The inflation hedging ability of real estate investment in Thailand

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น.ส.พิมพ์พิมุกต์ รอดนิกร

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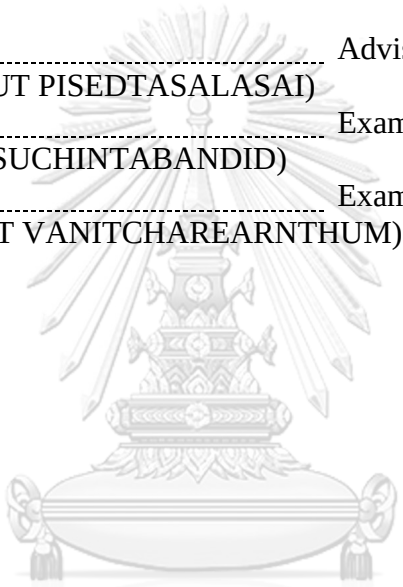

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ABSTRACT

This study is conducted with the purpose to investigate the inflation hedging ability of real estate investment, both direct and indirect, including single-houses, town houses, condominium, and SETPREIT in Thailand. The Johansen cointegration test was used to akishort run dynamic movements, the Vector Error Correction (VEC) model for cointegrated time series was applied to analyze. In addition, Granger causality test is conducted to see whether the cause of inflation is independent from the movements in the price of real estate assets. In addition, the impulse response functions, and variance decompositions were also incorporated with the purpose to emphasis the impact of the real estate investment to inflation and vice versa.

The empirical findings, obtaining through the cointegration tests suggest that there is an existence of the long-run relationship between the price of properties, including townhouse, condominium and SETPREIT. With the long-term relationship existing between the real estate assets, and inflation, these real estate assets have an ability to hedge against inflation (Gunasekarage, 2008); (Le Moigne & Viveiros, 2020); (Taderera, 2019). Therefore, in summary in the long run, the real estate assets, including townhouse, condominium, and SETPREIT can be applied as a hedge against inflation.

In the short run, the result suggests that condominium and SETPREIT have dynamic relationships with inflation. The Granger causality suggests that the direction of causality is from the price of condominium and SETPREIT to inflation, which implies that the past information and the variations of the price of condominium and SETPREIT can be used to predict inflation. Consequently, the price of real estate assets in Thailand, consisting condominium and SETPREIT are considered to have an influence on the variation of inflation.

1. Introduction

1.1 Background

Inflation is one of the economics problems that leads to the effect on the wealth of investors, owning to the fact that inflation deteriorate the total value of their prosperity. However, among other economics problems inflation seems to be the problem that has not been concerned or gained an attention, because the inflation rate around the world was quite low and had no significant impact to the affluence of investors.

Inflation is brought into the spotlight as an issue for investors nowadays, because the inflation rate around the world has steadily increased since 2021. The current growth of inflation around the world has come two reasons. The first reason is that the increasing in price of the commodities, such as food and gas. Due to the COVID-19 pandemic around the world, the supply chains of food have broken down. Besides, the shortages of labors, along with bad weather have also created the rising in prices of food commodities. The second reason is that the increasing in the number of circulating cash in the global economy as a result of the cash stimulus policies during COVID-19 lockdowns. From these reasons, the inflation is now one of economics problem that raise a huge concern for investors around the world, even millionaires for the first time in recent history. Therefore, Preserving the value of prosperity against all the negative impacts, resulting from the inflation has become one of the objectives of investors.

Real estate was observed and discussed by many studies about its ability as a good hedge of inflation. Fama and Schwert (1977) discovered that the private residential real estate in US can fully hedge both expected and unexpected inflation (Fama, 1977). Bond and Seiler (1998) made a point that the investors should include real estate investment in their portfolio in order to hedge an inflation, along with reducing the volatility of the portfolio returns (Bond, 1998). Therefore, Real estate is expected to be an asset that can hedge an inflation, because the rental fees, or lease agreements can be adjusted overtime in response to the direction of inflation rate.

However, the result of many studies appears to suggest that the hedging ability of real estate is different, based on the area that the studies conducted.

Gunasekarage, Power, and Ting Zhou (2008) found that in the long run the ability of inflation hedging of real estate assets became stronger (Gunasekarage, 2008), similar to Le Moigne, and Viveiros (2020), which indicated that total return of real estate investment can provide a full hedge of inflation (Le Moigne & Viveiros, 2020). On the other hand, from (Zhou, 2010), it found that in China the real estate was not an effective asset for inflation hedging. Therefore, the inflation hedging of real estate can be assumed to exist in all areas, and still have room for further studies.

Thailand is one of counties in South East Asian region that gets a lot of attention from investors around the world. Even, in the last few years, Thailand was struggle with the slowdown of economy due to the COVID-19 pandemic situation, along with political instability, but both Thai and foreign investors still have a confidence that in the Thai's economy still has a strong ability to recover, and even becomes stronger in the long run. However, rising inflation rate nowadays is the problem that has gradually been concerned for both Thai and foreign investors. In order to create the positive atmosphere for investment, the problem related to inflation rate need to be addressed, because it causes the difficulty to protect the wealth of investors. Thus, the inflation hedging ability of real estate in Thailand is worth to be taken into account for consideration.

1.2 Objectives and contribution

This study has an intention to provide the empirical evidence on the diversification benefits and the role of real estate assets as an inflation hedging instruments for Thai market with the three main objectives and hypotheses as follows:

First, this study aims to investigate the long-term relationship between the real estate investment and inflation rate. In order to serve as a good hedge of inflation, the long-term co-movements between the price of real estate and inflation rate are existed. According to (Gunasekarage, 2008), it reveals that comparing with other financial assets real estate assets can be served as a good hedge of inflation as they exhibit the long-term relationships. Furthermore, Canadian real estate assets also have inflation-hedging ability from the reason that real estate returns and inflation have a long-run constant relation over time (Le Moigne & Viveiros, 2020). Thus, the first hypothesis is

that the long-run relationship should be observed between the real estate assets and inflation.

Second, this study also has an intention to examine the influence of the inflation on the price of real estate assets. With the intuition that the changes inflation should lead to the movements in the price of real estate assets, this study hypothesized that the inflation tends to be the factor that have an influence on the price of real estate assets. Then, the real estate assets can provide persuasive hedge against inflation. According to Gunasekarage, Power, and Ting Zhou (2008), the residential, commercial, and industrial real estate can be predicted by using the inflation rates. Therefore, the real estate assets can be served as the long-tern hedges against inflation as the cause of inflation is not related to the movements in price of real estate assets (Gunasekarage, 2008).

