Asia REITs interdependence and the impact of COVID-19 pandemic

Mr. Boonchai Asawapiched

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ความสัมพันธ์ของทรัสต์เพื่อการลงทุนในอสังหาริมทรัพย์ (REITs) ในเอเชีย และผลกระทบจากการระบาดของโรคติดเชื้อไวรัสโคโรนา 2019 (COVID-19)

นายบุญชัย อัศวพิเชษฐ

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By	Mr. Boonchai Asawapiched
Field of Study	Finance
Thesis Advisor	Assistant Professor ANIRUT PISEDTASALASAI, Ph.D.

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INDEPENDENT STUDY COMMITTEE

.... Chairman

()

.... Advisor

(Assistant Professor ANIRUT PISEDTASALASAI, Ph.D.)

.... Examiner

(Assistant Professor BOONLERT JITMANEEROJ, Ph.D.)

.... Examiner

(JANANYA STHIENCHOAK, Ph.D.)

บุญชัย อัศวพิเชษฐ : ความสัมพันธ์ของทรัสต์เพื่อการลงทุนในอสังหาริมทรัพย์ (REITs) ในเอเชีย และผลกระทบจากการระบาดของโรคติดเชื้อไวรัสโคโรนา 2019 (COVID-19) . (Asia REITs interdependence and the impact of COVID-19 pandemic) อ.ที่ปรึกษาหลัก : ผศ. ดร.อนิรุต พิเสฏฐศลาศัย

This study investigates Asia REIT interdependence and the impact of COVID-19 pandemic. The data of six major REIT markets in Asia (Japan, Singapore, Hong Kong, Thailand, Malaysia, and Taiwan) have been applied with Johansen cointegration test, Granger causality test, impulse response functions, and variance decomposition. In addition, U.S. REIT is incorporated to emphasis the its impact on Asia markets. The results indicate market integration at long-run period as REIT performance is closely related to the direct real estate market whereas REIT is affected by shocks and noise like stock in short-run. Moreover, it is found that Asia developed markets (Japan, Singapore, Hong Kong) are segmented and influence others which could be due to similar economic situation and the liquidity spilling over to emerging markets. The interdependent significantly changes after the breakout of COVID-19 suggesting international diversification in short run. It varies depending on the characteristics and capital structure of REIT. While, the recovery of REIT may rely on different disease control measures, monetary policy, and fund flow. The results show that the markets dominated by hotel and retail REIT (Singapore, Thailand, and Malaysia) have higher cointegration and differentiate from the others. Furthermore, the impact of U.S. significantly increases during the COVID-19 period which is the possible effect of massive COVID-19 stimulus packages of U.S. to Asian REIT markets.

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1. Introduction

1.1 Background

Real estate investment trusts (REIT) are an important investment vehicle that allows all investors to invest in large-scale and diversified portfolios of income-producing real estate as securitized and publicly tradeable forms. REIT were first established in 1960 by the United States Congress (NaREIT 2021). Since then, there were more than 800 REIT globally in approximately 50 countries, with a total market capitalization of over $2 trillion. While, around 270 REIT with market capitalization of $410 Billion (20% of global market) belong to Asia (EPRA 2020).

The growth of Asia REIT is crucial despite the relatively short history of REIT in Asia. The first launch was led by Japan in 2001 followed by Singapore in 2002. Hong Kong, Malaysia, and Taiwan started in 2005 (CFA 2011). Thailand successfully launched its first REIT in 2014 as a replacement of property funds offering greater flexibility comparing to previous regulations on property funds (JLL 2017). Other Asia countries, such as China, have begun preparing for launching publicly tradable REIT (CBRE 2020). Since the first establishment of REIT in Japan and Singapore, the Asia market has grown exponentially due to improving regulation, better corporate governance, and greater transparency. It also plays an important role in a multi-asset portfolio to reduce risk for international real estate securities funds ((Joseph, Graeme et al. 2006); (Bloomberg 2020)).

According to the rapid growth of Asia REIT, there are studies on REIT diversification benefits in the mixed asset portfolio suggesting some diversification which changes over time and depends on market conditions ((Newell, Yue et al. 2010); (Newell and Anh 2010); (Anh 2011); (Newell and Hsu 2012)). However, most of the studies focus on diversification benefits of REIT with other asset classes in a specific country. Relatively few scholars have discussed the interdependence between Asia REIT to analyze international diversification. Some studies focus on global integration and the effect of global financial crisis on REIT including a few major Asia markets. Their studies indicated possible diversification opportunities at the medium and short-run periods since global REIT linkages increases with investment horizons. Whereas, cross-market linkages vary with countries and changed significantly after the crises period. Moreover, well-developed markets tend to lead/lag smaller or less developed market ((Bum 2009); (Yong and Do 2017); (Ijasan, Tweneboah et al. 2019)).

On 31 Dec 2019, the first case of COVID-19 was reported by Wuhan Municipal Health Commission, China (WHO 2020). Then, it has spread around the world and impacted all financial markets worldwide. Asia REIT have also been hardly hit with various magnitudes in difference countries. Based on the data from Bloomberg, Japan REIT was most affected with the negative return of 47% follow by Singapore, Thailand, and Hongkong with the approximately negative return of 30-35% since the beginning of 2020. However, Asia REIT recovered with huge different pattern. Singapore REIT had negative return at only 7% in the end of 2020. While, REIT return in Thailand remained negative at 27%.

Due to the coronavirus-battered economy, the world gross domestic product is projected to be −4.9% in 2020, which is worse than the 2008–2009 financial crisis (IMF 2020). The COVID-19 crisis has triggered unprecedented stimulus policy responses by countries worldwide. Unsurprisingly, U.S. Federal Reserve Bank (Fed) has announced the unlimited QE on 23 March 2020 and U.S. Congress has passed the largest stimulus packages in American history. On 9 April 2020, Fed announced a massive $2.3 trillion in loans to households, local governments and small and large businesses (FED 2020). The stock markets around the world react positively to the news.

1.2 Objectives and Contributions

Due to limited studies in Asia REIT interdependent and the recently outbreak of COVID-19. This study aims to provide empirical evidence of Asia REIT interdependent with three main objectives as follows:

First, this study contributes to the existing literatures by addressing evidence of REIT interdependence among Asia markets and United States. Further than diversification benefits of individual Asia REIT in a mixed asset portfolio as suggested by previous researches ((Newell, Yue et al. 2010); (Newell and Anh 2010); (Anh 2011); (Newell and Hsu 2012)), investors could possibly incorporate international REIT from different Asia markets into a domestic portfolio to seek even more diversification if markets are not perfectly correlated. Even though, it is possible to find integration of REIT markets at long-run due to similar economic driven factors ((Oikarinen, Hoesli et al. 2011); (Hoesli and Oikarinen 2012); (Geng 2018)). The markets could have different short run dynamic, speed of adjustment, casual relation, and market segmentation. In which, it would allow investors to diversify their investment and stimulate fund flow across Asia REIT markets. Moreover, this is one of a few studies that apply impulse response functions and variance decomposition to observe the short run dynamic and variance transmission resulted from shocks so as to reflect possible contagion effect and market segmentation.

Second, several empirical studies suggest that the U.S. stock markets are closely linked with world markets ((Eun and Shim 1989), (Campbell and P. 1992), (Hardouvelis, Malliaropilos et al. 2006)). Whereas, the U.S. REIT market is the largest one in the world. Previous studies found that the U.S. REIT market has significant impact on various developed REIT markets in Asia especially after crisis periods due to volatility spillovers and the size effect impacts ((Bum 2009); (Yong and Do 2017); (Ijasan, Tweneboah et al. 2019)). While, some studies ((Bum 2009); (Gupta and Marfatia 2018)) find that developed markets are segmented and influence emerging markets which could be due to similar economic situation of developed markets and the liquidity spilling over to emerging markets. Therefore, this study aims to emphasis the influences of developed markets on emerging markets.

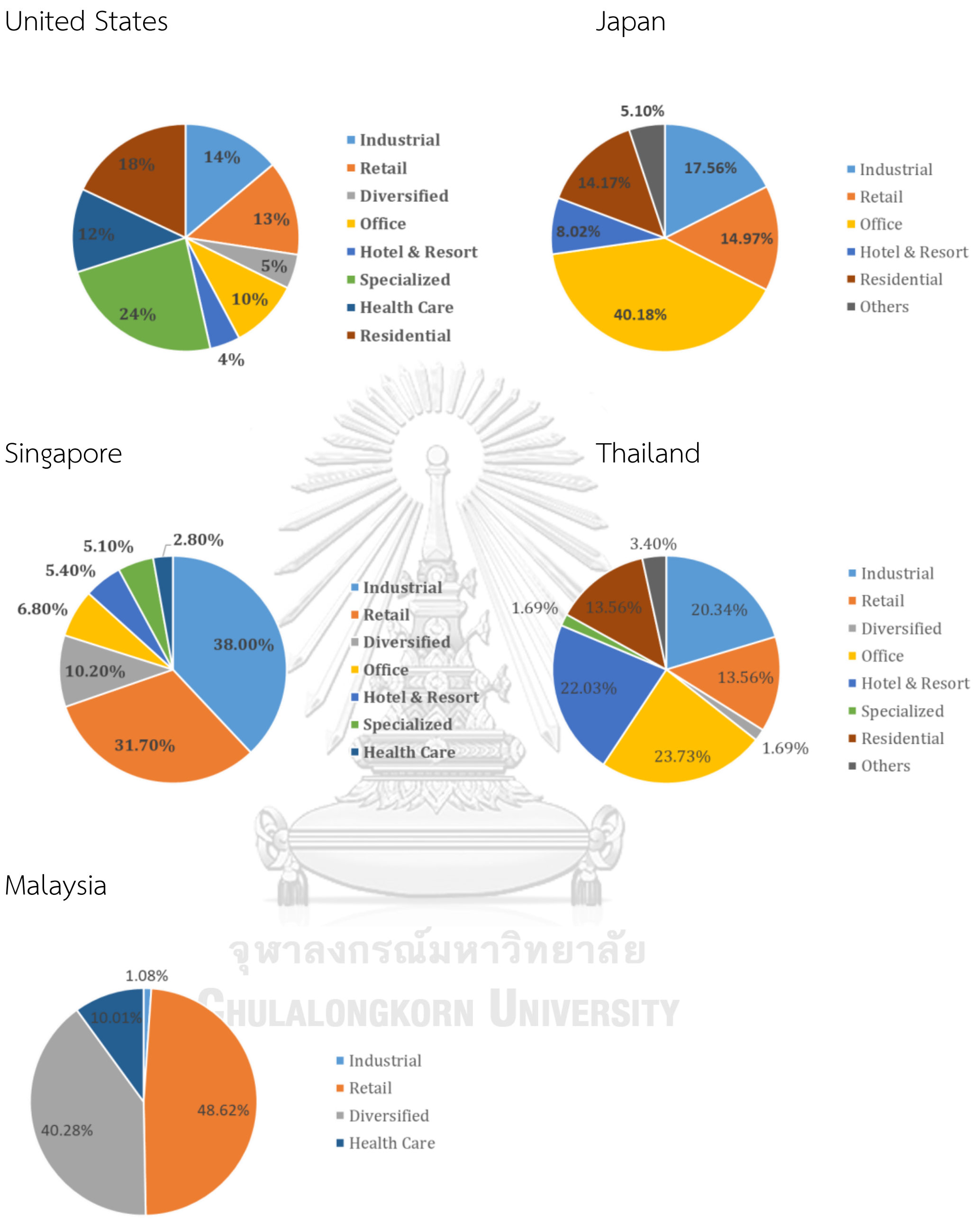
Third, to the best of my knowledge, this is the first study focusing on Asia REIT interdependence during COVID-19 pandemic to investigate whether the COVID-19 pandemic pronounces or changes the interdependence. As the COVID-19 pandemic has significant impacts on Asia REIT, the market interdependent may display clear different patterns before and after the pandemic outbreak. When the COVID-19 has officially been declared, all markets crash down simultaneously. However, the market recovery shows difference figures which could be due to each country disease control measures, monetary policy, and fund flow. Moreover, possible COVID-19-related changes in people behaviors and different forward strategic plan could lead to new market segmentation or tied up previously correlated markets even closer. As a consequence, investors would have to adjust their portfolio accordingly.

