). Research with sample periods longer than 3 months is selected to elaborate this point, since this short amount of time may produce inconsistent results, which can be seen by the contradictory outcomes of the papers written by Akhtaruzzaman et al. (2021); Chopra and Mehta (2022). With that, Guo et al. (2021) use 6 months data to confirm that there is risk transmitting to Asia, occurred by the US and Europe during the pandemic. At this point, the US and Europe are understood to have higher correlation with Asia (Guo et al., 2021) (assume to include Thailand). In other word, the diversification benefit should be reduced between Thailand and these places during the Covid-19. Besides, Granath and Carlsson (2019) also affirm that the correlation between international REITs and stocks rise during the 2008 global financial crisis. Thus, the author hypothesizes the second research question that

H2: The Covid-19 crisis reduce the REITs diversification benefit against SET index.

Thailand is the least likely country to contribute the highest diversification advantage. Although the Thai REITs perform unlike the domestic stock in the long run (Chaisrichawla, 2017), denoting the good diversification potential, Caporale et al. (2021); Granath and Carlsson (2019); Niskanen and Falkenbach (2010) together confirm that the cross-region diversification provides higher benefit than the within-region. Japan and Singapore then seem to be the next least countries of being the best diversification benefit provider to the Thai equity market after Thailand itself, since it locates in the same region. However, Japan may contribute to this benefit slightly higher than Singapore, since Caporale et al. (2021) find no correlation between Japan and Asian countries base on their sample periods covering the global financial crisis. For

the rest of the candidates, there is no clear evidences of the financial integration or contagion level to make the comparison among them. However, the study applies Granath and Carlsson (2019) words. They say that REITs market maturity can be used as a benchmark to imply the degree of the diversification benefit for the cross-regional comparison. In this case, the US represents as the most mature REITs market in the world (Beng & Lim, 2019). It then supposes to contribute the superlative diversification benefit against Thai equity market. Thus, the author hypothesizes the third research question that

H3: The US outperform all the other countries as the diversification benefit provider against Thai stock index.

Chapter 4

Data

This study uses Thai stock, domestic, and international REITs total return indices net dividend to examine the diversification benefit. The SET Index, including stocks of all the companies listed in SET, is used as the proxy for Thai stock index. The domestic and international REITs indices representatives and its' constituents are disclosed in Table 1. This study chooses all these REITs indices on purpose as it is the benchmark for the Thai funds that invest in only these countries and the region. Unfortunately, it may not be the best practice for the stocks-REITs analysis exclusively.

Table 1: Represented REIT Indices

Countries and a Region	Represented Indices	Constituents
United State of America (US)	FTSE Nareit All Equity REITs	Listed REITs
Japan (JP)	Tokyo Stock Exchange REIT Index	Listed REITs
Singapore (SG)	iEdge S-REIT Index	Listed REITs
Europe (EU)	FTSE EPRA Nareit Dev Europe REITs	Listed REITs
Thailand (TH)	SETPREIT Index	Listed REITs and Property Fund

The SETPREIT index is not composed of the REITs alone as shown in the table above. Besides, the study has to postulate that the FTSE EPRA Nareit Dev Europe REITs index (EREE) covers only the REITs. This assumption is originated from the similar name to the FTSE EPRA Nareit Dev Europe index (EPRA). The EPRA officially describes that it is composed of real estate stocks and REITs. However, the EREE has lower price and the name seem to be more specific to the REITs than that of the EPRA. All these indices' prices are in US dollar and are acquired on the daily basis, since high frequency data is necessary when using GARCH model (Sjö, 2010). Besides, the timeframes for this data are from 1st January 2011 to 31th January 2022 for full period, from 1st January 2011 to 30th December 2019 for pre Covid-19 period, and from 31st December 2019 to 31th January 2022 for during Covid-19 period. All of them are obtained from the Bloomberg database.

The Table 2 shows descriptive statistic of the daily return for all indices. These daily returns are computed by using the changes in the natural logarithms of the indices. Of all the REIT indices, the US REITs index provides the highest average return, and it is even higher than the SET index. Moving on to a measure of the asymmetry of the daily returns, most indices yield more negative skewness than the SET index except the EU REIT index return. In other words, most of the indices distribute longer left tails than the SET index, implying that it is more likely to see negative returns from these indices apart from the EU than the SET index. Like the skewness, all the indices have higher kurtosis than the SET index. This denotes that the SET index has less fat tailed risk than those indices. Apart from these major moments, the unconditional correlation is also calculated. Singapore REITs index shows the highest correlation and Japan

REITs index represents the lowest correlation to the SET index. In this case, Japan REITs index offers the highest diversification benefit to the SET index.

Table 2: Summary statistic of daily return for the SET and REIT indices

Index Returns	Mean	Stand Div	Skewness	Kurtosis	Unconditional Correlation with SET
SET	0.0294	1.0391	-1.1342	14.8502	1.0000
TH REITs	0.0291	0.5995	-2.3669	30.5470	0.4451
US REITs	0.0346	1.2898	-1.7936	30.3012	0.2322
EU REITs	0.0215	1.2427	-1.0399	18.3339	0.4036
SG REITs	0.0190	0.8251	-1.1857	28.7535	0.4671
JP REITs	0.0431	1.2368	-1.3130	47.4170	0.1792

Moreover, the returns properties are diagnosed further by using following tests, which also presented in the Table 3. Significant Jarque-Bera statistics represent as the evidence of deviation from the normal distribution of all the daily returns. The Ljung-Box test using the Q(5) statistics, present autocorrelation characteristic for all of the index returns. Unit root and ARCH tests are then conducted using the augmented Dickey-Fuller (ADF) and the Lagrange Multiplier (LM) statistics respectively before running Dynamic Conditional Correlation (DCC) Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model. As the results, the ADF statistic confirms the stationary characteristic, and the LM statistic shows the existence of time-varying variance of all the daily returns.

Table 3: Summary statistic of daily return for the SET and REIT indices (Continue)

Index Returns	Jarque-Bera Test	Ljung-Box Test	ADF Unit root Test	ARCH-LM Test
SET	25416.5627	20.0910	-21.0510	338.7000
TH REITs	107616.6042	166.1662	-17.9350	554.7210
US REITs	102801.5368	90.5957	-20.9040	643.4180
EU REITs	38344.1123	43.9608	-21.9270	398.2590
SG REITs	91215.7639	90.0804	-19.5750	866.1240
JP REITs	240749.9835	159.5624	-13.4140	716.1820

Chapter 5
Methodology

The purpose of this research is to compare the diversification benefit between the international REITs indices and Thai equity index. With that, DCC-GARCH model invented by Engle (2002) is employed to be utilized. The author follows the process to deal with the comparison between the assets that have commonly been done by various scholars, not only Granath and Carlsson (2019) but also those with different scopes such as REITs versus stocks within a country, done by Chong et al. (2009); Fei et al. (2010) and REITs together with real estate securities versus stocks, done by Liow (2010).