Third, this study also attempts to make a contribution to the existing literatures by adding evidence of the interdependence between the price of real estate and inflation. Even though, there is an existence of the long-run relationship between the real estate assets and inflation (Gunasekarage, 2008) ; (Le Moigne & Viveiros, 2020); (Taderera, 2019), each type of real estate assets and inflation can also have different short-run dynamic. In order to make a further study about the short-run dynamic and variance transmission that resulted from the shocks by applying the impulse response function and variance decomposition.

To the best of my knowledge, this is the first paper, focusing on both direct and indirect investment of real estate in Thailand. The study added the Real Estate Investment Trust (REITs) in Thailand, which have been established not many years ago into account. Due to the direct investment in real estate assets might be hard access and require certain amount of principals to invest, therefore the study of the inflation hedging ability of REITs in Thai market will provide the optional real estate investment that is applicable to all investors. **Moreover, this study also make additional contributes to previous literatures by studying about the short-run dynamics between the real estate assets and inflation. Besides, this paper study about the case of inflation hedging by using the achieved evidence from Thailand, which has not been studied for the past 10 years. So, the inflation hedging ability**

of real estate assets in Thailand might end up not align with the results from other countries.

2. Literature Review

2.1 Real estate is a good investment for diversifying portfolio

Real estate should be considered as one of the assets in portfolio. Due to the main reasons that real estate, both direct and indirect is a good investment for diversifying risk. **In Australia, direct investment of real estate, whether in commercial, or residential brought a significant advantage in portfolio diversification to investors (Heaney, 2012)**. From the analysis of the quarterly returns of real estate and stock market returns in Australia during the 3rd quarter of 1986 to the 3rd quarter of 2009, the existence of benefits that investors received from diversified portfolio, combining real estate investment and stock portfolio are clearly supported (Heaney, 2012).

In case of indirect investment in real estate via Real Estate Investment Trusts (REITs), based on the return of Turkish REITs (T-REITs) relative to portfolio investment, including shares of bank and investment trust companies in Borsa Istanbul (BIST) during July 2008 till March 2015, it suggested that **in order to enhance the return of portfolio, and achieve potential benefits of risk reduction, investors should include T-REITs in their portfolio (Coşkun, 2017).** Another important reason is that real estate is normally perceived as an asset with a good inflation hedging ability. There are many studies in the past that conducted by using different location, types of real estate, periods of time, methodology, macroeconomics components.

2.2 Real estate is considered as a good hedge of inflation

There are many studies, conducting the analysis about the relation between direct investment in real estate and inflation hedging around the globe. The results from the research that conducted in developed market and studied about developing markets, suggest that real estate is a good hedge of inflation.

Based on (Gunasekarage, 2008), the research tried to study about the relationship between the inflation rate and returns of real estate and financial assets investment in New Zealand during December 1979 to December 2003 and received the

result **that the real estate provides a strong hedge of inflation in the long term**. During the period of 1970s, investors of New Zealand had been through a very bad performance of stock market, and also high inflation (Gunasekarage, 2008). However, in the meantime there was a strong growth of real estate funds, which lead to higher investment in real estate (Gunasekarage, 2008). So, many researchers tried to study about how to use real estate as a hedge of inflation (Gunasekarage, 2008).

In order to address the question of this research whether real estate, as well as other financial assets was appropriate to use as a hedge of inflation, the cointegration technique, and causality tests were employed on the quarterly data in the period between December 1979 and December 2003 (Gunasekarage, 2008). In conclusion, it was revealed from the research that the changes of asset prices were not the causes of high inflation (Gunasekarage, 2008). Moreover, in the long run the real estate assets of New Zealand had a stronger ability in hedging inflation, comparing with other financial assets (Gunasekarage, 2008).

In more recent studies, they also found that **in Canada the real estate investment is a good hedge of inflation**. According to Le Moigne, and Viveiros (2020), the research studied about the inflation hedging characteristics of private real estate in Canada during 1973 to 2007 (Le Moigne & Viveiros, 2020). The research was conducted by using cointegration and Granger causality tests as a methodology in examining the long run relationship between inflation and the real estate return (Le Moigne & Viveiros, 2020). This research showed that total and appreciation returns from real estate provide a full hedge of inflation, both expected and unexpected (Le Moigne & Viveiros, 2020). Cointegration tests reveal a positive relationship between inflation and total return of real estate in the long term (Le Moigne & Viveiros, 2020). Besides, Granger causality tests also found the causality from total returns of real estate to inflation, which can imply that the total returns can be used to predict the inflation rates in the future (Le Moigne & Viveiros, 2020).

There is also a study related to the commercial real estate in South Africa by (Taderera, 2019). This study tried to investigate that whether commercial real estate is a good hedge against inflation in South Africa by applying the Vector Error Correction (VEC) model. The study found that in the short run, commercial real estate investments

are a hedge against inflation. However, in the long run only retail and industrial property can be used for hedging inflation. So, the real estate investments should be included in portfolio with the purpose to shield the wealth of investors.

In China, which is the country that the real estate system had just been transformed from welfare-oriented housing system, controlled ownership by the government to privatization, the research found that real estate should not be considered as a good hedge of inflation. Zhou and Clements (2010) examined the ability in hedging inflation of real estate in China (Zhou, 2010). The inflation in China had steadily increased, response to a rise in the price levels of goods over the period of time (Zhou, 2010). Due to the fact that China was the country with high saving rates, therefore high inflation rate put pressure on the investors (Zhou, 2010). Consequently, real estate investment was selected by investors in order to provide the hedge of inflation (Zhou, 2010).

The research was conducted to investigate the inflation hedging ability of real estate during 2000 to 2008, which is the period after the privatization of real estate, and used an Auto Regressive Distributive Lag (ADRL) cointegration to study the long run association between inflation and real estate prices in China (Zhou, 2010). Unfortunately, **the result of the research was that real estate investment is not an effective inflation hedging in China, contradicting to many previous studies and perceptions (Zhou, 2010)**.

2.3 The inflation hedging ability of Real Estate Investment Trust is not stable and quite unclear.

Apart from the direct investment in real estate, the indirect investment, which is the investment via real estate investment trusts, or fund also provide an effective hedge against inflation. Salisu, Raheem, and Ndako (2020) studied about the reaction of assets with the various characteristics in the market to the increasing of inflation, and found that real estate investment trust is the best for inflation hedging (Salisu, 2020). For real estate, it is an investment, as well as, consumption goods (Salisu, 2020). The rising in price due to inflation was transferred to real estate price through prices of construction materials (Salisu, 2020).