In this study, REIT market data of United States, Japan, Singapore, Hong Kong, Thailand, Malaysia, and Taiwan starting from 1 January 2013 to 31 March 2021 are applied. The Standard and Poor’s REIT indices are employed for United States, Japan, Singapore, Hong Kong, Thailand, while REIT indices for Malaysia, and Taiwan are constructed by using a value-weighted method.

To achieve the objectives of this study, cointegration and causation among Asia REIT and the United States are investigated using Johansen Cointegration Test (Johansen 1988, Johansen 1991) and Granger Causality Test (Engle and Granger 1987). Impulse response functions and variance decomposition derived from the vector error correction model (VECM) are also applied to observe the short run dynamic and variance transmission resulted from shocks so as to reflect possible contagion effect

Moreover, this study split the data and designate the market representatives. First, REIT data is disaggregated into two sub-periods which include pre-COVID-19 pandemic (1 January 2013 to 31 December 2019) and during COVID-19 pandemic (1 January 2020 to 31 March 2021) to assess the impact of COVID-19 pandemic on Asia REIT interdependence comparing the result between two sub-periods. Second, The REIT markets are classified into developed REIT markets (United States, Japan, Singapore, and Hong Kong) and emerging REIT markets (Thailand, Malaysia, and Taiwan) according to S&P in order to investigate the market segregation between developed and emerging markets. Third, the REIT markets which have majority in hotel and retail industry (Singapore: 37%, Thailand: 36%, and Malaysia: 49%) are specified as it has been affected with the greatest impact to address the benefit of industry diversification of Asia REIT during the COVID-19 pandemic. Figure 1 shows the sector break down of REIT markets for United States, Japan, Singapore, Thailand, and Malaysia. Whereas, the markets dominated by hotel and retail industry are Singapore, Thailand, and Malaysia with the combining percentage of 37%, 36%, and 49% respectively. For Hong Kong and Taiwan, almost all of the REIT are diversified type.

Figure 1 sector breakdown of REIT markets



1.3 Research Hypothesis

The hypothesis of market integration of Asia REIT markets at long-run periods is made because the long-run REIT performance is closely related to the direct real estate market in which controlled by similar economic factors such as population, interest rates, long-term supply whereas REIT is affected by shocks and noise like stock in short-run ((Oikarinen, Hoesli et al. 2011); (Hoesli and Oikarinen 2012); (Geng 2018)). While, developed markets (United States, Japan, Singapore, Hong Kong) should be segmented and influence emerging markets (Thailand, Malaysia, and Taiwan). These could be due to similar economic situation of developed markets and the liquidity spilling over to emerging markets ((Bum 2009); (Gupta and Marfatia 2018)).

Before the outbreak of COVID-19, the clustering of Asia markets and the contagion effect may varies depending on the characteristics and capital structure of REIT (Bum 2009). However, it is expected to change after the breakout of COVID-19. When the COVID-19 has officially been declared, all markets crash down simultaneously. But, developed markets (United States, Japan, Singapore, Hong Kong) shows much faster recovery than emerging market (Thailand, Malaysia, and Taiwan) after the COVID-19 which could be due to different disease control measures, monetary policy, and fund flow. (Ma, Rogers et al. 2020) suggest that developed markets trend to have greater ability to apply aggressive government fiscal policy which help reduce negative impacts, while emerging countries are most likely to experience larger negative impacts from COVID-19. Therefore, these could lead to wider gap between developed and emerging markets and could also be considered as a higher possibility for diversification.

Table 1: U.S. REIT return by asset classes (SOURCE: NAREIT US REIT ASSOCIATION)

Asset classes	2019 Average annual return (%)	Jan - Apr 2020 Return (%)
Industrial	48.71	-3.17
Retail	10.65	-41.16
Office	31.42	-22.63
Hotel & Resort	15.65	-45.81
Specialized	27.39	-31.89
Health Care	21.2	-30.42
Residential	30.89	-18.05

Due to the COVID-19, all REIT have varying degrees of negative impact. (Ma 2021) suggests that the impact of the pandemic is more serious for hotel and retail REIT since almost all global travel is banned due to COVID-19 and many types of retail business are forced to close (Table 1 shows, for example, the return of U.S. REIT during January and April 2020 compared with average annual return in 2019). Singapore, Thailand, and Malaysia where the combining dominates of hotel and retail REIT account for 37%, 36%, and 49% respectively. Therefore, the hypothesis of greater market cointegration of Singapore, Thailand, and Malaysia during the COVID-19 period is made.

During the COVID-19 pandemic, countries worldwide have released stimulus policies to boost up the damaged economy. Whereas, U.S. Federal Reserve Bank (Fed) has announced the unlimited QE on 23 March 2020 and U.S. Congress has passed the largest stimulus packages in American history. Several empirical studies suggest that the U.S. stock markets are closely linked with world markets ((Eun and Shim 1989), (Campbell and P. 1992), (Hardouvelis, Malliaropilos et al. 2006)). Whereas, the U.S. REIT market is the largest one in the world. Previous studies found that the U.S. REIT market has significant impact on various developed REIT markets in Asia especially after crisis periods due to volatility spillovers and the size effect impacts ((Bum 2009); (Yong and Do 2017); (Ijasan, Tweneboah et al. 2019)). Therefore, this study hypothesizes that the U.S. REIT market trend to has greater impact on to the developed Asia REIT markets (Japan, Singapore, and Hong Kong) during the COVID-19 period.

2. Literature Review

2.1 REITs diversification benefits in the mixed asset portfolio

(Newell and Hsu 2012) found that the performance (average annual return, Sharpe ratio) of Japan REIT (7.11%, 0.35) outperformed property companies (4.64%, 0.16), shares (1.03%, 0.05), and bond (1.04%, 0.23). Moreover, J-REIT showed some portfolio diversification benefits with property companies (corr = 0.62), shares (corr = 0.58), and bond (corr = -0.02). However, GFC had higher impact on the Japan REIT (−28.44%, -0.94) and property companies (−29.52%, -0.81) than shares (-25.04%, -0.97). During the crisis, the correlation coefficient of 0.76 (J-REIT and property companies) and 0.78 (J-REIT and shares) indicate that J-REIT diversification benefits significantly reduced.

In Singapore (Newell and Anh 2010), REIT also has the highest annualized mean return and Sharp ratio (15.37%, 0.60) compared to property companies (14.96%, 0.52), shares (10.89%, 0.48), and bond (3.25%, 0.45). Meanwhile, the correlation between the Singapore REIT with shares (0.84) and property companies (0.70) was strong reflecting little portfolio diversification benefit. GFC has the largest negative impact on Singapore REIT return (−20.85%, -0.51). On the other hand, the sub-period correlation analysis reveals that REIT had a weak relationship with shares (0.45) and property companies (0.39) before the crisis. The correlation increased to 0.94 (REIT and shares) and 0.78 (REIT and property companies), respectively, during the crisis. This reduced portfolio diversification benefit by S-REIT.

(Anh 2011) suggested that Thai REIT provides the lowest annualized return and Sharp ratio (0.56%, -0.2) among property companies (3.35%, 0.02), shares (13.1%, 0.38), and bond (4.61%, 0.79). Thai-REIT provides some diversification as it moderately correlated with property stocks (r=0.67) and shares (r=0.67). It also negatively correlated to bond (r=-0.37). Thai REIT was much less impacted by GFC (-8.81%, -0.79) compare to property companies (-44.08%, -0.98), shares (-29.85%, -0.8). Moreover, the result showed that the correlation between Thai REIT and other assets increased and decreased significantly during and after GFC respectively.

2.2 REITs interdependent

(Bum 2009) analyzes the impact of the U.S. real estate market collapse on the Asia-Pacific real estate markets (Korea, Japan, and Australia) by examining linkages between the U.S. and other countries, cointegration among Asia-Pacific REIT, and contagion effects. Johansen co-integration analysis (1988, 1990) using the error correction model (ECM) was applied. Results indicate that co-movements between U.S. and Korean have become significant only after the breakout of global financial crisis, Japanese REIT shows weak relationship with the U.S. REIT, and Asia-Pacific REIT have weak cointegration with different magnitudes of contagion effects.

(Yong and Do 2017) studied interdependence of REIT market in six countries including Australia, Hong Kong, Japan, Singapore, the UK and the US during and after the crisis periods of the Sub-prime Mortgage Crisis, Global Financial Crisis and European Debt Crisis. They applied a bivariate E-GARCH-M model which is a combination of the Nelson (1991) E-GARCH model and the Engle, Lilien and Robins (1987) GARCH-in-mean (GARCH-M) to capture cross-market relationships. Their results found cross-market linkages vary with countries and changed significantly after the crises period. They showed that the returns of REIT in Australia, the UK and US to be segmented, and interdependence for Hong Kong, Japan and Singapore markets. While, asymmetric effects of volatility spillovers between markets exist during the crises period, but this only persists in some countries.

(Ijasan, Tweneboah et al. 2019) used another technique called multivariate wavelet method to explores dynamic correlation and interdependence of five global REIT markets including United States, Hong Kong, Belgium, South Africa and Australia. Their results showed evidence against a segmented global REIT market with the following findings: First, there were possible diversification opportunities as the market correlation dissipate at the medium, and short-run periods. However, global REIT linkages increases with investment horizons. Second, well-developed REIT tend to lead/lag relatively smaller or less developed market.

2.3 Industry diversification of REITs

(Ma 2021) analyzes the average return rate, FFO growth rate and dividend rate of US and Singapore REIT during the COVID-19 periods. He found that when the COVID-19 pandemic and the overall economic environment is unstable, all REIT have varying degrees of negative impact, especially for hotel REIT and retail REIT, the adverse impact is more serious, and the adverse impact on logistics REIT and digital computer room REIT is small. The results show that US and Singapore REIT can better resist risks by adopting the diversified portfolio theory.

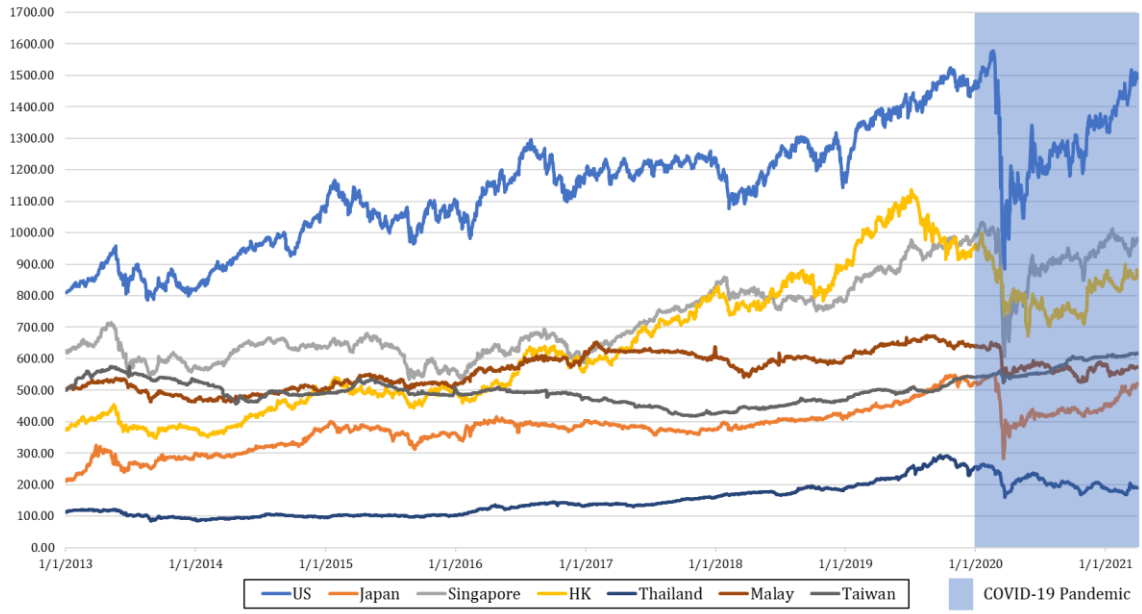
(Ping and Jalil 2016) study the property types diversification strategy of Malaysian REIT during 2010 and 2014. Their study suggests that property type diversification play a significant role in Malaysia REIT but little influence of property types diversification strategy toward Malaysian REIT performance. The study shows Malaysian REIT performance of dividend yield (DY) has a positive correlation value with commercial lot property type and Malaysian REIT performance of expected return (ER) have a highest positive correlation value with industrial property types.