As Jitmaneeroj (2018) works is very clear and concise, the author mainly adopts his explanations on the DCC-GARCH model to this study. It starts by specifying $r_t = \left[r_{1,t}, r_{2,t}\right]$ to be a 2×1 vector, which is the combination of Thai stock and REITs total return indices net dividend series respectively. Both are calculated by using the changes in natural logarithms of the indices. The conditional mean equations are then shown below as the reduced-form vector autoregressive process (VAR).

$$A(L)\, r_t = \varepsilon_t \qquad \varepsilon_t \sim N(0, H_t) \qquad t = 1, 2, 3, \ldots, T \tag{1}$$

where,

- $A(L)$ is a matrix in the lag operator L, and $\varepsilon_t = \left[\varepsilon_{1,t}, \varepsilon_{2,t}\right]$ is a vector of the error terms with the following specification.

$$H_t = D_t R_t D_t \tag{2}$$

where,

- H_t is the off-diagonal element or the conditional covariance, formed by the equation of $h_{ij,t} = \rho_{ij,t}\sqrt{h_{ii,t}h_{jj},t}$,
- $D_t = diag\left\{\sqrt{h_{i,t}}\right\}$ for $i = 1,2$ is a 2×2 diagonal matrix of univariate time varying GARCH(1,1) models, represented by $h_{i,t} = \omega_{0i} + \omega_{1i}\varepsilon^2_{i,t-1} + \omega_{2i}h_{i,t-1}$, and
- $R_t = \{\rho_{ij,t}\}$ for i , $j = 1$, 2 is a matrix of conditional correlation coefficients of the standardized residuals $\tilde{\varepsilon}_t$, with $\tilde{\varepsilon}_t = D_t^{-1}\varepsilon_t$. The matrix R_t is subsequently presented as

$$R_t = Q_t^{*-1}Q_tQ_t^{*-1} \tag{3}$$

where,

- Q_t is a 2×2 positive definite matrix, comprising of the conditional covariance, and
- Q_t^{*-1} is an inverted diagonal matrix with the square root of the diagonal element of Q_t and the Q_t matrix is then provided as

$$Q_t = \left(1-\theta_1-\theta_2\right)\overline{Q} + \theta_1\tilde{\varepsilon}_{t-1}\tilde{\varepsilon}'_{t-1} + \theta_2Q_{t-1} \tag{4}$$

where,

- $\overline{Q}$ is 2×2 unconditional variance matrix of $\tilde{\varepsilon}_t$,
- θ_1 and θ_2 are scalar parameters that respectively detect the previous shocks and the dynamic conditional correlation effects, and
- $Q_t^* = \left(q^*_{ii,t}\right) = \left(\sqrt{q_{ii,t}}\right)$ is a diagonal matrix combined by the square root of the i^{th} diagonal elements of Q_t, and θ_1 and θ_2 are non-negative coefficients which satisfy $\theta_1 + \theta_2 < 1$.

Chong et al., 2009 state that the equation (3) can be finally rewritten, the conditional correlation between i, j, and time t is described as follow.

$$\rho_{ij,t} = \frac{q_{ij,t}}{\sqrt{q_{ii,t} q_{jj,t}}} \quad (5)$$

where,

- $\rho_{ij,t}$ is the conditional correlation between the assets.

To elaborate the result from equation (5), this study continues to follow Chong et al. (2009) for the next 2 equations. The equation (6) is to regress the conditional correlation on a time trend.

$$\rho_{ij,t} = \alpha + \mu t \quad (6)$$

where,

- the μ coefficient represents the conditional correations to have trends overtime, if it is statistically significant
- the t is the time

The equation (7), which is also employed from Chong et al. (2009), examines the relationship between the conditional correlations and the conditional volatilities.

$$\rho_t = \alpha + \beta_S \sqrt{h_{S,t}} + \beta_R \sqrt{h_{R,t}} + \varepsilon_t \quad (7)$$

where,

- the subscript S and R represent Thai stocks and the international REITs respectively,
- the $\sqrt{h}$ stands for the conditional volatility or the time-varying risk of its subscripts' market,
- the β coefficient suggests the relationship between the REITs-stocks return conditional correlation and the conditional volatility of the market respectively to the subscripts

Eventually, the regression model (5) reveals the diversification benefit against Thai market risk. If the conditional correlations do not reach 1 (perfect correlation),

there are diversification benefits between the SET and REITs indices. This model is to justify the first hypothesis for this study. It is then elaborated further by the equation (6) to show how the conditional correlation change over the full period, which allow the reader to see the clearer picture of the result. Moreover, the regression model (7) compares the diversification benefit among the target countries REIT indices. The significant positive β_S implies the rise of the REITs-stock correlation with the Thai equity market volatility. However, if it is significantly negative, the REITs-stock correlation drops during the period of high equity market volatility. Accordingly, the lower the β_S is, the more benefit the investors get from using the REITs as the diversifier against the stocks. This model is applied to all the periods in this study to justify the second and third hypothesis.

As this study is designed to follow Chong et al. (2009) by using the regression model (7) to compare the diversification benefit degree, a limitation of the study is that it does not use statistical test to proove the comparison. Besides, it also does not incorporate potential transaction costs and exchange rate risk for rebalancing the portfolios. Additionally, this research also suggests the optimal minimum variance REITs-stock portfolios for the target readers to observe the clearer picture of this diversification, since this kind of portfolio seem to be a recent trend in Thailand as it was emerged by TMBAM Eastspring, one of the Thai portfolio management companies this year. The optimal minimum variance REITs-stock portfolios allow the readers to minimize their risk (or variance) for these assets investment without deducting the return (Chkili, 2016), which also align with the MPT concept. To form these portfolios, the study uses the equation below, created by Kroner and Ng (1998). Following closely to the concept, this study focuses on minimizing variance and avoids complex

calculation by having no constraints on the portfolio's return. Kroner and Ng (1998) suggested that to form such portfolio, one should use the portfolio's optimal weight given by the following equation.

$$W_{R,t} = \frac{h_{S,t} - h_{SR,t}}{h_{R,t} - 2h_{SR,t} + h_{S,t}} \quad \text{and} \quad W_{R,t} \begin{cases} 0 & W_{R,t} < 0 \\ W_{R,t} & if \quad 0 < 1 \\ 1 & W_{R,t} > 1 \end{cases} \tag{8}$$

where,

- $W_{R,t}$ is the REITs optimal weight in a one-dollar portfolio of the REITs and stocks at time t.
- $(1 - W_{R,t})$ is the stock optimal weight in a one-dollar portfolio of the REITs and stocks at time t
- $h_{S,t}$ and $h_{R,t}$ are the conditional variance for the stocks and REITs' market respectively at time t
- $h_{SR,t}$ is the conditional covariance between the stocks and the REITs' return at time t.
- the conditional variance and covariance are generated and acquired from the DCC-GARCH model.