The research was conducted based on the Fisher hypothesis framework, in order to create the conditional heteroscedasticity effects (Salisu, 2020). **The result from the sample data, which was the returns of stock, gold, and real estate investment trust in before and after global financial crisis (between mid-2007 and early 2009), showed that real estate investment trust had the strongest power in hedging inflation, followed by stocks, while gold has no ability in provide the protection of inflation risk (Salisu, 2020).**

Another studies, conducted by Pierdzioch, Risse, Gupta and Nyakabawo (2019), examined about the co-movement between the returns from REITs and both expected and unexpected inflation in order to achieve finding whether REITs investment had ability in hedging inflation (Pierdzioch, 2019). From this research, **the inflation hedging ability of REITs is quite volatile, and still have no clear direction of their movements in different economics circumstances (Pierdzioch, 2019).** This research came up with the idea of using "Bayesian Additive Regression Trees" (BART) to investigate the relationship between the REITs returns and inflation, based on the monthly returns of three REITs indexes, including equity REITs indexes, Mortgage REITs indexes, and Composite REITs indexes in US during 1979-2016 (Pierdzioch, 2019).

The research decided to use BART modeling as a tool to find the result whether the returns from REITs had a relationship with expected and unexpected inflation, owning to the advantages of the model, such as allowing complex nonlinearities in the links between the returns from REITs and inflation rate to be in the model etc. (Pierdzioch, 2019). Unfortunately, the result that the research observed was quite unclear. **The ability of REITs investment in hedging inflation was ambiguous, due to the association among inflation rate and REITs returns was mixed** (Pierdzioch, 2019). **The ability of REITs investment to hedge against inflation was not persistent** (Pierdzioch, 2019). **During negative dependence period, opposite co-movements between REITs returns and both expected and unexpected inflation, REITs indexes have no ability in hedging inflation** (Pierdzioch, 2019). **On the other hand, in positive dependence period, REITs indexes partially hedged inflation** (Pierdzioch, 2019).

In order to see the clear picture about the ability of inflation hedging of REITs investment, the other studies that came up with different model should be considered. According to Chang (2017), it came up with the specific model test about REITs hedging against inflation called the "Markov-switching GRG copula". However, **the inflation hedging ability of REITs, perceived from this study still fluctuate.** The aim of this research was exploring both positive and negative dependence between inflation and returns from REITs at different quantiles, based on the sample data including the annual inflation rate and all REITs total index in US from January 1991 to July 2013 (Chang, 2017).

Empirical results from the Markov-switching GRG copula revealed that **there were negative and positive co-movement about the relationship between REITs returns and inflation rate (Chang, 2017).When there was a negative relationship between REITs returns and inflation rate, the inflation could not be hedged by REITs index (Chang, 2017).** On the other hand, when the relationship between REITs returns and inflation rate is positive, the rising inflation rate can be supported by higher REITs returns (Chang, 2017). Hence, REITs index has an ability in hedging inflation (Chang, 2017). From the studies, they appear to suggest that even **real estate is the best for inflation hedging, comparing with other assets in the market, such as gold, or stock. Unfortunately, the ability of inflation hedging is not persistent.** REITs investment can hedge inflation, when there is a positive linkage between inflation and REITs returns.

2.4 Real estate assets are considered to a good leading indicator of inflation.

The dynamics of real estate prices is employed to predict and understand the movements of macroeconomic. According to Buehler (2016), the paper stated that in case of US, the downturns in the commercial real estate prices contributed to some macroeconomic indicators, consisting of bond yields, consumer confidence, employment, and particularly inflation rates. Even, there was a presence of macroeconomic risk in global economy, some investors still decided to increase the debt in real estate investments to ensure reasonable returns (Buehler, 2016). The behavioral of investors in decision-making is the key to understand the dynamics in the real estate assets price (Buehler, 2016). Therefore, the crash in the prices of the

commercial real estate has a linkage with macroeconomics indicators, which include inflation rates (Buehler, 2016).

3. Data

3.1 Source of Data

Inflation

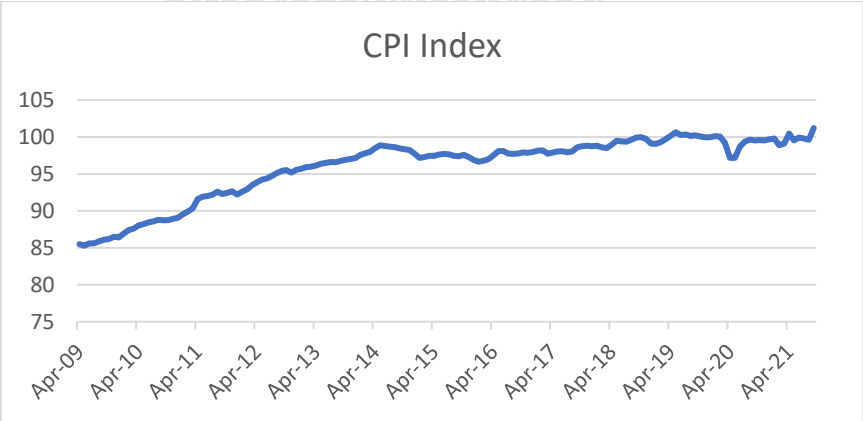
The Consumer Price Index (CPI) is the measurement of the weighted average prices of consumer goods and service. The data of CPI index can be observed from Bloomberg. The variation of CPI reflects the changes price level in the economy, in the other word it indicates the cost of living in the country. Therefore, CPI index is often used to estimate the inflation with the equation

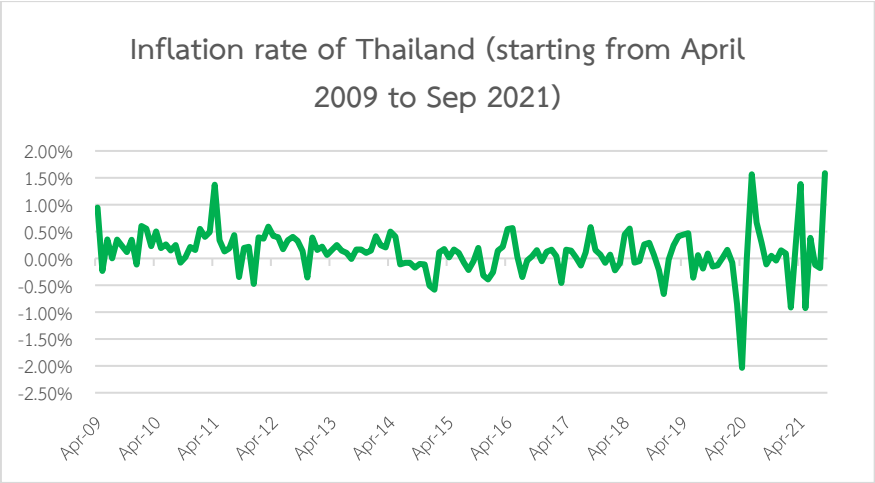
$$\text{Inflation rate in time t} = \frac{\text{CPI in t} - \text{CPI in t}-1}{\text{CPI in t}-1} * 100 \quad (1)$$

In this paper, the changes in CPI index on monthly basis during April 2008 to Sep 2021 are used as a proxy of inflation.