3. Data

REIT market data of United States, Japan, Singapore, Hong Kong, Thailand, Malaysia, and Taiwan starting from 1 January 2013 to 31 March 2021 are applied. The Standard and Poor's REIT indices are employed for United States, Japan, Singapore, Hong Kong, Thailand (Note that S&P Thailand REIT index include both property funds and REIT in the calculation), while REIT indices for Malaysia, and Taiwan are constructed by using a value-weighted method.

The REIT markets are classified into developed REIT markets (United States, Japan, Singapore, and Hong Kong) and emerging REIT markets (Thailand, Malaysia, and Taiwan) according to S&P. Whereas, Singapore, Thailand, and Malaysia are group as the REIT markets which have majority in hotel and retail industry and also has been affected with the greatest impact of COVID-19 pandemic.

Figure 2: Daily S&P REIT gross total return indices of United States, Japan, Singapore, Hong Kong, Thailand and value weighted indices of Malaysia and Taiwan starting from 1 January 2013 to 31 March 2021



The study period commenced from 1 January 2013 to 31 March 2021. The beginning date (1 January 2013) is selected when the data is available for all markets. In addition, these data were disaggregated into two groups to measure their linkage across time.

i) pre-COVID-19 pandemic: 1 January 2013 to 31 December 2019

ii) during COVID-19 pandemic: 1 January 2020 to 31 March 2021

While, the date for COVID-19 outbreak is determined by reference to WHO when the first case of COVID-19 was reported by Wuhan Municipal Health Commission On 31 Dec 2019.

3.1 Descriptive statistics

Table 2: Descriptive statistics

Markets	US	Japan	Singapore	HK	Thailand	Malay	Taiwan
Full period (1 Jan 2013 - 31 Mar 2021)							
Minimum daily return (%)	-20.884	-20.385	-10.839	-10.123	-12.440	-6.916	-4.111
Maximum daily return (%)	8.666	12.952	8.659	6.229	5.940	6.109	3.877
Average daily return (%)	0.028	0.042	0.021	0.039	0.024	0.006	0.010
Average daily standard deviation (%)	1.294	1.252	0.959	1.093	0.981	0.680	0.355
Pre-COVID (1 Jan 2013 - 31 Dec 2019)							
Minimum daily return (%)	-4.852	-7.730	-4.957	-4.367	-6.467	-5.555	-4.111
Maximum daily return (%)	3.392	5.667	4.082	5.647	5.940	6.109	3.877
Average daily return (%)	0.033	0.050	0.026	0.052	0.045	0.013	0.004
Average daily standard deviation (%)	0.905	0.961	0.691	0.991	0.791	0.609	0.356
During COVID (1 Jan 2020 - 31 Mar 2021)							
Minimum daily return (%)	-20.884	-20.385	-10.839	-10.123	-12.440	-6.916	-3.498
Maximum daily return (%)	8.666	12.952	8.659	6.229	5.846	3.932	1.331
Average daily return (%)	0.002	-0.002	-0.005	-0.033	-0.093	-0.033	0.041
Average daily standard deviation (%)	2.545	2.276	1.843	1.544	1.684	0.988	0.349

The return and risk (represented by standard deviation) of Asia and US REIT markets are shown in Table 2. For the full period, Japan has the highest average daily return of 0.042% (10.570% p.a.). While, Malaysia has the lowest average daily return of 0.006% (1.581% p.a.). In Pre-COVID, most of the markets have higher return than the full period except for Taiwan (Full period 0.010% or 2.450% p.a., Pre-COVID 0.004% or 1.060% p.a.). The markets that have highest and the lowest average daily return in this period are Hongkong (0.052% or 12.994% p.a.) and Taiwan (0.004% or 1.060% p.a.) respectively. After the breakout of COVID-19, almost all markets have negative average yearly return with high volatility as indicated by high standard deviation in which Thailand has the highest negative return of 0.093% (-23.54% p.a.). On the other hand, US has a little positive average daily return of 0.002% (0.42% p.a.). The return of Taiwan during COVID is even higher than the one in Pre-COVID period (Pre-COVID 0.004% or 1.06% p.a., During COVID 0.041% or 10.23% p.a.).

3.2 Correlations of REIT markets

Full period (1 Jan 2013 - 31 Mar 2021)							
Markets	**US**	**Japan**	**Singapore**	**HK**	**Thailand**	**Malay**	**Taiwan**
US	1.0000	0.9531	0.8330	0.8984	0.8420	0.8477	0.0256
Japan		1.0000	0.8153	0.8490	0.8378	0.7652	0.1258
Singapore			1.0000	0.8858	0.9137	0.6581	0.2735
HK				1.0000	0.9217	0.8341	-0.0287
Thailand					1.0000	0.7753	0.1654
Malay						1.0000	-0.2221
Taiwan							1.0000
Pre-COVID (1 Jan 2013 - 31 Dec 2019)							
Markets	**US**	**Japan**	**Singapore**	**HK**	**Thailand**	**Malay**	**Taiwan**
US	1.0000	0.9475	0.8118	0.9086	0.8586	0.9061	-0.3811
Japan		1.0000	0.7723	0.8464	0.8340	0.8141	-0.2555
Singapore			1.0000	0.9251	0.9412	0.7611	-0.2358
HK				1.0000	0.9342	0.8632	-0.3757
Thailand					1.0000	0.8243	-0.1702
Malay						1.0000	-0.3763
Taiwan							1.0000
During COVID (1 Jan 2020 - 31 Mar 2021)							
Markets	**US**	**Japan**	**Singapore**	**HK**	**Thailand**	**Malay**	**Taiwan**
US	1.0000	0.9405	0.8984	0.7328	0.3137	0.5512	0.3370
Japan		1.0000	0.8471	0.7505	0.4279	0.6620	0.1813
Singapore			1.0000	0.5694	0.2687	0.4671	0.4446
HK				1.0000	0.4673	0.7042	-0.0256
Thailand					1.0000	0.8621	-0.6463
Malay						1.0000	-0.4578
Taiwan							1.0000

Table 3: Correlations of REIT markets

The correlations of REIT markets seem high ranging from 0.66 to 0.95 in the overall study period except for Taiwan which has low and negative correlation with the others. U.S. and Japan have the highest correlation of 0.95. While, Malay and Taiwan have the highest negative correlation of -0.22. In pre-covid period, there are higher correlation of HK, Thailand, and Malaysia with the other markets. Whereas, the correlation of Japan, Singapore, and Taiwan with the other markets become lower. The highest correlation is also found for U.S. and Japan in this period (0.95) in which U.S. and Taiwan have the highest negative correlation of -0.38. During Covid period, most of the markets show significant lower correlation comparing with the pre-covid period. For example, the highest correlation of Thailand with other markets decreases from 0.94 to the lowest one of 0.27. The highest correlation is also found for U.S. and Japan in this period (0.94) in which Thailand and Taiwan have the highest negative correlation of -0.65.

3.3 Unit root test

In the analysis of time series data, it is required to test for stationary (statistical properties of a time series do not change over time). Supposing that the two variables seem to move together; each data series may be non-stationary. If the variables are non-stationary, there may be a spurious relationship between the two variables making no economic significance of the spurious regression.

There are several methods used to check the stationary of the data such as Dickey-Fuller test and ADF test (Dickey and Fuller 1979), Phillips–Perron test (Phillips and Perron 1988), and KPSS test (Kwiatkowski, Phillips et al. 1992). However, one of the most commonly used Augmented Dickey-Fuller (ADF) test is employed to assess the stationarity in this study using Akaike's information criterion (AIC) to select the lag range (Akaike 1973). The specification of the ADF test is shown below:

$$\Delta x_t = \beta_0 + \beta_1 t + \gamma x_{t-1} + \sum_{i=1}^{n}(\delta_i \Delta x_{t-i}) + \varepsilon_t \qquad (1)$$

Where: x_t is the natural log form of daily REIT indices

β_0 is a constant

β_1 represents a time trend

γ represents the coefficient presenting process root

n is the lag order of the first-differences autoregressive process

δ_i are the estimated parameters

ε_t is assumed to be the white noise

The hypothesis can be written as

$$H_0 : \gamma = 0$$

$$H_1 : \gamma < 0$$

If γ = 0, it indicates that x_t is a non-stationary time series. In contrast, the series is stationary if γ < 0.

First, ADF is applied to analyze whether the data has trend or interception using t-statistic to justify their significant. If it found not to be significant, trend or interception will not be considered. Second, apply ADF at level (no different) setting up condition for trend or interception as found in the first step and use ACI to determine the lag. Then, compare ADF statistic with critical value at 1% and 5%. If ADF statistic is more than critical value, the data is stationary (the stationary is found at level, I(0)). Third, supposing that unit root is found in the second step. ADF with difference will be continued until it is stationary. Normally, there will be stationary no further than the second different. Then, the stationary in the first different is called as integrate order at I(1). The REIT indices are examined in the natural log form using ADF tests with constant and trend. Expectedly and in line with the previous literatures (Bum 2009), all of the return indices appear to be non-stationary in levels and stationary in differences, and also the fundamental variables seem to be I(1). First differences of the natural log form REIT indices are stationary at 1 per cent level of significance for ADF tests for all period.

Table 4: Unit root test using Augmented Dickey-Fuller (ADF) test with the following equation, $\Delta x_t = \beta_0 + \beta_1 t + \gamma x_{t-1} + \sum_{i=1}^{n}(\delta_i \Delta x_{t-i}) + \varepsilon_t$ (Where x_t is the natural log form of daily REIT indices. β_0 is a constant. β_1 represents a time trend. γ represents the coefficient presenting process root. n is the lag order of the first-differences autoregressive process. δ_i are the estimated parameters. ε_t is assumed to be the white noise). Akaike's information criterion (AIC) is applied to select the lag range. The coefficient in the table represents the process root (γ), it indicates that the data is a non-stationary time series if γ = 0. In contrast, the series is stationary if γ < 0. The number in parenthesis are t-statistics. *** indicates 1 percent significant level ** indicates 5 percent significant level * indicates 10 percent significant level

Overall Study Period (1 Jan 2013 - 31 Mar 2021)

Variable	Level	Difference
LNHK	-0.0032 (-1.6959)	-1.0122 (-33.8752)***
LNJAPAN	-0.0122 (-3.1885)	-0.9310 (-11.3801)***
LNMALAY	-0.0042 (-1.9172)	-1.0689 (-13.6080)***
LNSINGAPORE	-0.0075 (-3.1964)	-0.8299 (-11.0389)***
LNTAIWAN	-0.0001 (-0.0841)	-0.8470 (-20.7326)***
LNTHAILAND	-0.0038 (-2.5843)	-0.6842 (-9.7868)***
LNUS	-0.0124 (-3.3533)	-1.1818 (-10.3955)***

Pre-Covid (1 Jan 2013 - 31 Dec 2019)

Variable	Level	Difference
LNHK	-0.0080 (-2.7531)	-1.0545 (-31.5515)***
LNJAPAN	-0.0105 (-2.6928)	-0.9077 (-12.2133)***
LNMALAY	-0.0062 (-2.1484)	-1.2942 (-28.5218)***
LNSINGAPORE	-0.0041 (-2.2317)	-0.7333 (-12.0480)***
LNTAIWAN	-0.0005 (-0.3746)	-0.8218 (-18.8880)***
LNTHAILAND	-0.0034 (-2.4787)	-0.8500 (-18.3153)***
LNUS	-0.0126 (-3.3827)	-1.0154 (-31.1750)***

Covid (1 Jan 2020 - 31 Mar 2021)

Variable	Level	Difference
LNHK	-0.0228 (-2.1113)	-1.0491 (-7.7123)***
LNJAPAN	-0.0312 (-2.5729)	-0.9140 (-4.5407)***
LNMALAY	-0.0389 (-2.7046)	-0.8780 (-5.3617)***
LNSINGAPORE	-0.0341 (-2.9190)	-0.7762 (-4.9168)***
LNTAIWAN	-0.0246 (-2.0409)	-1.0750 (-19.3029)***
LNTHAILAND	-0.0387 (-3.3382)	-0.7291 (-13.5683)***
LNUS	-0.0300 (-2.3114)	-0.9996 (-9.6232)***

4. Methodology

To determine the interdependence among Asia REIT market, several analyses are applied as follows. First, the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller 1979) is employed to assess the stationarity of the data both level and different. Second, if the data found to be stationary with the first different I(1). (Johansen 1988, Johansen 1991) is applied to test the long-run relationship. Third, this study conducts Granger Causality Test (Granger 1969) for the data found be stationary with the first different I(1) and there are long-run relationship to observe the lead/lag relationship among Asia REIT market and also the speed of adjustment to the long-run equilibrium when it deviate at short run due to the shock. Last, movement of REIT indices corresponding to the shock and the composition of variances that caused by shocks from individual market and the others are conducted through impulse response function and variance decomposition.