The optimal weight solves an issue of calculating the optimal fully-invested portfolio holding without any shorting constraints, mimicking an everyday problem portfolio managers face. It can be said that the weight attains the optimal minimum variance portfolio assuming that the expected returns of assets are all zero, making it equivalent to simply approximating the risk-minimizing portfolio weights.

All the specifications in the equation (8) are obtained from the DCC-GARCH model result as an average number for each index to calculate the average $W_{R,t}$. The study uses this approach, which was done by Kumar (2014), for the practitioners'

benefit. They can just look at the average weights over the time to rebalance their portfolios by buying the under-weighted asset and selling the over-weighted one than the optimal benchmarks resulted from the model (8). They do not have to rely on each point in time for rebalancing their portfolio, which increase their transaction costs.

Chapter 6

Empirical Result

Data presented in Table 4 is the estimated results of a bivariate DCC-GARCH model for daily returns of the SET index and each of the international and local REIT indices. The conditional mean of the daily returns is modeled as a VAR process that optimal lag lengths are selected by Akaike information criterion. The conditional variance is built by using a DCC-GARCH process where the variance of each disturbance term acts in accordance with a GARCH (1,1) process.

From the estimation of mean equations, the daily return of the SET index and REIT indices in all countries except the US are significantly affected by the past returns of their own dynamics. In other words, the previous days' returns can predict the current return of these indices. The number of lags or days for these index returns to be significant are varying among 1- 9 lags. For the transmission of returns between the SET and REIT indices, the only country that SET index return cannot predict the return of REIT index among these is Singapore. However, some lag numbers of REIT indices' return, ranging from 1 to 7 in Singapore, the US, and EU are statistically significant to forecast the SET index return.

Moving on to the conditional variance equation results, the coefficient ω_0, ω_1, and ω_2 are highly significant. This indicates that variance and covariance are time-varying. Though, the coefficient on the lagged squared error (ω_1) is relatively small

comparing to that of the coefficient on the lagged conditional variance (ω_2). The sum of ω_1 and ω_2 almost reach to unity, varying from 0.9054 to 0.9962. This can be inferred shocks to the conditional variance are highly persistent for both stock and REITs. In particular, all of the REITs present a weaker persistence than the SET index. Note that both Θ_1 and Θ_2, the parameters that control the conditional quasi-correlations dynamics, are estimated to be statistically significant for all cases. This basically means DCC-GARCH model is more suitable for the data analysis in this case than the CCC-GARCH model since the time-invariant assumption behind it is too restrictive.

Table 4: Results of the DCC-GARCH model estimation

	Thai REITs		SET	
SET (-1)	0.0364***	(0.0092)	0.0442**	(0.0209)
SET (-2)	0.0229**	(0.0092)	0.0155	(0.0206)
SET (-3)	-0.0097	(0.0091)	-0.0169	(0.0207)
TH REITs (-1)	0.0614***	(0.0236)	0.0073	(0.0300)
TH REITs (-2)	0.0961***	(0.0224)	0.0095	(0.0305)
TH REITs (-3)	0.0824***	(0.0221)	0.0339	(0.0301)
Arch (ω_1)	0.2286***	(0.0230)	0.0946***	(0.0103)
Garch (ω_2)	0.7349***	(0.0235)	0.8918***	(0.0111)
Cons (ω_0)	0.0154***	(0.0392)	0.0134***	(0.0032)
Log likelihood	-4809.5240	-	-	-
Θ_1	0.0204***	(0.0077)	-	-
Θ_2	0.9612***	(0.0220)	-	-

	US REITs		SET	
SET (-1)	-0.0400*	(0.0226)	0.00305	(0.0232)
SET (-2)	-0.00388	(0.0225)	0.0118	(0.0228)
SET (-3)	-0.0195	(0.0226)	-0.0211	(0.0227)
SET (-4)	-0.0228	(0.0228)	-0.0133	(0.0223)
US REITs (-1)	-0.0139	(0.0232)	0.174***	(0.0176)
US REITs (-2)	0.0198	(0.0236)	0.0187	(0.0186)
US REITs (-3)	-0.0137	(0.0234)	0.00992	(0.0184)
US REITs (-4)	-0.0365	(0.0226)	-0.00779	(0.0179)
Arch (ω_1)	0.1556***	(0.0167)	0.1408***	(0.0152)
Garch (ω_2)	0.7972***	(0.0206)	0.8232***	(0.0177)
Cons (ω_0)	0.0490***	(0.0098)	0.0299***	(0.0067)
Log likelihood	-10834.2410	-	-	-
Θ_1	0.0113***	(0.0036)	-	-
Θ_2	0.9402***	(0.0260)	-	-

	EU REITs		SET	
SET (-1)	-0.0275	(0.0214)	0.0366*	(0.0213)
SET (-2)	0.0166	(0.0212)	0.0063	(0.0210)
SET (-3)	0.0141	(0.0215)	-0.0138	(0.0210)
SET (-4)	0.0468**	(0.0211)	0.0100	(0.0210)
SET (-5)	-0.0221	(0.0212)	0.0229	(0.0210)
SET (-6)	-0.0117	(0.0209)	-0.0339*	(0.0206)
SET (-7)	0.0533**	(0.0211)	0.0023	(0.0203)
SET (-8)	-0.0069	(0.0211)	0.0250	(0.0202)
SET (-9)	-0.0250	(0.0211)	-0.0147	(0.0204)
SET (-10)	-0.0226	(0.0211)	0.0507**	(0.0202)
EU REITs (-1)	0.0438**	(0.0216)	0.0424***	(0.0155)
EU REITs (-2)	-0.0169	(0.0215)	0.0191	(0.0149)
EU REITs (-3)	-0.0108	(0.0214)	0.0348**	(0.0152)
EU REITs (-4)	-0.0490**	(0.0209)	-0.0017	(0.0151)
EU REITs (-5)	0.0207	(0.0207)	0.0165	(0.0149)
EU REITs (-6)	0.0094	(0.0204)	-0.0169	(0.0150)
EU REITs (-7)	0.0014	(0.0201)	0.0055	(0.0148)
EU REITs (-8)	0.0034	(0.0203)	-0.0163	(0.0149)
EU REITs (-9)	-0.0355*	(0.0203)	-0.0064	(0.0150)
EU REITs (-10)	0.0071	(0.0197)	-0.0025	(0.0147)
Arch ($\omega 1$)	0.1430***	(0.0157)	0.1040***	(0.0118)
Garch ($\omega 2$)	0.8390***	(0.0174)	0.8870***	(0.0121)
Cons ($\omega 0$)	0.0340***	(0.0080)	0.0122***	(0.0032)
Log likelihood	-7116.3110	-	-	-
$\Theta 1$	0.0166***	(0.0055)	-	-
$\Theta 2$	0.9510***	(0.0130)	-	-