Figure 1: CPI index and inflation rate in Thailand from April 2009 to September 2021

Figure 1 represents the CPI index, and inflation rate, which derived from CPI index calculation between April 2009 to September 2021.





From these graphs, we can see clearly that CPI index gradually increased. When it was used to calculate the inflation rate, it can be concluded that the inflation rate in Thailand is quite low, and ranging between -0.50% and 1.40% until around April 2021. During April 2021, the inflation rate sharply decreased to -2.00% as a result from the arrival of the COVID-19 pandemic crisis, which leads to the slow-down of global economic growth. The overall inflation around the world decreased continuously. After that the inflation gradually increases to over 1.50%, and continued to fluctuate around -1.00% to 1.5%.

Thai real estate market

For Thai real estate market, this study employed the monthly prices indexes of Thai real estate, which is achieved from three available housing indices, including single-detached houses with land, town houses with land, and condominium, which can be achieved from Bank of Thailand (BOT). In Thailand, the real estate price indices were derived from calculating 17 commercial banks' mortgage loan in Bangkok and vicinities, including Samut Prakan, Nonthaburi, Pathum Thani, Nakhon Pathom, and Sanut Sakhon. The Single-House, Townhouse, and condominium price indices were computed by using Rolling window and time dummy hedonic regressions method (3-month moving average), controlling housing characteristics, consisting of age, storey, entrepreneurs and the distance to metropolitan transportation services).

Real Estate Investment Trust (REIT) index

Real Estate Investment Trust (REIT) is a type of investment that allows individuals to invest in large-scale, high income producing real estates, including office

buildings, shopping malls, apartments, hotels, resorts, or warehouses etc. Real Estate Investment Trust (REIT) market data of Thailand, starting from 2009, which is the year that REITs are originated in Thailand are applied in this study. For Thailand, the sample data of REIT index can be found from SET Property Fund & REITs (SETPREIT) index. The study employed monthly SETPREIT index during April 2009 till Sep 2021.

Figure 2: Monthly cumulative of price of real estate investment indices of Thailand (starting from April 2009 to Sep 2021)

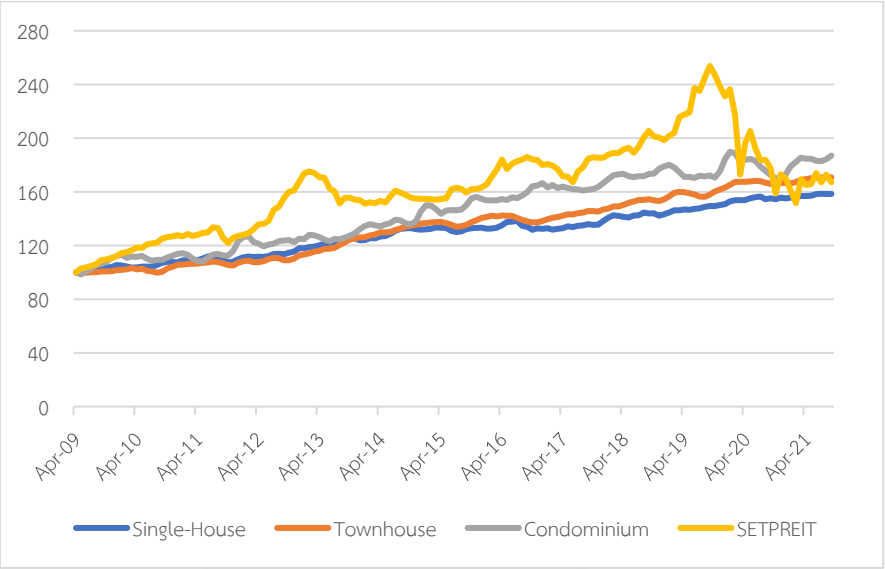


Figure 2 shows the monthly cumulative return for the inflation and the price of real estate assets in Thailand. It clearly shows that the price of real estate assets surged up, and continuously increase, while the inflation rate in Thailand was quite stable, and rarely changed over the studied period. However, concentrating only on the price of each real estate assets, not including inflation, the price of alternative investment in real estate, SETPREIT is outperformed, followed by the price of condominium, townhouse, and single-house respectively.

3.2 Descriptive statistics

Table 1: Descriptive statistics of monthly return of real estate investment and inflation

Variables	Maximum	Minimum	Median	Mean	Std. Dev.
Single-House	0.0214	-0.0261	0.0025	0.0031	0.0080
Townhouse	0.0234	-0.0159	0.0033	0.0035	0.0073
Condominium	0.6362	-0.0348	0.0038	0.0042	0.0160
SETPREIT	0.1379	-0.1992	0.0120	0.0093	0.0359
Inflation	0.0159	-0.0203	0.0012	0.0012	0.0041

Table 1 shows summary statistics for the return of real estate assets and inflation during the studied period, which starts from April 2009 to September 2021. This table reveals that among the real estate assets. SETPREIT had the best performance with mean monthly return of 0.93%, while single-house performed the worst with an average return at 0.31%. The monthly nominal average returns (standard deviation) on single-house, townhouse, condominium, and SETPREIT were 0.31% (0.80%), 0.35% (0.73%), 0.42% (1.60%), and 0.93% (3.59%) respectively. The monthly nominal average return from SETPREIT was higher than that for the other real estate assets in this study, however, this outstanding performance come with a much higher level of risk; the standard deviation of SETPREIT returns at 3.59% was the highest, comparing with the other types of examined real estate assets. However, the table also shows that the return of real estate assets outperformed the average rate of inflation of 0.12% over the study period.