4.1 Johansen Cointegration Test

Cointegration test can be used to identify long-run relationship of two or more non-stationary time series or I(1). It was first introduced by (Granger 1986) in the sense that variables may deviate from each other in the short-run but they cannot move away from some equilibrium in the long term. However, with limitation of Granger test, (Johansen 1988, Johansen 1991) allows for more than one cointegrating relationship. Therefore, the following equation was specified to assess long-run relationships using the Johansen method and use ACI to determine the lag:

$$\Delta x_t = \mu + \sum_{i=1}^{k-1}(\Gamma \Delta x_{t-i}) + \Pi x_{t-k} + \varepsilon_t \qquad (2)$$

Based on the Johansen's model, ε_t is a sequence of zero-mean p-dimensional white noise vectors. Variables are included in x_t and it is a p x 1 vector. Γ and Π denotes p x p matrix that contains information about the rank.

To determine the number of cointegrating vector (Rank (Π)), it can be divided into 3 cases.

1. Full rank: When Rank (Π) = p, it means that vector p denoted all variables is stationary, I(0)
2. Rank (Π) = 0 implying all variables are non-stationary, I(1) and the absence of long-run relationship among variables.
3. Rank = r in which 0 < rank (Π) < p there will be r cointegrated relationship

In the Johansen methodology, two test statistics – trace and maximum eigenvalue - are used.

Trace test: λ trace (r) = - T $\sum_{i=r+1}^{n} ln(1 - \lambda_i)$ (3)

Maximum eigenvalue test: λ max (r, r+1) = - T $ln(1 - \lambda_{r+1})$ (4)

Where: T denotes the number of observations

λ_i is the maximum eigenvalue of Π matrix

The Trace value is use to test hypothesis

H_0 : The number of cointegration vector is less than or equal to r

H_1 : The number of cointegration vector is more than r

The Maximum eigenvalue is use to test hypothesis

H_0 : The number of cointegration vector is less than or equal to r

H_1 : The number of cointegration vector is more than r + 1

4.2 Granger Causality Test from the vector error correction model (VECM)

When the data is found to be stationary at level I(0) or there are long-run relationship for the stationary data at first different, I(1). Error correction mechanism can be applied to explain the adjustment of variables in short run by reflecting the speed of adjustment. When variables deviate from the equilibrium due to shocks, it would adjust to long-run equilibrium based on Granger Representative Theorem (Granger 1969). Moreover, the Granger causality test can be used to determine whether one time series is useful for forecasting another. In particular, if a variable lead/lag another in the time series.

$$\Delta x_{US,t} = a_{US} + \Phi_{US}ECT_{t-1} + \sum_{i=1}^{k}(\alpha_{US,i}\Delta x_{US,t-i}) + \sum_{i=1}^{k}(\alpha_{JA,i}\Delta x_{JA,t-i}) + \sum_{i=1}^{k}(\alpha_{SG,i}\Delta x_{SG,t-i}) + \sum_{i=1}^{k}(\alpha_{HK,i}\Delta x_{HK,t-i}) + \sum_{i=1}^{k}(\alpha_{TH,i}\Delta x_{TH,t-i}) + \sum_{i=1}^{k}(\alpha_{MA,i}\Delta x_{MA,t-i}) + \sum_{i=1}^{k}(\alpha_{TAI,i}\Delta x_{TAI,t-i}) + \varepsilon_{US,t} \tag{5}$$

$$\Delta x_{JA,t} = a_{JA} + \Phi_{JA}ECT_{t-1} + \sum_{i=1}^{k}(\alpha_{JA,i}\Delta x_{JA,t-i}) + \sum_{i=1}^{k}(\alpha_{US,i}\Delta x_{US,t-i}) + \sum_{i=1}^{k}(\alpha_{SG,i}\Delta x_{SG,t-i}) + \sum_{i=1}^{k}(\alpha_{HK,i}\Delta x_{HK,t-i}) + \sum_{i=1}^{k}(\alpha_{TH,i}\Delta x_{TH,t-i}) + \sum_{i=1}^{k}(\alpha_{MA,i}\Delta x_{MA,t-i}) + \sum_{i=1}^{k}(\alpha_{TAI,i}\Delta x_{TAI,t-i}) + \varepsilon_{JA,t} \tag{6}$$

$$\Delta x_{SG,t} = a_{SG} + \Phi_{SG}ECT_{t-1} + \sum_{i=1}^{k}(\alpha_{SG,i}\Delta x_{SG,t-i}) + \sum_{i=1}^{k}(\alpha_{US,i}\Delta x_{US,t-i}) + \sum_{i=1}^{k}(\alpha_{JA,i}\Delta x_{JA,t-i}) + \sum_{i=1}^{k}(\alpha_{HK,i}\Delta x_{HK,t-i}) + \sum_{i=1}^{k}(\alpha_{TH,i}\Delta x_{TH,t-i}) + \sum_{i=1}^{k}(\alpha_{MA,i}\Delta x_{MA,t-i}) + \sum_{i=1}^{k}(\alpha_{TAI,i}\Delta x_{TAI,t-i}) + \varepsilon_{SG,t} \tag{7}$$

$$\Delta x_{HK,t} = a_{HK} + \Phi_{HK}ECT_{t-1} + \sum_{i=1}^{k}(\alpha_{HK,i}\Delta x_{HK,t-i}) + \sum_{i=1}^{k}(\alpha_{US,i}\Delta x_{US,t-i}) + \sum_{i=1}^{k}(\alpha_{JA,i}\Delta x_{JA,t-i}) + \sum_{i=1}^{k}(\alpha_{SG,i}\Delta x_{SG,t-i}) + \sum_{i=1}^{k}(\alpha_{TH,i}\Delta x_{TH,t-i}) + \sum_{i=1}^{k}(\alpha_{MA,i}\Delta x_{MA,t-i}) + \sum_{i=1}^{k}(\alpha_{TAI,i}\Delta x_{TAI,t-i}) + \varepsilon_{HK,t} \quad (8)$$

$$\Delta x_{TH,t} = a_{TH} + \Phi_{TH}ECT_{t-1} + \sum_{i=1}^{k}(\alpha_{TH,i}\Delta x_{TH,t-i}) + \sum_{i=1}^{k}(\alpha_{US,i}\Delta x_{US,t-i}) + \sum_{i=1}^{k}(\alpha_{JA,i}\Delta x_{JA,t-i}) + \sum_{i=1}^{k}(\alpha_{SG,i}\Delta x_{SG,t-i}) + \sum_{i=1}^{k}(\alpha_{HK,i}\Delta x_{HK,t-i}) + \sum_{i=1}^{k}(\alpha_{MA,i}\Delta x_{MA,t-i}) + \sum_{i=1}^{k}(\alpha_{TAI,i}\Delta x_{TAI,t-i}) + \varepsilon_{TH,t} \quad (9)$$

$$\Delta x_{MA,t} = a_{MA} + \Phi_{MA}ECT_{t-1} + \sum_{i=1}^{k}(\alpha_{MA,i}\Delta x_{MA,t-i}) + \sum_{i=1}^{k}(\alpha_{US,i}\Delta x_{US,t-i}) + \sum_{i=1}^{k}(\alpha_{JA,i}\Delta x_{JA,t-i}) + \sum_{i=1}^{k}(\alpha_{SG,i}\Delta x_{SG,t-i}) + \sum_{i=1}^{k}(\alpha_{HK,i}\Delta x_{HK,t-i}) + \sum_{i=1}^{k}(\alpha_{TH,i}\Delta x_{TH,t-i}) + \sum_{i=1}^{k}(\alpha_{TAI,i}\Delta x_{TAI,t-i}) + \varepsilon_{MA,t} \quad (10)$$

$$\Delta x_{TAI,t} = a_{TAI} + \Phi_{TAI}ECT_{t-1} + \sum_{i=1}^{k}(\alpha_{TAI,i}\Delta x_{TAI,t-i}) + \sum_{i=1}^{k}(\alpha_{US,i}\Delta x_{US,t-i}) + \sum_{i=1}^{k}(\alpha_{JA,i}\Delta x_{JA,t-i}) + \sum_{i=1}^{k}(\alpha_{SG,i}\Delta x_{SG,t-i}) + \sum_{i=1}^{k}(\alpha_{HK,i}\Delta x_{HK,t-i}) + \sum_{i=1}^{k}(\alpha_{TH,i}\Delta x_{TH,t-i}) + \sum_{i=1}^{k}(\alpha_{MA,i}\Delta x_{MA,t-i}) + \varepsilon_{TAI,t} \quad (11)$$

Referring to equation (5) – (11), the aim of this mechanism is to see the adjustment of REIT indices in short run to long-run equilibrium of six Asia REIT markets including United States and to test whether lagged values of variables can explain endogenous variables significantly. For these reasons, there are four equations used in this study and use ACI to determine the lag.

Whereas, x_t denotes a matrix of endogenous variables, a is a vector of constant, Φ is a speed of adjustment, $\alpha_i$represent beta coefficients for the endogenous variables with k number of lags and ε_t is the white noise error term.

A hypothesis was formed to test the causality relationship. If the null hypothesis is rejected, it means that one series Granger cause another series. The hypothesis for equation (5) are shown below in which it is the same for other models.

H_0: $\alpha_1 = \alpha_2 = \ldots = \alpha_k = 0$ H_1: at least one of the α not equal to 0.

For the speed of adjustment (Φ), it is theoretically ranging between -1 and 0. If it is statistically significant, the closer the number to -1, the higher speed of adjustment. However, positive number implies that the process it not converging in the long run.

4.3 Impulse response function and variance decomposition

Based on the cointegrating long-run relations, the VECM model can be used to see the movement of REIT markets corresponding to the shock through the graph of impulse response function. The long-run response magnitudes are investigated by the accumulated reactions of the REIT returns. If REIT markets are co-integrated in long term, the accumulated responses to shocks should be similar and that could lead to the loss of diversification benefits between the markets. In contrast, if the relative reaction magnitudes notably differed between markets, the diversification benefits may exist.

Variance decomposition allow us to analyze the proportion of the variation effected by shocks of individual market and others. If the forecast error variance decompositions show that a notable share of the long-term forecast error variance of a REIT market is explained by other REIT markets, the analysis indicates the long-term influence of those markets. The greater proportion, the stronger this kind of result is.