	SG REITs		SET	
SET (-1)	0.0080	(0.0149)	0.0437**	(0.0230)
SET (-2)	0.0198	(0.0144)	-0.0148	(0.0227)
SET (-3)	0.0063	(0.0143)	-0.0031	(0.0227)
SET (-4)	0.0193	(0.0147)	0.0073	(0.0225)
SG REITs (-1)	0.0649***	(0.0242)	0.0312	(0.0288)
SG REITs (-2)	0.0469**	(0.0233)	0.0131	(0.0285)
SG REITs (-3)	-0.0048	(0.0225)	0.0630**	(0.0289)
SG REITs (-4)	-0.0191	(0.0228)	-0.0086	(0.0285)
Arch (ω_1)	0.1720***	(0.0183)	0.1236***	(0.0132)
Garch (ω_2)	0.7334***	(0.0256)	0.8597***	(0.0146)
Cons (ω_0)	0.0403***	(0.0061)	0.0142***	(0.0046)
Log likelihood	-5027.4960	-	-	-
Θ_1	0.0346***	(0.0099)	-	-
Θ_2	0.9155***	(0.0265)	-	-

	JP REITs		SET	
SET (-1)	0.0619***	(0.0202)	0.0716***	(0.0248)
SET (-2)	0.0448**	(0.0210)	-0.0019	(0.0243)
SET (-3)	0.0180	(0.0197)	0.0055	(0.0240)
SET (-4)	0.0321	(0.0202)	0.0167	(0.0231)
SET (-5)	-0.0318*	(0.0188)	0.0515**	(0.0227)
JP REITs (-1)	0.0203	(0.0268)	0.0194	(0.0191)
JP REITs (-2)	0.0338	(0.0250)	0.0034	(0.0185)
JP REITs (-3)	-0.0848***	(0.0231)	0.0077	(0.0189)
JP REITs (-4)	-0.0052	(0.0216)	0.0147	(0.0182)
JP REITs (-5)	-0.0091	(0.0192)	0.0049	(0.0174)
		(0.0370)		
Arch (ω_1)	0.3760***		0.1738***	(0.0182)
Garch (ω_2)	0.5810***	(0.0325)	0.8224***	(0.0177)
		(0.0147)		
Cons (ω_0)	0.0870***		0.0101*	(0.0058)
Log likelihood	-5033.0450	-	-	-
		(0.0050)		
Θ_1	0.0102**		-	-
	0.9674***			
Θ_2		(0.0101)	-	-

Notes: ***, ** and * denote statistical significance at the 1%, 5% and 10%, respectively.

Table 5 summarizes statistics of the conditional correlation between the SET and REIT indices returns, estimated by the bivariate DCC-GARCH model. It conveys three implications to this study. First all the average conditional correlations are statistically significant. These results, where Singapore REIT index return posits the highest and Japan REIT index return displays the lowest average conditional correlation with SET index, agree with the unconditional correlations presented in Table 2. Second, there is a large gap in the volatilities of the conditional correlations, represented by the standard deviation raging from 4.03% for US REIT index return to 11.52% for Thai REIT index return. And third, all the REIT indices return provide the diversification benefit to the return from SET index because on average they do not reach the perfect correlation with SET index return. This aligns with the first hypothesis in this study and follow the conclusion from Granath and Carlsson (2019); Mull and Soenen (1997);

Niskanen and Falkenbach (2010) that the international REITs diversification is possible for equity portfolio.

Table 5: Summary statistic of the conditional correlation

Index Returns	Average Conditional Correlation	Std. Dev.
SET-TH REITs	0.3057***	0.1152
SET-US REITs	0.1609***	0.0403
SET-EU REITs	0.3091***	0.0643
SET-SG REITs	0.3553***	0.0984
SET-JP REITs	0.1556***	0.0608

Notes: ***, ** and * denote statistical significance at the 1%, 5% and 10%, respectively.

Table 6 represents the result from the equation (6). It aims to show the trends over time of these conditional correlations between REITs and SET indices returns for all countries. The μ provides significant negative results in all the countries except for Thailand. This means that overtime the conditional correlation trend of international REIT-SET indices returns become more uncorrelated or the diversification benefit between them is higher. To further prove the other hypothesis, this study constructs the table 7, 8, and 9 by following the equation (7) in the methodology. The coefficients of SET Volatility in those tables reveal the positive and significant values at 1%, 5%, and 10%. These imply that the conditional correlations between SET and REIT index returns rise when the SET index volatility or the risk in Thailand stock market is high during all the periods of this study. This is disappointing for international and domestic REIT investors who aim to use it to diversify their Thai equity portfolio.

Table 6: The Relation between Conditional Correlation and Time Trend

Index Returns	μ(*1000)	t-Stat	Adjusted R^2
SET-TH REITs	0.0103***	5.4600	0.0105
SET-US REITs	-0.0020***	-2.8100	0.0028
SET-EU REITs	-0.0021**	-1.9800	0.0011
SET-SG REITs	-0.0056***	-3.2400	0.0040
SET-JP REITs	-0.0054***	-4.6700	0.0103

Notes: ***, ** and * denote statistical significance at the 1%, 5% and 10%, respectively.

Table 8 and 9 portray the difference between the pre and during Covid-19 period respectively. The coefficients of SET index volatility clearly increase from pre Covid-19 (Table 7) to during Covid-19 (Table 8) periods for most countries' REIT index return conditional correlations with the SET index return except Thailand and Singapore. This confirms that the second hypothesis is true with only the US, Europe, and Japan REIT indices. In the case, the results align with studies from Charif et al. (2022); Demiralay and Kilincarslan (2022), who say that some REIT returns rise during the heightened uncertainty period, and some do not respond to the economic uncertainty respectively.