Table 2: Correlation analysis between the return of real estate investment and inflation

Variables	Inflation	Single House	Townhouse	Condo	SETPREIT
Inflation	1.0000				
Single House	-0.0424	1.0000			
Townhouse	-0.0976	0.4556	1.0000		
Condo	-0.1487	0.1130	0.2155	1.0000	
SETPREIT	-0.0313	0.1401	-0.0144	0.1234	1.0000

Based on Table, it shows that the return for the real estate asset groups had a weak negative correlation with the inflation rate as the values ranged from -0.03 to -0.15. Condominium has the highest negative correlation with inflation rate at -0.1487. This correlation result indicates that the relationships between all real estate assets and inflation tend to move in the different direction. Specifically, when the inflation rate in Thailand increases, the price of investigated real estate assets will decrease.

3.3 The Augmented Dickey-Fuller (ADF) test

Before conducting the investigation about the relationship between the inflation and real estate price, the stationary of variables in the model needs to be examined. According to (Fuller, 1981), an Augmented Dickey-Fuller (ADF) test was conducted to test the stationary of variables in the model, including each property types of real estate, SETPREIT, CPI index with the following equation;

$$\Delta X_t = \beta_0 + \beta_1 t + \gamma X_{t-1} + \sum_{i=1}^{n} (\delta_i \Delta X_{t-i}) + \varepsilon_t \quad (2)$$

Where: X_t represents CPI index in Thailand and the price of real estate from Thai market. β_1 is the coefficient that representing time trend t, and γ is the coefficient, presenting the process root. n is the lag of this case, which in this paper the selected lag is the one that generates the lowest value of Akaike's information criterion (AIC) when the test is conducted in each variable.

The hypothesis for test can be written as

- The null hypothesis (H_0): $\gamma = 0$
- The alternative hypothesis (H_1): $\gamma < 0$

The null hypothesis is failed to rejected if the absolute value from test statistics is lower than the critical value (5% significance level), which means that the data is non-stationary. On the other hand, the absolute value from test statistics is higher than the critical value (5% significance level), the null hypothesis is rejected, and it means that the data is stationary and no unit root exists.

ADF test in this paper is firstly applied at level (no different), setting up condition for trend and interception. If there is an existence of unit root at level, ADF with difference will be continued until it is stationary.

Table 3: Unit root testing

The table represents the ADF test both in level and first difference results by using the equation (2) as follows;

$$\Delta X_t = \beta_0 + \beta_1 t + \gamma X_{t-1} + \sum_{i=1}^{n} (\delta_i \Delta X_{t-i}) + \varepsilon_t \quad (2)$$

the numbers in the table represent t-statistic values and if the absolute t-statistic value is greater than critical value, the data is stationary. *** indicates 1 percent significant level

	t-statistic Level	t-statistic 1st Difference
CPI Index	-2.3734	-5.2658***
Single-House	-2.3049	-4.1127***
Townhouse	-2.4163	-4.1836***
Condominium	-1.4407	-7.6979***
SETPREIT	-2.7696	-4.1465***

The unit root testing is conducted for CPI index and price of real estate, which are Single-House, Townhouse, Condominium, and SETPREIT by using an Augmented Dickey-Fuller (ADF) test to check the stationary. Table 3 represents the ADF results, which column (1) suggests that the null hypothesis of the unit-root test at level is failed

to reject. In column (2), the null hypothesis of the unit-root test in first difference is rejected at 1% significance level. Therefore, these results imply that the variables are non-stationary at the level, while the results also indicate that the price of real estate and CPI index are stationary in first difference. So, the price of single-house, townhouse, condominium, SETPREIT, and CPI index are I(1) series. With I(1) series, the cointegration analysis between these variables can proceed.

4. Methodology

The long-run relationship between real estate investment returns and inflation will be examined by cointegration model called "Johansen co-integration tests", as this model is applicable to the non-stationary variables. Then, in the next step Vector Error Correction Model (VECM) is introduced to examine the adjustment of variables in the short-run, when variables are deviated from the equilibrium due to shocks. VECM is also used to perform Granger Causality Test in order to determine whether one variable is useful for prediction another variable. Moreover, VECM is applied to operate Impulse Response Function (IRF) and Variance Decomposition. For Impulse Response Function (IRF), It is used to analyze the dynamic effects of the model in responding to the shock, while Variance Decomposition explains about the variation ratio, as a result from its own shocks against shocks of other variables in the model.

4.1 Measuring the long run relationship between the price of real estate and inflation

The regression of non-stationary series on a stationary series will lead to distorted results. However, there is a case that even the tested variables are non-stationary, but the regression is not fault, if they can establish the long-run relationship. This case is called "cointegration"

The cointegration analysis is employed in order to illustrate the movement between the inflation rate and investigated real estate investment assets. For this study, Johansen co-integration tests are the most appropriate tests to employed, due to their model concentrate on the cointegration of multi variables, when the order of integration is the same.

The report from Johansen made an assumption that cointegrated variables are connected by a vector autoregressive (VAR) with p lags, which are the lags that set the

error terms free from autocorrelation, and become stationary (Johansen, 1988); (Johansen, 1990). Therefore, Johansen co-integration tests start from the first order of Vector Autoregressive (VAR) model given by;

$$X_t = \mu + A_1 X_{t-1} + \cdots + A_4 X_{t-k} + \varepsilon_t \quad (3)$$

This VAR model can be re-written as,

$$\Delta X_t = \mu + \sum_{i=1}^{k-1} (\Gamma_i \Delta X_{t-i+1}) + \pi X_{t-k} + \varepsilon_t \quad (4)$$

Where: $\pi = \sum_{i=1}^{k-1} A_i - I$;

In this case, the X_t vector contains only two elements: the price of real estate (either single-house, townhouse, condominium, and SETPREIT) and CPI index at time t. πX_{t-k} represents the relationship in the long-run between variables. $\pi = \sum_{i=1}^{k-1} A_i - I$;the matrix that represents the amount of cointegration vectors in the model. Moreover, k is the number of lag length, which in this paper, the lag of all the conducted cointegration tests is specified at 4, which is sufficient for data points in this paper.

In Johansen Cointegration Test, there are two ratio tests being applied with the objective to identify the amount of cointegration vectors. These two test statistics are called “The Maximum Eigenvalue test” and “The Trace test”.

For the Maximum Eigenvalue test (λ_{max}), the equation is computed as:

$$\lambda_{max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \quad (5)$$

which the hypotheses are as follows,

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

For the Trace test (λ_{trace}), the equation is computed as:

$$\lambda_{trace}(r) = -T \sum_{i=r+t}^{n} ln(1 - \hat{\lambda}_i) \quad (6)$$

which the hypotheses are as follows,

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

This cointegration test can proceed repeatedly until it fails to reject. If the null hypothesis of r=0 is rejected, and fails to reject the null hypothesis of one cointegration, then it suggests that there is at least one cointegrating equation for all study period. Therefore, it implies that there is an existence of a long run co-movements between inflation and real estate price index.