5. Result

5.1 Johansen Cointegration Test

Table 5 Johansen Cointegration Test with the following equation was specified to assess long-run relationships using the Johansen method and use ACI to determine the lag, $\Delta x_t = \mu + \sum_{i=1}^{k-1}(\Gamma \Delta x_{t-i}) + \Pi x_{t-k} + \varepsilon_t$ (Variables are included in x_t and it is a p x 1 vector. Γ and Π denotes p x p matrix that contains information about the rank. ε_t is a sequence of zero-mean p-dimensional white noise vectors). Two test statistics (trace and maximum eigenvalue) are used (Trace test: λ trace (r) = - T $\sum_{i=r+1}^{n} ln(1-\lambda_i)$ and Maximum eigenvalue test: λ max (r, r+1) = - T $ln(1-\lambda_{r+1})$, where T denotes the number of observations and λ_i is the maximum eigenvalue of Π matrix, H_0 : The number of cointegration vector is less than or equal to r and H_1 : The number of cointegration vector is more than r). In the table, r or rank (Π) is the number of cointegrating vectors. The number in parenthesis are Trace statistic and Max-Eigen statistic. *** rejects null hypothesis at 1 percent significant level ** rejects null hypothesis at 5 percent significant level * rejects null hypothesis at 10 percent significant level. Lag length for the model for all periods is 3. Test includes constant but no linear trend.

Null hypothesis	Overall Study Period (1 Jan 2013 - 31 Mar 2021)	Pre-Covid (1 Jan 2013 - 31 Dec 2019)	Covid (1 Jan 2020 - 31 Mar 2021)
Cointegration: trace test	indicates 3 cointegrating eqn(s)	indicates 1 cointegrating eqn(s)	indicates 1 cointegrating eqn(s)
r = 0	(173.2561)***	(139.0720)**	(143.4983)**
r ≤ 1	(117.2866)***	(92.6390)	(85.4999)
r ≤ 2	(81.5813)**	(63.9504)	(56.5153)
r ≤ 3	(47.6893)	(46.0393)	(38.7854)
Cointegration: max-eigen test	indicates 1 cointegrating eqn(s)	indicates no cointegrating eqn(s)	indicates 1 cointegrating eqn(s)
r = 0	(55.9695)***	(46.4330)*	(57.9984)***
r ≤ 1	(35.7053)	(28.6886)	(28.9846)
r ≤ 2	(33.8920)*	(17.9111)	(17.7299)
r ≤ 3	(17.7324)	(15.2535)	(14.8570)

The Johansen Cointegration Test is applied on the non-stationary series using the natural log form of daily REIT indices to examine the long-run relationship among the markets. Based on the VAR model and the Akaike Information Criterion (AIC), three lags with constant but no linear trend is found to be the best fit with the model. As shown in table 5, null hypothesis of r = 0 is rejected, it suggests at least one cointegrating equation for all study period that govern the long-run co-movements of the variables. However, trace test and max-eigen test produce little contradiction. For example, trace test and max-eigen test indicates three cointegrating equations and one cointegrating equation respectively in overall study period. (Johansen and Juselius 1990), (Kasa 1992), and (Serletis 1997) recommend the use of trace statistics given that trace statistics are more importance as it considers all of the smallest eigenvalues and hold more power than the maximum eigenvalue statistic.

The cointegrating relationship are observed for the overall study period (trace test - three cointegrating equations), pre-covid period (trace test - one cointegrating equation) and covid period (trace test - one cointegrating equation). The result suggests stronger linkage between markets in the overall study period as reflected in higher number of cointegrating equations. It supports the hypothesis of market integration at long run period which is consistent with the previous literature as long-run REIT performance is closely related to the direct real estate ((Oikarinen, Hoesli et al. 2011); (Hoesli and Oikarinen 2012); (Geng 2018)). However, there is one cointegrating equation for both pre-covid and covid period (trace test) which does not reflect significant change in the degree of linkage between markets during both periods.

5.2 **Granger Causality Test from the vector error correction model (VECM)**

5.2.1 Adjustment coefficients and short run coefficients of VECM

As cointegration test indicates long-run relationship among Asia REIT and US REIT, vector error correction model can be applied to explain the short run mechanisms. The results are consistent with the cointegration test as the model suggests that there is a long-term adjustment process between Asia REIT markets and US REIT market. The error correction term is found to be negative and significant at the level of at least 5% except for the case in which US and Thailand are dependent variables in overall study period.

The results show clear different figure in pre-covid and covid period. The significance of the error correction terms depends on the dependent variables in pre-covid period. For example, the error correction term is found to be negative and significant at the level of 5% where Hongkong, Japan, and Malaysia are dependent variables, the error correction terms are positive or not significant when dependent variables are Singapore, Taiwan, Thailand, and US. While, it does not show long-term adjustment of the markets in covid period as reflected in positive error correction term. This could be due to the study period which does not cover all of the COVID period. Each REIT market has been hit with various magnitudes and has not converted back to equilibrium. Based on the data from Bloomberg, Japan REIT was most affected with the negative return of 47% follow by Singapore, Thailand, and Hongkong with the approximately negative return of 30-35% since the beginning of 2020. However, Asia REIT recovered with huge different pattern. Singapore REIT had negative return at only 7% in the end of 2020. While, REIT return in Thailand remained negative at 27%.

For the overall study period, the coefficients of the lagged values are significant suggesting high lead-lag relationship among Asia markets and United States in short run. However, the relationship among Asia markets and United States varies in short run during pre-covid and covid period with stronger relationship in the latter. The results are consistent with the previous study of (Yong and Do 2017) and (Ijasan, Tweneboah et al. 2019). They suggest that REIT linkages increases with investment horizon. While, cross-market linkages vary with countries and changed significantly after the crises period. It also supports the hypothesis that the clustering of Asia markets and the contagion effect is expected to change after the breakout of COVID-19 due to different disease control measures, monetary policy, and fund flow.

The hypothesis that developed markets (United States, Japan, Singapore, Hong Kong) should be segmented and influence emerging markets (Thailand, Malaysia, and Taiwan) is emphasized. This study find that US REIT market influences all Asia markets in both pre-covid and covid period. While, lagged values of major Asia markets (Japan and Singapore) effect short run return of Asia markets higher during Covid. It is due to similar economic situation of developed markets and the liquidity spilling over to emerging markets ((Bum 2009); (Gupta and Marfatia 2018)). It is also consistent with the study of (Ijasan, Tweneboah et al. 2019) suggesting that well-developed REIT tend to lead/lag relatively smaller or less developed market. Moreover, there is also a little higher lead-lag relationship among Singapore, Thailand, and Malaysia during Covid period. It suggests possible segmentation of the markets that are dominated by hotel and retail REIT as the impact of the pandemic is more serious and continuing for these markets.

Table 6 Vector Error Correction Model (Overall Study Period). The following is an example equation used for the first column (please refer to equation 5 to 11 for more details) $\Delta x_{HK,t} = a_{HK} + \Phi_{HK} ECT_{t-1} + \sum_{i=1}^{k}(\alpha_{HK,i}\Delta x_{HK,t-i}) + \sum_{i=1}^{k}(\alpha_{US,i}\Delta x_{US,t-i}) + \sum_{i=1}^{k}(\alpha_{JA,i}\Delta x_{JA,t-i}) + \sum_{i=1}^{k}(\alpha_{SG,i}\Delta x_{SG,t-i}) + \sum_{i=1}^{k}(\alpha_{TH,i}\Delta x_{TH,t-i}) + \sum_{i=1}^{k}(\alpha_{MA,i}\Delta x_{MA,t-i}) + \sum_{i=1}^{k}(\alpha_{TAI,i}\Delta x_{TAI,t-i}) + \varepsilon_{HK,t}$ (x_t denotes a matrix of endogenous variables, a is a vector of constant, Φ is a speed of adjustment, α_i represent beta coefficients for the endogenous variables with k number of lags and ε_t is the white noise error term). For the speed of adjustment (Φ), it is theoretically ranging between -1 and 0. If it is statistically significant, the closer the number to -1, the higher speed of adjustment. However, positive number implies that the process it not converging in the long run. A hypothesis was formed to test the causality relationship. If the null hypothesis is rejected, it means that one series Granger cause another series (H_0: α_1 = α_2 = ... = α_k = 0 and H_1: at least one of the α not equal to 0). In the table, the number in the first row represents the speed of adjustment (Φ). The other rows are beta coefficients (α_i). The figures in the parenthesis are t-statistics. *** indicates 1 percent significant level ** indicates 5 percent significant level * indicates 10 percent significant level

Overall Study Period (1 Jan 2013 - 31 Mar 2021)

Error Correction	Δ ln HK	Δ ln Japan	Δ ln Malaysia	Δ ln Singapore	Δ ln Taiwan	Δ ln Thailand	Δ ln US
ECT	-0.0028 (-3.4631)***	-0.0040 (-4.4744)***	-0.0020 (-4.0695)***	-0.0017 (-2.4755)**	-0.0006 (-2.0591)**	-0.0004 (-0.6218)	0.0037 (3.8173)***
Δ ln Hong Kong (-1)	-0.0004 (-0.0149)	-0.0560 (-2.1835)**	0.0128 (0.8786)	-0.0196 (-1.0029)	-0.0131 (-1.6878)*	0.0081 (0.3905)	-0.0354 (-1.2621)
Δ ln Hong Kong (-2)	-0.0949 (-4.0092)***	-0.1020 (-3.9726)***	-0.0022 (-0.1530)	-0.0484 (-2.4803)**	0.0096 (1.2282)	0.0087 (0.4211)	-0.0363 (-1.2922)
Δ ln Japan (-1)	-0.0070 (-0.3313)	0.1667 (7.3206)***	0.0505 (3.8934)***	0.0613 (3.5408)***	-0.0008 (-0.1163)	-0.03556 (-1.9330)*	0.1001 (4.0519)***
Δ ln Japan (-2)	0.0103 (0.4990)	-0.1241 (-5.5222)***	0.0352 (2.7533)***	0.0621 (3.6336)***	-0.0124 (-1.8248)*	0.0826 (4.5507)***	0.0554 (2.2538)**
Δ ln Malaysia (-1)	-0.0572 (-1.5825)	0.0823 (2.0989)**	-0.1484 (-6.6512)***	-0.0490 (-1.6444)	-0.0150 (-1.2580)	-0.0922 (-2.9103)***	-0.0303 (-0.7058)
Δ ln Malaysia (-2)	-0.0245 (-0.6792)	0.0799 (2.0464)**	-0.0455 (-2.0482)**	0.1012 (3.4048)***	0.0109 (0.9204)	0.0477 (1.5101)	0.1107 (2.5903)***
Δ ln Singapore (-1)	0.0126 (0.3926)	0.1142 (3.2857)***	0.0690 (3.4897)***	-0.0139 (-0.5275)	0.0311 (2.9515)***	0.0178 (0.6350)	-0.0930 (-2.4450)**
Δ ln Singapore (-2)	0.0836 (2.6722)***	0.0982 (2.8958)***	0.0470 (2.4350)**	0.0464 (1.7985)*	0.0290 (2.8152)***	-0.0350 (-1.2760)	0.1016 (2.7389)***
Δ ln Taiwan (-1)	-0.0098 (-0.1461)	0.0704 (0.9683)	-0.0075 (-0.1823)	-0.0884 (-1.5970)	0.0291 (1.3188)	-0.0041 (-0.0702)	0.0598 (0.7517)
Δ ln Taiwan (-2)	0.0694 (1.0346)	-0.218 (-2.9994)***	-0.0037 (-0.0894)	0.1489 (2.6931)***	0.0448 (2.0313)**	0.0499 (0.8503)	0.0394 (0.4960)
Δ ln Thailand (-1)	-0.0490 (-1.8965)*	-0.1597 (-5.7010)***	0.0329 (2.0638)**	-0.0373 (-1.7525)*	-0.0137 (-1.6171)	0.1634 (7.2213)***	0.0039 (-0.4522)
Δ ln Thailand (-2)	0.0197 (0.7658)	0.0716 (2.5650)**	0.0215 (1.3542)	0.0692 (3.2615)***	-0.0016 (-0.1878)	0.0220 (0.9763)	-0.0348 (0.1271)
Δ ln US (-1)	0.1657 (8.2830)***	0.2269 (10.4650)***	0.0490 (3.9730)***	0.2436 (14.7710)***	0.0333 (5.0551)***	0.1682 (9.6003)***	-0.0348 (-1.4661)
Δ ln US (-2)	0.0594 (2.8341)***	0.0096 (0.4208)	-0.0471 (-3.6459)***	0.0427 (2.4710)**	-0.0088 (-1.2792)	0.0383 (2.0859)**	0.1068 (4.2975)***