Table 7 presents the full period of the SET-REIT index returns conditional correlation and SET conditional volatility relation. Obviously, the coefficients of SET index volatility show the lowest value for SET-US REIT index returns conditional correlation. It means that the SET-US REIT index return conditional correlation increase when the SET index volatility is high at the smallest level among the target country. In other word, it simply provides the highest benefit over the full period of this study. This justify the third hypothesis and it is consistent with Granath and Carlsson (2019) words, that the US as the most mature REIT market offer the greatest diversification benefit. To further confirm this result, both split periods in this study, displayed in Table 8 and 9 also provide the same outcomes.

Table 7: The Relation between Conditional Correlation and Conditional Volatility (Full Period)

	Intercept		SET Volatility		REITs Volatility		Adjusted
	α	t(α)	β	t(β)	β	t(β)	R^2
SET-TH REITs	0.2423***	65.4700	0.1674***	36.3500	-0.0243***	-3.7600	0.4207
SET-US REITs	0.2109***	123.7400	0.0096***	3.8200	0.0132***	7.4200	0.0925
SET-EU REITs	0.2973***	121.8300	0.0362***	11.9400	0.0313***	12.5500	0.2619
SET-SG REITs	0.3438***	91.4900	0.0393***	6.8300	0.0621***	8.4100	0.1881
SET-JP REITs	0.1560***	61.2500	0.0482***	15.9100	0.0037*	1.8000	0.1774

Notes: ***, ** and * denote statistical significance at the 1%, 5% and 10%, respectively.

Table 8: The Relation between Conditional Correlation and Conditional Volatility (Pre Covid-19 Period)

	Intercept		SET Volatility		REITs Volatility		Adjusted
	α	t(α)	β	t(β)	β	t(β)	R^2
SET-TH REITs	0.2062***	45.6700	0.2134***	44.4300	-0.0779***	-10.4700	0.4779
SET-US REITs	0.2160***	82.2500	0.0076**	2.5400	0.0087***	3.6300	0.0172
SET-EU REITs	0.2754***	77.1900	0.0413***	11.6500	0.0492***	16.2900	0.2321
SET-SG REITs	0.2746***	43.0000	0.0390***	6.2300	0.1833***	15.3700	0.2224
SET-JP REITs	0.1531***	42.6300	0.0488***	13.0100	0.0039	1.4200	0.1110

Notes: ***, ** and * denote statistical significance at the 1%, 5% and 10%, respectively.

Table 9: The Relation between Conditional Correlation and Conditional Volatility (During Covid-19 Period)

	Intercept		SET Volatility		REITs Volatility		Adjusted
	α	t(α)	β	t(β)	β	t(β)	R^2
SET-TH REITs	0.4038***	72.7800	0.0915***	13.4600	-0.0112	-1.1500	0.4848
SET-US REITs	0.2123***	77.23	0.0095**	2.04	0.0150***	4.86	0.3667
SET-EU REITs	0.3151***	78.6100	0.0707***	10.6500	-0.0104*	-1.9000	0.4757
SET-SG REITs	0.3605***	53.7500	0.0314***	2.5900	0.0426***	3.2000	0.3122
SET-JP REITs	0.1705***	36.9000	0.0441***	8.1700	0.0034	1.0200	0.3491

Notes: ***, ** and * denote statistical significance at the 1%, 5% and 10%, respectively.

Figures 1, 2, 3, 4, and 5 elaborate the results from Tables 5 – 9. It shows graphs of the relationship between SET-REIT index return conditional correlations, the REIT index conditional volatilities, and the SET index conditional volatility for each of the target countries. These graphs are also plotted vertical lines located on 30 December 2019 to illustrate the split-up points between the pre and during Covid-19 periods.

All of the conditional correlation graphs in these figures never reach the perfect correlation of 1, which follow the third implication provided by the Table 5, validating that it is possible to use these REIT indices to diversify SET index. Table 8 and 9 confirm the second hypothesis that the diversification benefit contributed by REITs against SET is reduced during the Covid-19 period. The result seems to be same when looking at these Figures. Most of the SET-REIT conditional correlations roughly fluctuate higher during the Covid-19 period than the previous one when the SET volatility spikes and all graphs in all the Figures rise together astoundingly to generate the peak value in March 2020 (left side of the vertical line) on almost the exact same date. However, it is needed to see the table 8 and 9 for the exact view of how much the relationship move during the comparing periods owing to thorough differences with too many swings in the graphs.

Comparing all the countries together to determine the best REIT index for diversification against SET index, the outcome is approximately seen to align with the Table 7. When the SET volatility reaches its peaks in March 2020, the value of the conditional correlation values in the US are at the bottommost among the other, which is 0.3525. This imply that when the SET index experiences the highest risk, the SET-US REIT conditional correlation jump at the lowest level relatively to the others. Nevertheless, it is required to consider the numbers in Table 7, 8, and 9 again to perceive the precise results since the graphs are too fluctuated and too detailed to capture the accurate outcomes.

Figure 1: SET and TH REIT Conditional Volatility and SET-TH REIT Conditional Correlation

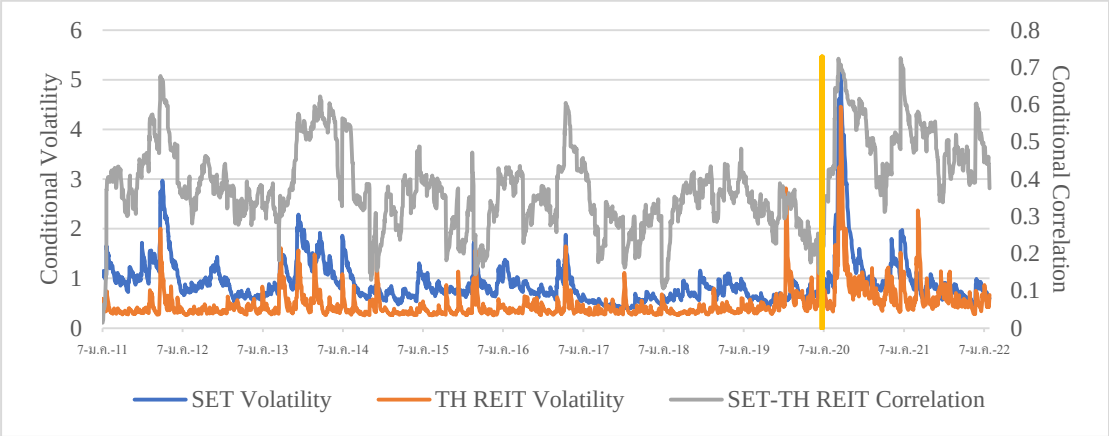


Figure 2: SET and US REIT Conditional Volatility and SET-US REIT Conditional Correlation