4.2 Measuring the short-run dynamics between the price of real estate and inflation

Since the cointegration can only estimate the long-run relationship between the inflation rate and each type of real estate investment, but it doesn't provide the details related to the short-term co-movement among those variables. Therefore, the Vector Error Correction Model (VECM) is introduced to examine the short-term movement between the inflation and real estate investment in case that the model exhibits the long run-relationship.

VECM is suitable estimation technique for examining the short-run movement which will be illustrated through the coefficients in the system changes (Eryigit & Eryigit, 2017), as well as deviations from equilibrium, resulting from shock. This model is a form of Vector Autoregressive (VAR) that includes the error correction term (Taderera, 2019). It will show the short-term relationship between the price of real estate and inflation.

The general form of Vector Error Correction Model (VECM) is as following (Engle, 1987);

$$\Delta X_t = a_{+}\Phi ECT_{t-1} + \sum_{i=1}^{k}(\alpha_i \Delta X_{t-i}) + \varepsilon_t \qquad (7)$$

Where: ECT_{t-1} represents the error correction term, which is the values of the deviation from the long run equilibrium from the previous period, which come from the cointegration equation of all X_t that $ECT_{t-1} = X_t - \hat{a} - \sum_{i=1}^{k}(\alpha_i \Delta X_{t-i})$ and Φ shows the speed of adjustment from the deviation to the long run equilibrium, ranging between

-1 and 0. If it is statistically significant, the closer the number to -1, the higher the speed of adjustment. A negative error correction term suggest that the system automatically reverts to a long run equilibrium (Taderera, 2019). On the other hand, A positive error correction implies that the process is not converging in the long run (Taderera, 2019). Besides, k is the lag length, which for VECM the lag length equal to the employed lag in the cointegration test minus 1. In this case, the lag length for VECM equals to 3.

4.3 Granger Causality Test from the Vector Error Correction Model (VECM)

According to Granger Representative theorem (Granger, 1969), the Granger causality test can be conducted from VECM with the purpose to determine whether one times series is useful for forecasting another. In this paper, the test will be separated into each type of real estate investment and inflation, which can be generalized in the following equation as:

$$\Delta X_{RE,t} = a_{RE} + \Phi_{RE} ECT_{t-1} + \sum_{i=1}^{k} (\alpha_{RE,i} \Delta X_{RE,t-i}) + \sum_{i=1}^{k} (\alpha_{CPI,i} \Delta X_{CPI,t-i}) + \varepsilon_{RE,t} \quad (8)$$

$$\Delta X_{CPI,t} = a_{CPI} + \Phi_{CPI} ECT_{t-1} + \sum_{i=1}^{k} (\alpha_{CPI,i} \Delta X_{CPI,t-i}) + \sum_{i=1}^{k} (\alpha_{RE,i} \Delta X_{RE,t-i}) + \varepsilon_{CPI,t} \quad (9)$$

Where: $X_{CPI,t}$ represents CPI index, and $X_{RE,t}$ denotes as the price of real estate (separated into each type consisting of single-house, townhouse, condominium and SETPREIT).

Referring to equation (8)-(9), the intention of this mechanism is to see the adjustment of real estate price and inflation in short-run to long-run equilibrium. A hypothesis was formed to test the causality relationship as follows,

$H_0: \alpha_1 = \alpha_2 = \alpha_3 = \cdots = \alpha_k = 0$

H_1: at least one of the α not equal to 0

If the null hypothesis is rejected; one series granger cause to another series. Therefore, the past values of that one series can be used to predict the future value of another series as well.

4.4 Measuring Impulse response function and Variance Decomposition

In the next step, the VECM equation is employed to conduct the Impulse response Function. The analysis pictures one Standard deviation of innovations/ shocks of one variable toward the other in the model (Yunus, 2020). The movements of variables in the equation will respond to the shock and deviate out from equilibrium. The change in one variable will impact others and create complex relationship that even when the shock is disappeared but still need time to manage to get back to equilibrium again (Yunus, 2020). Moreover, the Impulse response Function is also used to visualize the dynamic of magnitude, duration, persistency and direction, as well as the sign of relationship, whether it is negative or positive from shock (Yunus, 2020). In this case, the impulse response function is employed to present the response of the price of real estate to the shock of inflation rate and vice versa

Variance decomposition is employed to estimate and illustrate about the proportion of variations as a result of its own shocks against shocks in other variables in the model. If the forecast error variance decompositions show the notable share of long-term forecast error variance of the real estate index, explained by inflation. It can imply that there are the long-term influences of inflation on the price of real estate. The greater proportion suggests the stronger result.

5. Empirical Result

5.1 Long-term inflation hedging

Long-term relationship between the price index of the real estate, as well as real estate investment trusts and inflation will based on cointegration model. According to table 1, all the non-stationary monthly series in this paper are all integrated of order 1, or I(1). So, the cointegration model can be employed for analysis.

Table 4: Cointegration tests using Johansen's method

The table represents the cointegration results, receiving from the Johansen's method by using the equation (4) as follows and the cointegration equation has linear trend with 4 lags:

$$\Delta \mathbf{X_t} = \boldsymbol{\mu} + \sum_{i=1}^{k-1} (\boldsymbol{\Gamma_i} \Delta \mathbf{X_{t-i+1}}) + \boldsymbol{\pi} \mathbf{X_{t-k}} + \boldsymbol{\varepsilon_t}$$

In this table, r indicates the amount of cointegrating relationships, while the number in the table are Trace statistic, Max-Eigen statistic, and 5% critical values. ** denotes the rejection of the null hypothesis at 5 percent significant level. The optimal lag of the vector auto-regression for the cointegration test in this case is 4

Panel A: Single-house & Inflation		
Null	**Trace statistic**	**5% Critical Values**
r = 0	12.7884	15.4947
r ≤ 1	1.6931	3.8415
Null	**Max-Eigen Statistic**	**5% Critical Values**
r = 0	11.0954	14.2646
r ≤ 1	1.6931	3.8415
Panel B: Townhouse & Inflation		
Null	**Trace statistic**	**5% Critical Values**
r = 0	15.9162**	15.4947
r ≤ 1	4.3647**	3.8415
Null	**Max-Eigen Statistic**	**5% Critical Values**
r = 0	11.5515	14.2646
r ≤ 1	4.3647	3.8415
Panel C: Condominium & Inflation		
Null	**Trace statistic**	**5% Critical Values**
r = 0	18.1689**	15.4947
r ≤ 1	4.3174**	3.8415