Table 7 Vector Error Correction Model (Pre-Covid Period). The following is an example equation used for the first column (please refer to equation 5 to 11 for more details) $\Delta x_{HK,t} = a_{HK} + \Phi_{HK} ECT_{t-1} + \sum_{i=1}^{k}(\alpha_{HK,i}\Delta x_{HK,t-i}) + \sum_{i=1}^{k}(\alpha_{US,i}\Delta x_{US,t-i}) + \sum_{i=1}^{k}(\alpha_{JA,i}\Delta x_{JA,t-i}) + \sum_{i=1}^{k}(\alpha_{SG,i}\Delta x_{SG,t-i}) + \sum_{i=1}^{k}(\alpha_{TH,i}\Delta x_{TH,t-i}) + \sum_{i=1}^{k}(\alpha_{MA,i}\Delta x_{MA,t-i}) + \sum_{i=1}^{k}(\alpha_{TAI,i}\Delta x_{TAI,t-i}) + \varepsilon_{HK,t}$ (x_t denotes a matrix of endogenous variables, a is a vector of constant, Φ is a speed of adjustment, $\alpha_i$represent beta coefficients for the endogenous variables with k number of lags and ε_t is the white noise error term). For the speed of adjustment (Φ), it is theoretically ranging between -1 and 0. If it is statistically significant, the closer the number to -1, the higher speed of adjustment. However, positive number implies that the process it not converging in the long run. A hypothesis was formed to test the causality relationship. If the null hypothesis is rejected, it means that one series Granger cause another series (H_0: α_1 = α_2 = ... = α_k = 0 and H_1: at least one of the α not equal to 0). In the table, the number in the first row represents the speed of adjustment (Φ). The other rows are beta coefficients (α_i). The figures in the parenthesis are t-statistics. *** indicates 1 percent significant level ** indicates 5 percent significant level * indicates 10 percent significant level

Pre-Covid (1 Jan 2013 - 31 Dec 2019)

Error Correction	Δ ln HK	Δ ln Japan	Δ ln Malaysia	Δ ln Singapore	Δ ln Taiwan	Δ ln Thailand	Δ ln US
ECT	-0.0009 (-1.9876)**	-0.0011 (-2.5466)**	-0.0007 (-2.5034)**	-0.0001 (-0.3646)	-0.0001 (-0.6918)	-0.0004 (-1.037)	0.0020 (4.8665)***
Δ ln Hong Kong (-1)	-0.0634 (-2.4807)**	-0.0135 (-0.5507)	0.0141 (0.8942)	0.0075 (0.4293)	-0.0183 (-1.9655)**	-0.0095 (-0.4678)	0.0092 (0.3847)
Δ ln Hong Kong (-2)	-0.0579 (-2.2763)**	-0.0136 (-0.5561)	0.0198 (1.2613)	0.0365 (2.0964)**	0.0212 (2.2827)**	0.0123 (0.6080)	0.0720 (3.0351)***
Δ ln Japan (-1)	-0.0436 (-1.7385)*	0.0619 (2.5622)**	0.0219 (1.4166)	-0.0411 (-2.3936)**	-0.0139 (-1.5133)	0.0003 (0.0156)	-0.0122 (-0.5197)
Δ ln Japan (-2)	0.0011 (0.0454)	0.0004 (0.0187)	-0.0019 (-0.1220)	-0.0176 (-1.0402)	-0.0020 (-0.2223)	-0.0303 (-1.5447)	-0.0205 (-0.8901)
Δ ln Malaysia (-1)	0.0134 (0.3491)	0.0821 (2.2210)**	-0.1714 (-7.2423)***	-0.0120 (-0.4573)	0.0063 (0.4498)	-0.0281 (-0.9193)	-0.0436 (-1.2182)
Δ ln Malaysia (-2)	0.0049 (0.1270)	0.0135 (0.3649)	-0.0816 (-3.4571)***	0.0508 (1.9352)*	0.0098 (0.6992)	0.0300 (0.9844)	-0.0037 (-0.1025)
Δ ln Singapore (-1)	0.0603 (1.5327)	0.0806 (2.1290)**	0.0660 (2.7253)***	0.0215 (0.7981)	0.0387 (2.6978)***	0.0807 (2.5791)**	-0.0436 (-1.1877)
Δ ln Singapore (-2)	0.0535 (1.3659)	0.0547 (1.4511)	-0.0076 (-0.3146)	-0.0058 (-0.2151)	0.0116 (0.8101)	-0.0301 (-0.9670)	0.0273 (0.7486)
Δ ln Taiwan (-1)	-0.0022 (-0.0340)	0.0794 (1.2722)	0.0065 (0.1615)	-0.0320 (-0.7205)	0.0395 (1.6709)*	0.0148 (0.2873)	0.0497 (0.8217)
Δ ln Taiwan (-2)	0.0766 (1.1854)	-0.0789 (-1.2687)	-0.0288 (-0.7242)	0.0702 (1.5859)	0.0559 (2.3716)**	0.0183 (0.3552)	0.0924 (1.5345)
Δ ln Thailand (-1)	0.0212 (0.6891)	-0.0113 (-0.3833)	0.0284 (1.5002)	0.0473 (2.2452)**	-0.0090 (-0.7985)	0.0826 (3.3772)***	0.0550 (1.9178)*
Δ ln Thailand (-2)	0.0049 (0.1590)	0.0531 (1.8092)*	0.0305 (1.6213)	0.0264 (1.2650)	0.0075 (0.6742)	0.0616 (2.5388)**	-0.0263 (-0.9262)
Δ ln US (-1)	0.2475 (9.5820)***	0.2232 (8.9841)***	0.0628 (3.9465)***	0.2105 (11.9018)***	0.0356 (3.7787)***	0.1676 (8.1612)***	0.0600 (2.4914)**
Δ ln US (-2)	0.0256 (0.9343)	-0.0402 (-1.5278)	-0.0267 (-1.5832)	0.0476 (2.5351)**	0.0128 (1.2822)	0.0282 (1.2935)	-0.0463 (-1.8153)*

Table 8 Vector Error Correction Model (Covid Period). The following is an example equation used for the first column (please refer to equation 5 to 11 for more details) $\Delta x_{HK,t} = a_{HK} + \Phi_{HK}ECT_{t-1} + \sum_{i=1}^{k}(\alpha_{HK,i}\Delta x_{HK,t-i}) + \sum_{i=1}^{k}(\alpha_{US,i}\Delta x_{US,t-i}) + \sum_{i=1}^{k}(\alpha_{JA,i}\Delta x_{JA,t-i}) + \sum_{i=1}^{k}(\alpha_{SG,i}\Delta x_{SG,t-i}) + \sum_{i=1}^{k}(\alpha_{TH,i}\Delta x_{TH,t-i}) + \sum_{i=1}^{k}(\alpha_{MA,i}\Delta x_{MA,t-i}) + \sum_{i=1}^{k}(\alpha_{TAI,i}\Delta x_{TAI,t-i}) + \varepsilon_{HK,t}$ (x_t denotes a matrix of endogenous variables, a is a vector of constant, Φ is a speed of adjustment, $\alpha_i$represent beta coefficients for the endogenous variables with k number of lags and ε_t is the white noise error term). For the speed of adjustment (Φ), it is theoretically ranging between -1 and 0. If it is statistically significant, the closer the number to -1, the higher speed of adjustment. However, positive number implies that the process it not converging in the long run. A hypothesis was formed to test the causality relationship. If the null hypothesis is rejected, it means that one series Granger cause another series (H_0: α_1 = α_2 = ... = α_k = 0 and H_1: at least one of the α not equal to 0). In the table, the number in the first row represents the speed of adjustment (Φ). The other rows are beta coefficients (α_i). The figures in the parenthesis are t-statistics. *** indicates 1 percent significant level ** indicates 5 percent significant level * indicates 10 percent significant level

Covid (1 Jan 2020 - 31 Mar 2021)

Error Correction	Δ ln HK	Δ ln Japan	Δ ln Malaysia	Δ ln Singapore	Δ ln Taiwan	Δ ln Thailand	Δ ln US
ECT	0.0005 (2.4055)**	0.0011 (4.5204)***	0.0007 (5.9210)***	0.0008 (3.8405)***	0.0001 (2.4544)**	0.0004 (2.1014)**	-0.0004 (-1.3420)
Δ ln Hong Kong (-1)	0.2244 (3.5129)***	-0.0597 (-0.7539)	0.0144 (0.3707)	-0.0158 (-0.2410)	0.0013 (0.0893)	0.0475 (0.7226)	0.0244 (0.2390)
Δ ln Hong Kong (-2)	-0.2479 (-3.8834)***	-0.3546 (-4.4796)***	-0.0551 (-1.4171)	-0.2675 (-4.0838)***	-0.0231 (-1.6336)	-0.0214 (-0.3266)	-0.312 (-3.0521)***
Δ ln Japan (-1)	0.0387 (0.7920)	0.2752 (4.5409)***	0.092 (3.0883)***	0.2156 (4.2977)***	0.0209 (1.9261)*	-0.0459 (-0.9127)	0.2505 (3.1999)***
Δ ln Japan (-2)	0.0704 (1.4095)	-0.2372 (-3.8287)***	0.0803 (2.6362)***	0.1681 (3.2770)***	-0.0205 (-1.8530)*	0.2871 (5.5874)***	0.2075 (2.5928)**
Δ ln Malaysia (-1)	-0.2338 (-2.3633)**	0.1449 (1.1812)	-0.1020 (-1.6926)*	-0.1254 (-1.2350)	-0.0669 (-3.0546)***	-0.2832 (-2.7841)***	-0.0209 (-0.1322)
Δ ln Malaysia (-2)	-0.0271 (-0.2715)	0.4031 (3.2520)***	0.0408 (0.6693)	0.2038 (1.9865)**	0.0372 (1.6788)*	0.1271 (1.2362)	0.4709 (2.9414)***
Δ ln Singapore (-1)	-0.0400 (-0.5565)	0.0841 (0.9430)	0.0686 (1.5647)	-0.1266 (-1.7147)*	0.0320 (2.0079)**	-0.0678 (-0.9163)	-0.3175 (-2.7552)***
Δ ln Singapore (-2)	0.0940 (1.4212)	0.2053 (2.5050)**	0.0762 (1.8908)*	0.0080 (0.1182)	0.0641 (4.3759)***	-0.1234 (-1.8151)*	-0.0014 (-0.0131)
Δ ln Taiwan (-1)	-0.0678 (-0.2325)	0.3838 (1.0611)	0.0482 (0.2711)	-0.2201 (-0.7354)	-0.0223 (-0.3443)	-0.0469 (-0.1563)	0.0518 (0.1109)
Δ ln Taiwan (-2)	0.1028 (0.3574)	-0.9565 (-2.6820)***	0.2732 (1.5585)	0.6873 (2.3284)**	-0.0392 (-0.6150)	0.0883 (0.2986)	-0.4892 (-1.0622)
Δ ln Thailand (-1)	-0.1439 (-2.5242)**	-0.3729 (-5.2763)***	0.0499 (1.4366)	-0.1054 (-1.8026)*	-0.0125 (-0.9911)	0.3123 (5.3284)***	-0.0189 (-0.2073)
Δ ln Thailand (-2)	0.0805 (1.3617)	0.0515 (0.7032)	-0.0255 (-0.7065)	0.1486 (2.4501)**	-0.0171 (-1.3044)	-0.0507 (-0.8334)	0.1226 (1.2952)
Δ ln US (-1)	0.0669 (1.4952)	0.2004 (3.6116)***	-0.0402 (-1.4748)	0.1981 (4.3128)***	0.0207 (2.0918)**	0.1092 (2.3714)**	-0.0632 (-0.8821)
Δ ln US (-2)	0.0812* (1.8647)	0.0204 (0.3780)	-0.0984 (-3.7108)***	0.0576 (1.2895)	-0.0338 (-3.5050)***	0.0408 (0.9121)	0.2416 (3.4652)***