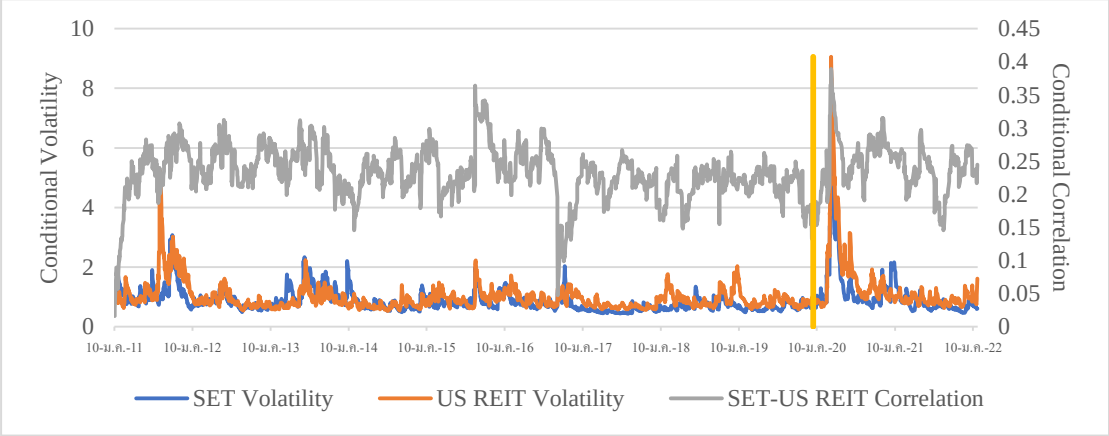


Figure 3: SET and EU REIT Conditional Volatility and SET-EU REIT Conditional Correlation

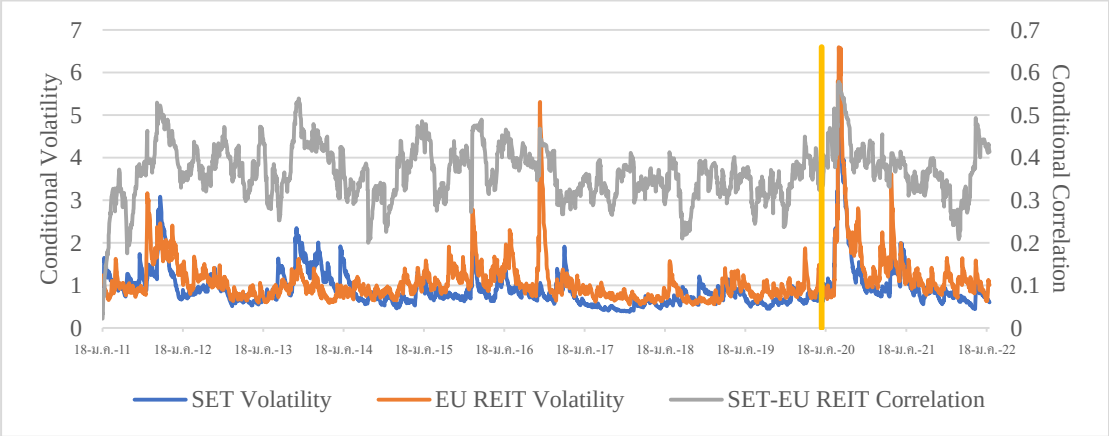


Figure 4: SET and SG REIT Conditional Volatility and SET-SG REIT Conditional Correlation

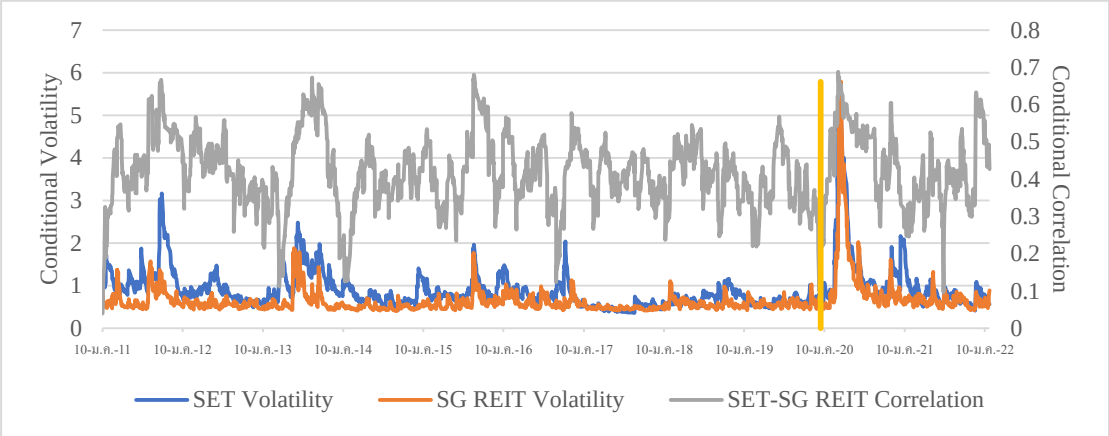
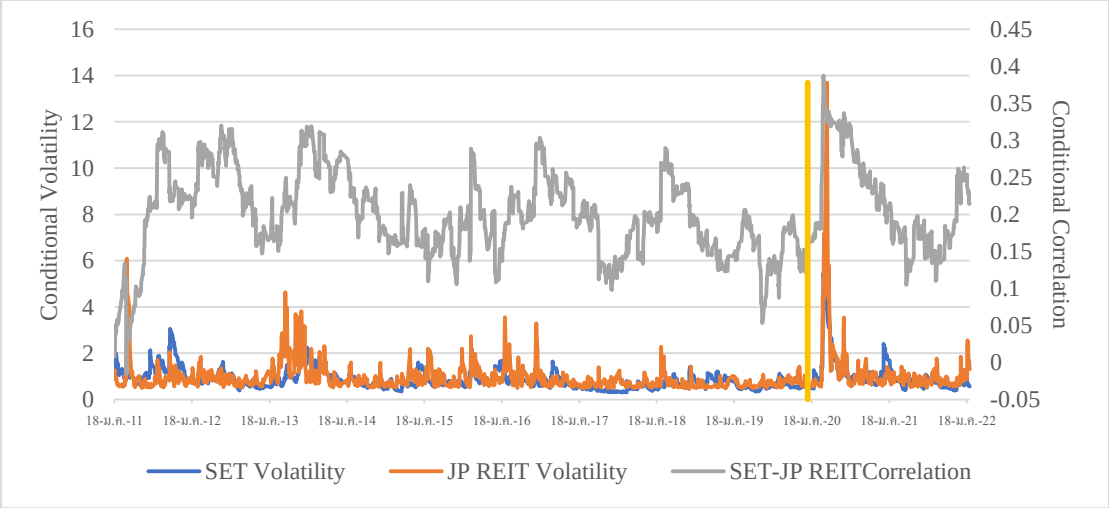


Figure 5: SET and JP REIT Conditional Volatility and SET-JP REIT Conditional Correlation



In addition, the optimal portfolios are formed by using the equation (8) in the methodology. The purpose of this is for the fund managers and investors to practically achieve the lowest risk without deducting return by roughly using these means in Table 10. The results suggest that only Thailand and Singapore REIT indices should be added into the portfolio for more than half of the weight. Inclusion of the rest should be less than that.