Null	Max-Eigen Statistic	5% Critical Values
r = 0	13.8515	14.2646
r ≤ 1	4.3174**	3.8415

Panel D: SETPREIT & Inflation

Null	Trace statistic	5% Critical Values
r = 0	19.3680**	15.4947
r ≤ 1	5.5221**	3.8415
Null	**Max-Eigen Statistic**	**5% Critical Values**
r = 0	13.8458	14.2646
r ≤ 1	5.5221**	3.8415

The results of the cointegration between the price of real estate and inflation is shown in the panel of Table 4 by applying the Johansen cointegration tests. As shown in the table 4, trace statistics suggest that there is at least two cointegration at 5 percent significant level between the price of townhouse and inflation, the price of condominium and inflation, as well as the price of SETPREIT and inflation. However, there were a little contradiction of the results between trace test and max-eigenvalue test. For example, trace test indicates that there is at least two cointegrating in the model, but at the same time max-eigenvalue test points out that there is no cointegration in the model. According to (Johansen, 1990), and (Kasa, 1992),comparing between trace statistics and max-eigenvalue test, trace statistics are more important and precise as it considers all of the smallest eigenvalues and hold more power than maximum eigenvalue statistic.

Hence, the results indicate that there is an existence of the long-run co-movements between the price of townhouse, condominium, SETPREIT and inflation. However, there is no existence of long-term relationship between the price of single-house and inflation, because trace statistics indicates that there is none of cointegration at 5 percent significant level.

This evidence is in line with the study from (Gunasekarage, 2008), (Le Moigne & Viveiros, 2020), and (Taderera, 2019), which point out that there is an existence of the long-term relationship between the real estate assets and inflation. Moreover, in case of REIT index, the obtained findings are also consistent with (Chang, 2017), which also suggests that there is an existence of the positive co-movements between REIT index and inflation in the long run.

Therefore, with the presence of the long-term relationship between the price of real estate assets, consisting of townhouse, condominium, and SETPREIT and the inflation rate it can imply that in case of Thailand, townhouse, condominium, and SETPREIT can be considered as a good inflation hedging instruments in the long-term. To get more understandings and details, related to the relationships between inflation rates and price of real estate assets, there are more tests to carried out in the next section.

5.2 Short-run dynamics

5.2.1 Adjustment coefficients and short run coefficients of VECM

As cointegration test indicates long-run relationship between inflation and price of real estate, including townhouse, condominium and SETPREIT, vector error correction model (VECM) can be employed to explain about mechanisms between those variables in the short-run.

The short-run dynamic analysis is estimated by employing the error correction model (ECM) with the lag length at 3, and the results are shown in Table 5. According to the panel B and C of Table 5, the CPI index take the effect from the short run adjustment in the price of condominium and SETPREIT in the first lag with the same values at 1.40% as shown in Table 5, suggesting that the CPI index react positively to the changes in the price of condominium and SETPREIT in the short-run. In addition, the speed adjustment coefficients to the equilibrium of CPI index are significantly negative in case of condominium and SETPREIT. This means that if an exogenous shock happens, 0.01% and 0.02% of the deviation of CPI index is absorbed within the first month. Comparing to the study in South Africa by (Taderera, 2019), they find that the total returns from retail property response positively to the changes of inflation. Therefore, the achieved results align with (Taderera, 2019), except that the result from

this paper reveal the reaction of inflation to the changes of inflation, but in case of (Taderera, 2019) is another way around.

For the results of townhouse, which are shown in the panel A of Table 5, the speed of adjustment coefficients to the equilibrium of the price of townhouse are significantly negative. This means that if the exogenous shock happens, 0.53% of the deviation of the price of townhouse can be absorbed to the long-run equilibrium, on the other hand the speed of adjustment coefficients to the equilibrium of the CPI index are significantly positive, indicating that the deviation of CPI index resulting from exogenous shock cannot converge to the long-run equilibrium. The 1st lagged differences of CPI index are not statistically significant, suggesting that there is no existence of the short-run relation between inflation and townhouse.

Table 6 presents the results obtained through the estimation of VAR model with the purpose to find the relationship between inflation and single-house. The reported results suggest that when the dependent variable is single-house, the coefficients of CPI index are not statistically significant at any lagged level. At the same period of time when the dependent variable is CPI index, the coefficients of single-house are not statistically significant at any lagged level as well. These results imply that the short-term relationship between single-house and inflation cannot be determined.

To sum up, the results in Table 5 and 6 suggest that there is an existence in the short-term relationship between the real estate assets, which in this case is condominium, and SETPREIT, and inflation, which is consistent with the findings from (Taderera, 2019), which suggest that there is an existence of short-term relationship between real estate properties and inflation.

Table 5: Vector Error Correction Model

The results in the table are measured by using error correction model (ECM) and achieved through the equation (8) and (9):

$$\Delta \mathbf{X_{RE,t}} = \mathbf{a_{RE}} + \mathbf{\Phi_{RE}} \mathbf{ECT_{t-1}} + \sum_{i=1}^{k} (\alpha_{RE,i} \Delta \mathbf{X_{RE,t-i}}) + \sum_{i=1}^{k} (\alpha_{CPI,i} \Delta \mathbf{X_{CPI,t-i}}) + \boldsymbol{\varepsilon}_{RE,t}$$

$$\Delta \mathbf{X_{CPI,t}} = \mathbf{a_{CPI}} + \mathbf{\Phi_{CPI}} \mathbf{ECT_{t-1}} + \sum_{i=1}^{k} (\alpha_{CPI,i} \Delta \mathbf{X_{CPI,t-i}}) + \sum_{i=1}^{k} (\alpha_{RE,i} \Delta \mathbf{X_{RE,t-i}}) + \boldsymbol{\varepsilon}_{CPI,t}$$

where, Φ represents the speed of adjustment, and the short-term relationship is presented by $\alpha_{RE,i}$(which is separated to $\alpha_{TH,i}$ for Townhouse, $\alpha_{CON,i}$ for condominium, $\alpha_{REIT,i}$ for SETPREIT, and $\alpha_{CPI,i}$ and the lag for this test is 3. The number in parenthesis are t-statistics. *** indicates 1 percent significant level, ** indicates 5 percent significant level, and * indicates 10 percent significant level. The other rows represent α_i, which indicates the short-term relationship, including the direction between the price of real estate and inflation.