5.2.2 Granger causality

Table 9 Granger causality/Block Exogeneity Wald test is employed to assess whether inclusion of the lagged value (from VECM) of a variable is important in explaining dynamics of other variables in the multivariate frame work in addition to the explanatory power of lag of these variables. *** indicates 1 percent significant level ** indicates 5 percent significant level * indicates 10 percent significant level

		Independent						
		HK	**JAPAN**	**MALAY**	**SINGAPORE**	**TAIWAN**	**THAILAND**	**US**
Overall Study Period								
Dependent	**HK**	-	-	-	Granger**	-	-	Granger***
	JAPAN	Granger***	-	Granger**	Granger***	Granger***	Granger***	Granger***
	MALAY	-	Granger***	-	Granger***	-	Granger**	Granger***
	SINGAPORE	Granger**	Granger***	Granger***	-	Granger***	Granger***	Granger***
	TAIWAN	-	-	-	Granger***	-	-	Granger***
	THAILAND	-	Granger***	Granger***	-	-	-	Granger***
	US	-	Granger***	Granger**	Granger***	-	-	-
Pre-Covid								
Dependent	**HK**	-	-	-	-	-	-	Granger***
	JAPAN	-	-	Granger*	Granger**	-	-	Granger***
	MALAY	-	-	-	Granger**	-	Granger*	Granger***
	SINGAPORE	-	Granger**	-	-	-	Granger**	Granger***
	TAIWAN	Granger***	-	-	Granger**	-	-	Granger***
	THAILAND	-	-	-	Granger**	-	-	Granger***
	US	Granger***	-	-	-	-	-	-
Covid								
Dependent	**HK**	-	-	Granger*	-	-	Granger**	-
	JAPAN	Granger***	-	Granger***	Granger**	Granger**	Granger***	Granger***
	MALAY	-	Granger***	-	Granger*	-	-	Granger***
	SINGAPORE	Granger***	Granger***	Granger*	-	Granger**	Granger**	Granger***
	TAIWAN	-	Granger**	Granger***	Granger***	-	-	Granger***
	THAILAND	-	Granger***	Granger***	-	-	-	Granger*
	US	Granger***	Granger***	Granger**	Granger**	-	-	-

The Granger causality relationship among the Asia REIT markets and US market is shown in Table 9. The results support the hypothesis that developed markets influence emerging markets. Most of the results suggest one directional Granger causality from developed markets onto emerging markets especially from U.S. to Asia markets. However, only some two-ways directional Granger causality are found between U.S. and Asia developed markets including Malaysia which is an emerging market. US market granger cause every country in all periods at 1 percent significant level, except for Thailand it shows weaker casual effect at 10 percent significant level during the Covid period. It could be due to the fact that Thailand REIT mainly consists of retail and hotel REIT which largely rely on foreign tourists in which Thailand has experienced several waves of COVID pandemic. The recovery of US REIT weakly spill over to REIT in Thailand. While, other developed Asia markets take turn to be the top casual market across periods. Singapore granger cause four other Asia markets for the overall study period and pre-covid period. Whereas, Japan is the first rank of developed Asia market that causes four other Asia markets during the covid period.

The finding also strengthens the hypothesis that contagion effect is changed and stronger after the breakout of COVID-19. It is found that the total number of causal effects significantly increase from ten to twenty-three in the pre-covid and covid period respectively comparing the nineteen causal effects in the overall study period.

5.3 **Impulse response function and variance decomposition**

Apart from analyzing the short run coefficient, adjustment coefficient, and Granger causality, the VECM model can be used to see the movement of REIT indices corresponding to the shock and analyze the proportion of the variation effected by shocks.

5.3.1 Impulse response function

In this section, the inter-relation of REIT markets is examined over time through impulse response analysis in the VECM model. It is a dynamic multiplier analysis among the variables, measuring how a standard deviation shock to a variable in the system is transmitted to others. Residual one standard deviation is used as a method for decomposition setting the impulses to one standard deviation of the residuals. This option ignores the correlations in the residuals and eliminates the problem of Cholesky ordering.

In all period, Asia markets appear to mainly respond to shocks given in its own market and US. While, shocks of developed markets effect some developed and emerging markets. To compare the result between pre-covid and covid period, there are higher fluctuation and respond to shocks in the latter. Impulse response functions show higher responses of Asia markets to the shock of US and dominate the shock of Asia markets, even higher than the shock of its individual especially for Japan and Singapore. This result strongly supports both hypothesis that the contagion effect changes after the breakout of COVID-19 and U.S. REIT market has greater impact on to the developed Asia REIT markets. Moreover, higher response to the shocks among Singapore, Thailand, and Malaysia is found which confirms the hypothesis of greater market cointegration of Singapore, Thailand, and Malaysia during the COVID-19 period (the combining dominates of hotel and retail REIT).

Figure 3: Impulse response function derived from VECM shows the movement of REIT returns corresponding to the shock of each market

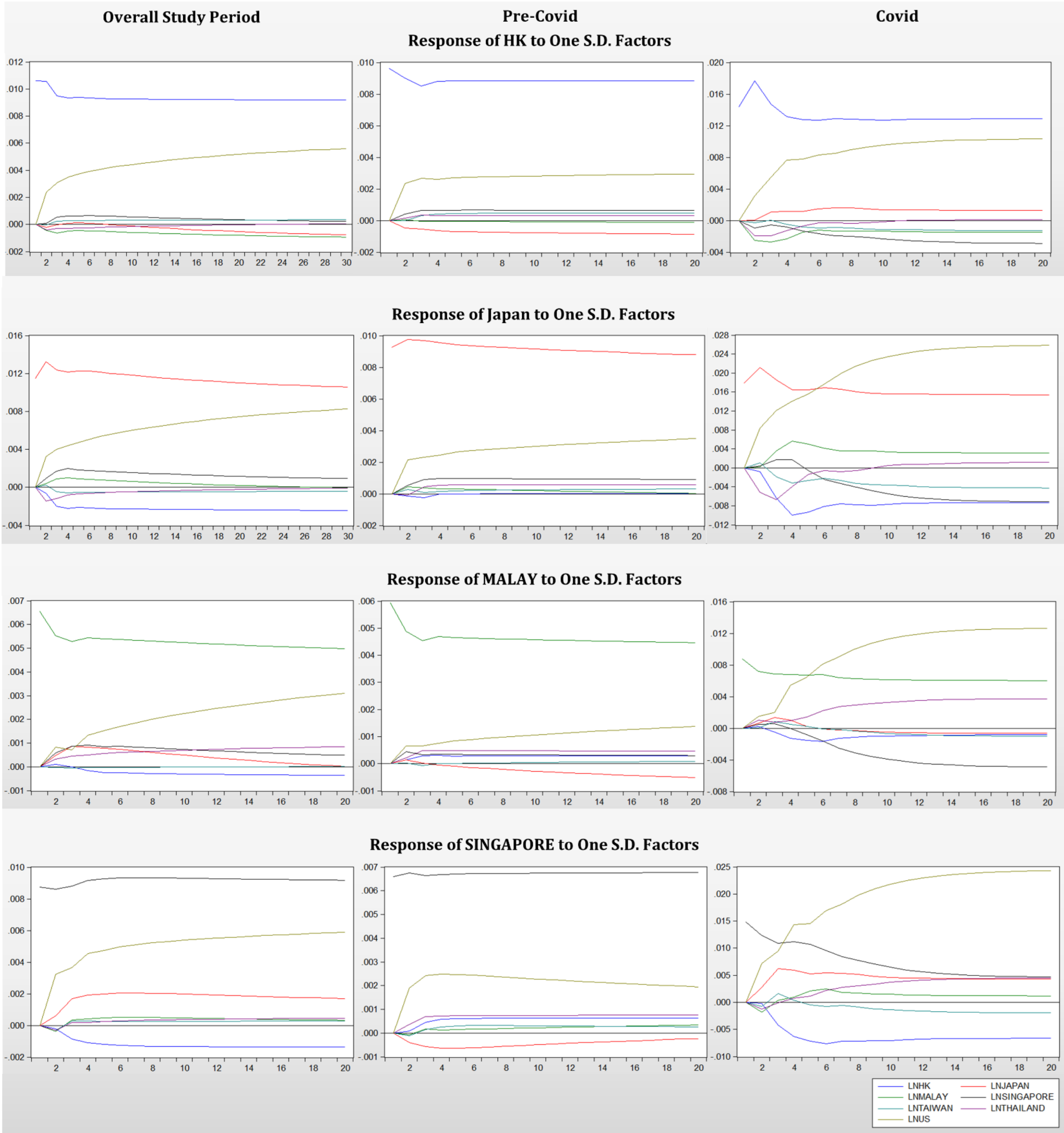
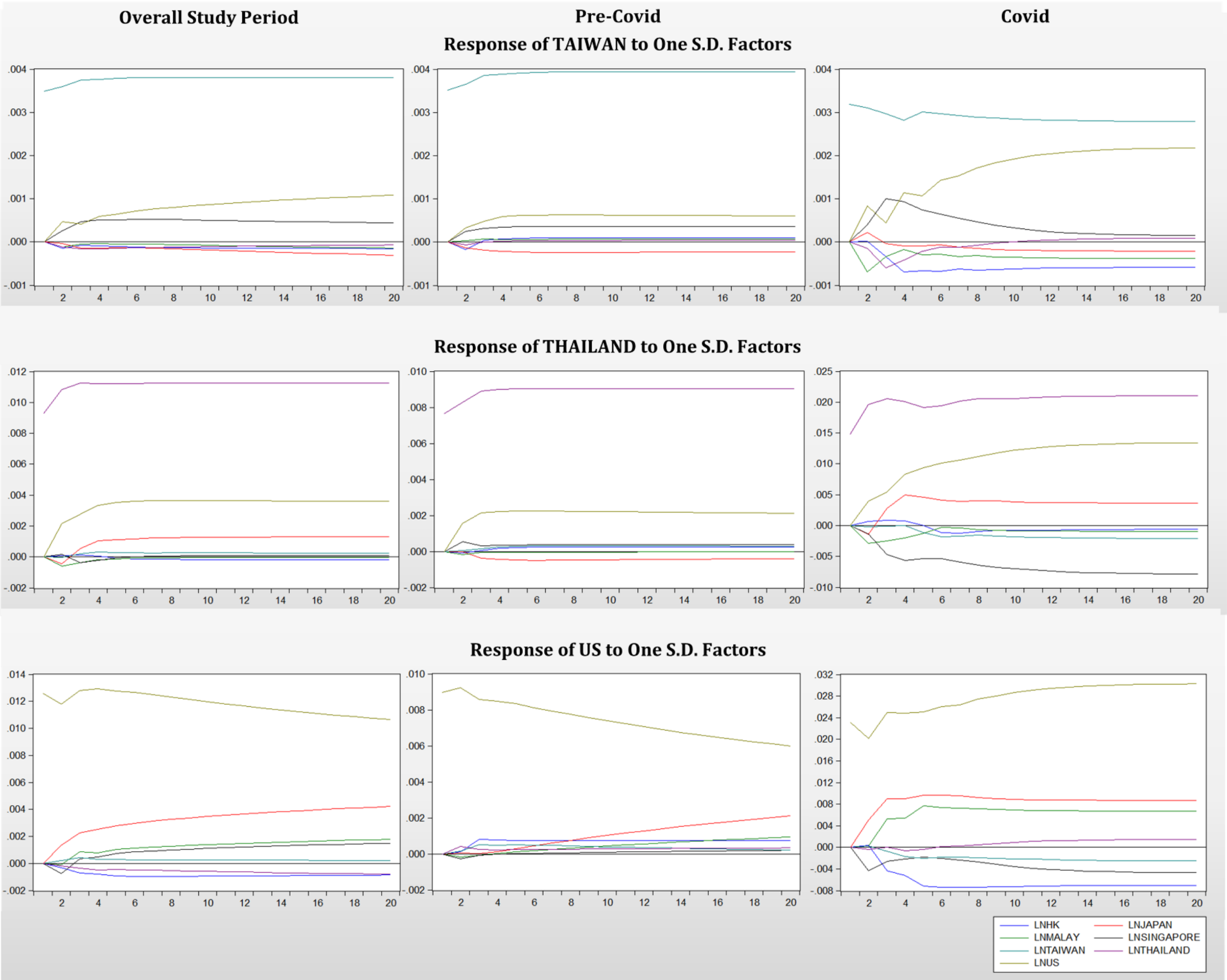


Figure 3: Impulse response function derived from VECM shows the movement of REIT returns corresponding to the shock of each market (continue)



5.3.2 Variance decompositions

In variance decompositions, the Choleski decomposition is applied to conduct the innovation accounting. The ordering in the Choleski decomposition may notably affect the results as first order will has higher share of variation. Therefore, several orderings are applied in order to get average value and mitigate the ordering problem. In the analysis, variance decompositions are investigated up to 20 lag periods. The results show that the forecast error variance which is explained by its own variance gradually decrease as time pass by and resulting in the increasing effect of the others. However, the values in period 1, 10, and 20 lag periods are shown for comparing the result in the overall study period, pre-covid period, and covid period (Table 10-12).