Table 10: Optimal minimum variance portfolio

	Mean	SD	Max	Min
TH REIT in SET-TH REIT Portfolio	0.7166	0.1798	0.9690	-0.0701
US REIT in SET-US REIT Portfolio	0.3699	0.1578	0.9063	-0.0065
EU REIT in SET-EU REIT Portfolio	0.2966	0.1791	0.8296	-0.0548
SG REIT in SET-SG REIT Portfolio	0.5437	0.1725	0.9341	-0.0110
JP REIT in SET-JP REIT Portfolio	0.4168	0.1999	0.9401	-0.0088

Chapter 7

Conclusion

There are some Thai mutual funds that focus on investing in REITs from Thailand, the US, Europe, Singapore, and Japan individually. This practically motivate this study to understand how these countries' REIT indices help the Thai mutual fund managers and investors diversify their domestic equity portfolio.

This equity-REIT diversification benefit study has been conducted by many before. However, only a few of them investigate the international perspective around this topic and none have analyzed structural break periods between pre and during Covid-19. The current study then aims to fill up these gaps by empirically using REIT indices employed from the individual focus of the Thai mutual funds against SET index. The pre Covid-19 period is determined to be from 1st January 2011 to 30th December 2019 and the during Covid-19 period is identified to be from 31st December 2019 to 31st January 2022.

Over these periods, the DCC-GARCH model is estimated and consequently the regression of the SET-REIT conditional correlation on SET conditional volatility are done to see the diversification benefit. Additionally, the optimal portfolio of REIT index from each of the countries and SET index is constructed for the fund managers and investors practical usage.

It turns out that the SET-REITs indices diversification is possible. This proves by the result from the DCC-GARCH model, which has no perfect conditional correlation. The first hypothesis is accordingly true. Moving on to the regression model, the outcomes display the increase in SET volatility coefficients for Thailand and Singapore REIT index returns. On the other hand, the US, EU, and Japan experience the other way around. The second hypothesis, saying that the Covid-19 reduce the diversification benefit of the REIT indices against the SET index, is then supported only by the US, EU, and Japan. When analyzing all the periods including the full timeframe, the SET volatility coefficient for the US REIT index return provides the least numbers. This justifies the third hypothesis for the study that the US REIT index provide the highest diversification benefit against the SET index.

The last finding of this study is added for the fund managers and investors practical use in general as the optimal minimum variance portfolios are formed. The results suggest the average optimal weights for all the individual REITs to be included in SET-REIT indices portfolios. The amounts are 71.66%, 36.99%, 29.66%, 54.37%, and 41.68% for Thailand, the US, Europe, Singapore, and Japan REIT indices respectively. With all these empirical data analyses, this study expects to portray the REIT indices from the target countries general characteristics and diversification benefit for the readers to further use in their research and practices.

There are two limitations of the study. First, it does not provide statistical test to proove the degree of diversification benefit comparison between the periods and among all the countries and region. Second, it does not include potential transaction costs and exchange rate risk for rebalancing the portfolios.

REFERENCES

Ahmad, W., Bhanumurthy, N. R., & Sehgal, S. (2015). Regime dependent dynamics and European stock markets: Is asset allocation really possible? *Empirica*, *42*(1), 77-107. https://doi.org/10.1007/s10663-014-9248-0

Akhtaruzzaman, M., Boubaker, S., & Sensoy, A. (2021). Financial contagion during COVID–19 crisis. *Finance Research Letters*, *38*, 101604. https://doi.org/https://doi.org/10.1016/j.frl.2020.101604

Beng, T. H., & Lim, A. (2019). *Singapore - A Global Hub for REIT Listings*. K. LLP.

Caporale, G. M., Gil-Alana, L. A., & You, K. (2021). Global and Regional Financial Integration in Emerging Asia. *Journal of Economic Integration*, *36*(2), 185-202.

Chaisrichawla, H. (2017). REIT for a Diversified Portfolio: False Myth or Fact?

Charif, H., Assaf, A., Demir, E., & Mokni, K. (2022). The effects of economic policy uncertainty on the US REITs ETFs: A quantile analysis. *Investment Analysts Journal*, *51*(1), 67-82. https://doi.org/10.1080/10293523.2022.2076372

Chiang, T. C., Lean, H. H., & Wong, W.-K. (2008). Do REITs Outperform Stocks and Fixed-Income Assets? New Evidence from Mean-Variance and Stochastic Dominance Approaches. *Journal of Risk and Financial Management*, *1*(1), 1-40. https://www.mdpi.com/1911-8074/1/1/1

Chkili, W. (2016). Dynamic correlations and hedging effectiveness between gold and stock markets: Evidence for BRICS countries. *Research in International Business and Finance*, *38*, 22-34. https://doi.org/https://doi.org/10.1016/j.ribaf.2016.03.005

Chong, J., Miffre, J., & Stevenson, S. (2009). Conditional Correlations and Real Estate Investment Trusts. *Journal of Real Estate Portfolio Management*, *15*(2), 173-184. https://doi.org/10.1080/10835547.2009.12089840

Chopra, M., & Mehta, C. (2022). Is the COVID-19 pandemic more contagious for the Asian stock markets? A comparison with the Asian financial, the US subprime and the Eurozone debt crisis. *Journal of Asian Economics*, *79*, 101450. https://doi.org/https://doi.org/10.1016/j.asieco.2022.101450

DekFinance, เ. (2021). จัดกลุ่มกองทุนรวม *REIT* และ *Infrastructure* มีเยอะแค่ไหนก็ไม่งง. Finnomena. https://www.finnomena.com/dekfinance/reit-infrastructure-category/

Demiralay, S., & Kilincarslan, E. (2022). Uncertainty Measures and Sector-Specific REITs in a Regime-Switching Environment. *The Journal of Real Estate Finance and Economics*. https://doi.org/10.1007/s11146-022-09898-w