Share of the long-term forecast error variance of Asia markets are explained by its own variance, US, and other major Asia markets (Singapore, Japan, and HK) which corresponding with hypothesis that developed markets (United States, Japan, Singapore, Hong Kong) influence emerging markets (Thailand, Malaysia, and Taiwan).

Moreover, the clustering of Asia markets and the contagion effect change after the breakout of COVID-19. Higher share of the long-term forecast error variance of Malaysia can be explained by Singapore and Thailand during Covid period as the majority of these markets are hotel and retail REIT. It shares close impact from COVID-19. Therefore, there is greater market cointegration of Singapore, Thailand, and Malaysia during the COVID-19 period. Furthermore, share of variance from US significantly increase during Covid which could be due to the effect of U.S. Federal Reserve Bank (Fed) unlimited QE measure which spill over to Asia markets as hypothesized.

Table 10 Variance decomposition (Overall Study Period) derived from VECM shows the proportion of the variation effected by shocks of individual market and others. The number in table shows the magnitudes of the forecast error variances that are explained by shocks of all markets. The reported values are on period 1, 10, and 20 (in percentage) based on VECMs using various Choleski ordering.

		Variance decomposition of							Total
		HK	**JAPAN**	**MALAY**	**SINGAPORE**	**TAIWAN**	**THAILAND**	**US**	
Overall Study Period									
Shock to (Period 1, 10, and 20)	**HK**	91.73	0.43	0.27	5.61	0.13	1.19	0.64	100.00
		77.36	0.50	0.31	8.46	0.22	1.13	12.01	100.00
		73.51	0.36	0.33	8.53	0.22	1.19	15.85	100.00
	JAPAN	1.59	89.81	0.64	5.93	1.05	0.09	0.90	100.00
		1.29	69.21	1.71	13.99	0.60	0.30	12.91	100.00
		1.23	63.98	1.49	14.37	0.50	0.23	18.20	100.00
	MALAY	0.52	0.54	94.81	2.68	0.27	0.90	0.27	100.00
		1.34	2.85	74.39	10.40	0.34	3.08	7.60	100.00
		1.22	2.08	68.75	10.63	0.31	3.70	13.32	100.00
	SINGAPORE	8.18	1.19	1.57	83.25	0.39	2.65	2.78	100.00
		5.08	4.53	2.23	66.93	0.50	2.24	18.49	100.00
		4.69	4.41	2.18	64.81	0.49	2.31	21.11	100.00
	TAIWAN	0.26	1.55	0.30	1.07	96.67	0.04	0.13	100.00
		0.51	1.22	0.30	5.14	90.36	0.09	2.38	100.00
		0.51	1.01	0.26	5.46	88.93	0.09	3.74	100.00
	THAILAND	0.91	0.05	0.42	3.85	0.03	94.56	0.17	100.00
		1.30	1.02	0.56	6.28	0.14	83.18	7.52	100.00
		1.30	1.26	0.61	6.75	0.16	81.68	8.24	100.00
	US	1.68	0.79	0.42	8.88	0.04	0.28	87.92	100.00
		1.41	7.16	1.85	12.79	0.16	0.22	76.42	100.00
		1.57	9.89	2.67	14.60	0.20	0.24	70.82	100.00

Table 11 Variance decomposition (Pre-Covid Period) derived from VECM shows the proportion of the variation effected by shocks of individual market and others. The number in table shows the magnitudes of the forecast error variances that are explained by shocks of all markets. The reported values are on period 1, 10, and 20 (in percentage) based on VECMs using various Choleski ordering.

		Variance decomposition of							Total
		HK	**JAPAN**	**MALAY**	**SINGAPORE**	**TAIWAN**	**THAILAND**	**US**	
Pre-Covid									
Shock to (Period 1, 10, and 20)	**HK**	92.67	0.38	0.07	5.81	0.05	0.80	0.22	100.00
		82.08	0.20	0.09	8.15	0.29	1.35	7.83	100.00
		80.96	0.21	0.08	8.30	0.34	1.38	8.73	100.00
	JAPAN	0.95	96.41	0.17	1.59	0.32	0.23	0.33	100.00
		1.69	83.50	0.50	5.34	0.51	1.03	7.43	100.00
		1.81	80.71	0.42	5.74	0.56	1.13	9.63	100.00
	MALAY	0.12	0.20	98.31	0.90	0.10	0.33	0.04	100.00
		1.14	0.22	89.94	3.39	0.14	2.04	3.13	100.00
		1.25	0.19	87.65	3.56	0.16	2.20	4.99	100.00
	SINGAPORE	8.15	0.49	0.48	87.01	0.26	2.82	0.79	100.00
		9.97	0.27	0.65	73.66	0.45	4.69	10.30	100.00
		10.35	0.27	0.79	73.48	0.48	4.93	9.69	100.00
	TAIWAN	0.10	0.44	0.12	0.85	98.45	0.02	0.02	100.00
		0.52	0.21	0.25	3.18	93.60	0.09	2.14	100.00
		0.59	0.20	0.27	3.40	93.10	0.10	2.34	100.00
	THAILAND	0.48	0.12	0.15	3.91	0.01	95.28	0.05	100.00
		0.92	0.07	0.16	5.87	0.11	87.78	5.09	100.00
		0.98	0.06	0.17	5.97	0.13	87.45	5.24	100.00
	US	0.60	0.67	0.06	2.46	0.02	0.09	96.09	100.00
		2.24	1.85	0.23	3.05	0.37	0.37	91.89	100.00
		2.84	4.95	0.83	3.73	0.38	0.53	86.73	100.00

Table 12 Variance decomposition (Covid Period) derived from VECM shows the proportion of the variation effected by shocks of individual market and others. The number in table shows the magnitudes of the forecast error variances that are explained by shocks of all markets. The reported values are on period 1, 10, and 20 (in percentage) based on VECMs using various Choleski ordering.

		Variance decomposition of							Total
		HK	JAPAN	MALAY	SINGAPORE	TAIWAN	THAILAND	US	
Covid									
Shock to (Period 1, 10, and 20)	HK	88.31	0.50	1.02	6.11	0.57	2.07	1.41	100.00
		69.04	1.00	1.27	6.55	0.42	1.47	20.24	100.00
		63.36	0.97	1.20	6.15	0.53	1.51	26.28	100.00
	JAPAN	2.26	74.62	1.66	13.48	6.09	0.20	1.70	100.00
		2.88	35.25	4.77	17.53	1.47	1.15	36.94	100.00
		2.23	27.73	3.95	14.61	1.19	0.59	49.70	100.00
	MALAY	2.85	1.82	85.61	4.89	2.09	1.84	0.90	100.00
		1.70	1.64	40.56	7.58	1.32	7.12	40.08	100.00
		1.29	0.85	28.24	5.01	1.19	8.68	54.74	100.00
	SINGAPORE	9.09	2.41	2.85	77.07	1.07	2.23	5.28	100.00
		3.08	5.90	3.66	43.48	0.64	2.14	41.10	100.00
		2.30	4.37	3.11	34.75	0.59	2.97	51.92	100.00
	TAIWAN	1.18	10.23	1.99	2.07	82.62	0.62	1.29	100.00
		1.20	8.15	1.29	13.40	65.49	0.48	9.98	100.00
		1.03	6.69	1.10	13.03	59.96	0.64	17.56	100.00
	THAILAND	2.21	0.11	0.76	3.31	0.33	92.94	0.35	100.00
		1.86	2.19	0.92	2.17	0.37	77.58	14.90	100.00
		1.59	1.98	0.84	1.90	0.50	73.29	19.90	100.00
	US	3.48	0.56	1.39	16.34	0.43	0.52	77.28	100.00
		1.61	9.39	7.67	16.31	0.37	0.33	64.32	100.00
		1.36	8.61	7.47	15.00	0.44	0.46	66.65	100.00

6. Conclusion

This study investigates REIT interdependence among Asia markets and the United States in which the effects of COVID-19 pandemic are observed through three sub-periods (overall study period, pre-COVID period, and COVID period). The key findings of this study based on the three objectives are summarized as follow.

First, there are market integrations of Asia REIT markets including US REIT at long-run periods as suggested by Johansen Cointegration Test. Moreover, VECM model strongly support their interdependent as the markets show high lead-lag relationship at short run and the convergence from short dynamics towards long run equilibrium in the overall study period. The results are consistent with the previous studies suggesting that the long-run REIT performance is closely related to the direct real estate market whereas REIT are affected by shocks and noise like stock in short-run ((Oikarinen, Hoesli et al. 2011), (Hoesli and Oikarinen 2012), and (Geng 2018).

Second, further finding is that developed markets are segmented and influence emerging markets. It is found that US market granger causes all Asia markets. Whereas, intermediate influences of Japan and Singapore to Asia emerging markets is detected. In term of the response to shocks and forecast error variance, shocks of developed markets effect both developed and emerging markets. Whereas, the long-term forecast error variance of Asia markets is explained by US market and other developed Asia markets (Singapore, Japan, and HK). These could be due to similar economic situation of developed markets and the liquidity spilling over to emerging markets.

Third, REIT interdependence among Asia markets and the United States significantly changes after the breakout of COVID-19. It is consistent with the previous study that the interdependent varies depending on the characteristics and capital structure of REIT (Bum 2009). While, the recovery of REIT may rely on different disease control measures, monetary policy, and fund flow. The lead-lag relationship between developed Asia markets and other Asia markets become stronger. While, the convergence from short dynamics towards long run equilibrium disappear in Covid period. This could be due to the study period which does not cover all of the COVID period. Each REIT market has been hit with various magnitudes and has not converted back to equilibrium. During COVID period, there are higher fluctuation and respond to shocks. Whereas, the response to the shock of US dominates the shock of Asia markets. Moreover, share of variance from US significantly increase during Covid period which is the possible effect of massive stimulus packages of the United States that spill over to the Asia markets. Moreover, the hypothesis of greater market cointegration of Singapore, Thailand, and Malaysia where the combining dominates of hotel and retail REIT (most effected by COVID-19) has been proven and suggested the benefit of industry diversification of Asia REIT during the COVID-19 pandemic. A little higher Lead-lag relationship among these markets is found. While, there exist higher granger causality, higher response to the shocks, and higher share of the long-term forecast error variance among these markets during COVID period.

In addition, the findings of this study suggest that REIT investors can achieve international diversification benefits during the Covid-19 pandemic, but they need to consider the linkages and the dominate of REIT industry in each market. Moreover, investors could seek opportunity to capitalize in the lag or heavily impacted markets while the markets have not yet risen to equilibrium.

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VITA

NAME	Boonchai Asawapiched
DATE OF BIRTH	18 May 1991
PLACE OF BIRTH	Bangkok
INSTITUTIONS ATTENDED	- Master of Science in Finance, Faculty of Commerce and Accountancy, Chulalongkorn University - Bachelor of Engineering (International and Twinning Program), Civil Engineering, First-Class Honors (Gold Medal), Faculty of Engineering, King Mongkut's University of Technology Thonburi
HOME ADDRESS	1, Soi Asawapiched 19, Asawapiched Road, Khwaeng Bang Ramat, Khet Taling Chan, 10170