Donadelli, M., & Paradiso, A. (2014). Is there heterogeneity in financial integration dynamics? Evidence from country and industry emerging market equity indexes. *Journal of International Financial Markets, Institutions and Money*, *32*, 184-218. https://doi.org/https://doi.org/10.1016/j.intfin.2014.06.003

Duttagupta, R., & Pazarbasioglu, C. (2021). *Miles to go: The future of emerging markets*. I. M. Fund. https://www.imf.org/external/pubs/ft/fandd/2021/06/pdf/the-future-of-emerging-markets-duttagupta-and-pazarbasioglu.pdf

Engle, R. (2002). Dynamic Conditional Correlation. *Journal of Business & Economic Statistics*, *20*(3), 339-350. https://doi.org/10.1198/073500102288618487

Fei, P., Ding, L., & Deng, Y. (2010). Correlation and Volatility Dynamics in REIT Returns: Performance and Portfolio Considerations. *The Journal of Portfolio Management*, *36*. https://doi.org/10.3905/JPM.2010.36.2.113

Fu, S., Liu, C., & Wei, X. (2021). Contagion in Global Stock Markets during the COVID-19 Crisis. *Global Challenges*, *5*(10), 2000130. https://doi.org/https://doi.org/10.1002/gch2.202000130

Granath, K., & Carlsson, C. (2019). *Investigating the Long- and the Short-Run Diversification Potential of REITs for Private Investors* [Student thesis, DiVA. http://urn.kb.se/resolve?urn=urn:nbn:se:liu:diva-160268

Guo, Y., Li, P., & Li, A. (2021). Tail risk contagion between international financial markets during COVID-19 pandemic. *International Review of Financial Analysis*, *73*, 101649. https://doi.org/https://doi.org/10.1016/j.irfa.2020.101649

Hyde, S., Bredin, D., & Nguyen, N. (2007). Chapter 3 Correlation dynamics between Asia-Pacific, EU and US stock returns. In S.-J. Kim & M. D. McKenzie (Eds.), *Asia-Pacific Financial Markets: Integration, Innovation and Challenges* (Vol. 8, pp. 39-61). Emerald Group Publishing Limited. https://doi.org/10.1016/S1569-3767(07)00003-9

Jiamchoatpatanakul, N. (2019). Does difference between NAV and market price make sense: Case of Thai Property funds and REITs. *KKU International Journal of Humanities and Social Sciences*, *9*(3), 164. https://so04.tci-thaijo.org/index.php/KKUIJ/article/view/202723

Jitmaneeroj, B. (2018). The effect of the rebalancing horizon on the tradeoff between hedging effectiveness and transaction costs. *International Review of Economics & Finance*, *58*, 282-298. https://doi.org/https://doi.org/10.1016/j.iref.2018.03.027

Kroner, K. F., & Ng, V. K. (1998). Modeling Asymmetric Comovements of Asset Returns. *The Review of Financial Studies*, *11*(4), 817-844. https://doi.org/10.1093/rfs/11.4.817

Kumar, D. (2014). Return and volatility transmission between gold and stock sectors: Application of portfolio management and hedging effectiveness. *IIMB Management Review*, *26*(1), 2. https://doi.org/https://doi.org/10.1016/j.iimb.2014.01.003

Li, H., & Majerowska, E. (2008). Testing stock market linkages for Poland and Hungary: A multivariate GARCH approach. *Research in International Business and Finance*, *22*(3), 247-266. https://doi.org/https://doi.org/10.1016/j.ribaf.2007.06.001

Liow, K., & Ye, Q. (2018). Volatility causality and contagion in international securitized real estate markets. *Journal of European Real Estate Research*, *11*(2), 244-168. https://doi.org/10.1108/JERER-11-2017-0042

Liow, K. H. (2010). Integration among USA, UK, Japanese and Australian securitised real estate markets: an empirical exploration. *Journal of Property Research*, *27*(4), 289-308. https://doi.org/10.1080/09599916.2010.500872

Liow, K. H., & Ye, Q. (2018). Regime dependent volatilities and correlation in international securitized real estate markets. *Empirica*, *45*(3), 457-487. https://doi.org/10.1007/s10663-017-9368-4

Loh, L. (2013). Co-movement of Asia-Pacific with European and US stock market returns: A cross-time-frequency analysis. *Research in International Business and Finance*, *29*, 1-13. https://doi.org/https://doi.org/10.1016/j.ribaf.2013.01.001

Malliaropulos, D., Hardouvelis, G., & Priestley, R. (2006). EMU and European Stock Market Integration. *The Journal of Business*, *79*, 365-392.

Markowitz, H. (1952). Portfolio Selection. *The Journal of Finance*, *7*(1), 77-91. https://doi.org/10.2307/2975974

Mull, S. R., & Soenen, L. A. (1997). U.S. REITs as an Asset Class in International Investment Portfolios. *Financial Analysts Journal*, *53*(2), 55-61. https://doi.org/10.2469/faj.v53.n2.2072

Niskanen, J., & Falkenbach, H. (2010). REITs and Correlations with Other Asset Classes: A European Perspective. *Journal of Real Estate Portfolio Management*, *16*(3), 227-239. https://doi.org/10.1080/10835547.2010.12089877

Okorie, D. I., & Lin, B. (2021). Stock markets and the COVID-19 fractal contagion effects. *Finance Research Letters*, *38*, 101640. https://doi.org/https://doi.org/10.1016/j.frl.2020.101640

Saengchote, K., & Charoenpanich, C. (2021). Cash flow uncertainty and IPO underpricing: evidence from income guarantee in Thai REITs. *Journal of Property Investment & Finance*, *39*(6), 590-608. https://doi.org/10.1108/JPIF-07-2020-0085

Sjö, B. (2010). *Lectures in Modern Economic Time Series Analysis, memo*

Tangjitprom, N., Chavalittumrong, P., & Leelalai, V. (2016). Does real estate fund in Thailand provide diversification benefits for stock investment? *AU Journal of Management*, *14*(2), 26-33. (Assumption University)

Zheng, T., & Zuo, H. (2013). Reexamining the time-varying volatility spillover effects: A Markov switching causality approach. *The North American Journal of Economics and Finance*, *26*, 643-662. https://doi.org/https://doi.org/10.1016/j.najef.2013.05.001

VITA

NAME	Korn Kongkittiwong
DATE OF BIRTH	18 January 1995
PLACE OF BIRTH	Bangkok
INSTITUTIONS ATTENDED	Chulalongkorn University
HOME ADDRESS	91/32 Soi Wachirathamsatit 1, Sukhumvit 101/1, Bangchak, Prakhanong, Bangkok 10260 Thailand