Panel A: Townhouse & Inflation

	Townhouse		CPI index
$\mathbf{\Phi_{TH}}$	-0.0054 (-1.7567)*	$\mathbf{\Phi_{CPI}}$	0.0045 (2.8209) ***
$\mathbf{\alpha_{TH,1}}$	0.5128 (6.3650) ***	$\mathbf{\alpha_{CPI,1}}$	0.2704 (3.0607) ***
$\mathbf{\alpha_{TH,2}}$	0.1024 (1.1306)	$\mathbf{\alpha_{CPI,2}}$	-0.2042 (-2.2686) **
$\mathbf{\alpha_{TH,3}}$	-0.3126 (-3.9558) ***	$\mathbf{\alpha_{CPI,3}}$	0.0495 (0.5578)
$\mathbf{\alpha_{CPI,1}}$	-0.2625 (-1.5423)	$\mathbf{\alpha_{TH,1}}$	0.0552 (1.3197)
$\mathbf{\alpha_{CPI,2}}$	-0.2320 (-1.3381)	$\mathbf{\alpha_{TH,2}}$	-0.0477 (-1.0150)
$\mathbf{\alpha_{CPI,3}}$	0.0976 (0.5707)	$\mathbf{\alpha_{TH,3}}$	0.0184 (0.4481)
$\mathbf{a_{TH}}$	0.3679 (4.5662) ***	$\mathbf{a_{CPI}}$	0.0839 (2.0060) **

Panel B: Condominium & Inflation

	Condominium		CPI index
$\mathbf{\Phi_{CON}}$	-0.0027 (-1.1864)	$\mathbf{\Phi_{CPI}}$	-0.0002 (-2.8230) ***
$\mathbf{\alpha_{CON,1}}$	-0.0073 (-0.0878)	$\mathbf{\alpha_{CPI,1}}$	0.1894 (2.1244) **
$\mathbf{\alpha_{CON,2}}$	-0.1267 (-1.3634)	$\mathbf{\alpha_{CPI,2}}$	-0.1131 (-1.2469)
$\mathbf{\alpha_{CON,3}}$	0.2786 (2.9834) ***	$\mathbf{\alpha_{CPI,3}}$	-0.0478 (-0.6019)
$\mathbf{\alpha_{CPI,1}}$	-5.2715 (-1.6205)	$\mathbf{\alpha_{CON,1}}$	0.0140 (6.1530) ***
$\mathbf{\alpha_{CPI,2}}$	-1.8374 (-0.5554)	$\mathbf{\alpha_{CON,2}}$	0.0013 (0.5168)

$\alpha_{CPI,3}$	0.6570 (0.2266)	$\alpha_{CON,3}$	-0.0005 (-0.1955)
a_{CON}	2.0889 (1.8409) *	a_{CPI}	0.0778 (2.5004) **

Panel C: SETPREIT & Inflation

	SETPREIT		**CPI index**
Φ_{REIT}	-0.0027 (-1.1864)	Φ_{CPI}	-0.0002 (-2.8230) ***
$\alpha_{REIT,1}$	-0.0073 (-0.0878)	$\alpha_{CPI,1}$	0.1894 (2.1244) **
$\alpha_{REIT,2}$	-0.1267 (-1.3634)	$\alpha_{CPI,2}$	-0.1131 (-1.2469)
$\alpha_{REIT,3}$	0.2786 (2.9834) ***	$\alpha_{CPI,3}$	-0.0478 (-0.6019)
$\alpha_{CPI,1}$	-5.2715 (-1.6205)	$\alpha_{REIT,1}$	0.0140 (6.1530) ***
$\alpha_{CPI,2}$	-1.8374 (-0.5554)	$\alpha_{REIT,2}$	0.0013 (0.5168)
$\alpha_{CPI,3}$	0.6570 (0.2266)	$\alpha_{REIT,3}$	-0.0005 (-0.1955)
a_{REIT}	2.0889 (1.8409) *	a_{CPI}	0.0778 (2.5004) **

Table 6: Vector Autoregression (VAR) to estimate the interrelationships between the price of Single-House and inflation

As the cointegration between the price of single-house and inflation cannot be found, therefore the VECM cannot be applied. So, Vector Autoregression (VAR) is introduced to study about the relationship between the price of single-house and inflation with the following equation:

$$X_{SH,t} = a_{SH} + \sum_{i=1}^{k}(\alpha_{SH,i}X_{SH,t-i}) + \sum_{i=1}^{k}(\alpha_{CPI,i}X_{CPI,t-i}) + \varepsilon_{SH,t} \quad (10)$$

$$X_{CPI,t} = a_{CPI} + \sum_{i=1}^{k}(\alpha_{CPI,i}X_{CPI,t-i}) + \sum_{i=1}^{k}(\alpha_{SH,i}X_{SH,t-i}) + \varepsilon_{CPI,t} \quad (11)$$

where, X_t is the vector that represents the price of single-house ($X_{SH,t}$), and CPI index ($X_{CPI,t}$). The selected lag length for the VAR model in this paper is 3, therefore the obtained results from VAR model will be consistent with the results, generated from VECM. $\alpha_{SH,i}$ and $\alpha_{CPI,i}$ are the coefficients for the endogenous variables, which represent the interrelationships between the price of single-house and inflation. From the reason that VAR model can be applied only with stationary variables, therefore the 1st differentiate of price index of single-house and CPI index is applied in the model. The number in parenthesis are t-statistics. *** indicates 1 percent significant level, and ** indicates 5 percent significant level. The other rows represent α_i, which indicates the relationship, including the direction between the price of single-house and inflation.

Panel D: Single-house & Inflation

	Single-house		CPI index
$\alpha_{SH,1}$	0.2258 (3.0469)***	$\alpha_{CPI,1}$	0.2711 (3.0193)***
$\alpha_{SH,2}$	0.1519 (2.0034)**	$\alpha_{CPI,2}$	-0.2002 (-2.1796)**
$\alpha_{SH,3}$	-0.4769 (-6.4181)***	$\alpha_{CPI,3}$	0.0435 (0.4881)
$\alpha_{CPI,1}$	-0.1394 (-0.7036)	$\alpha_{SH,1}$	0.0424 (1.2634)
$\alpha_{CPI,2}$	-0.0029 (-0.0143)	$\alpha_{SH,2}$	-0.0161 (-0.4699)
$\alpha_{CPI,3}$	0.2230 (1.1345)	$\alpha_{SH,3}$	-0.0051 (-0.1524)
a_{SH}	0.4066 (4.6349)***	a_{CPI}	0.0885 (2.2265)**

5.2.2 Granger causality test

Table 7: Granger causality test between the price of real estate and inflation

The results of the Granger causality test, outlined in the table are derived from VECM model (In case of the Granger causality test between the price of single-house and inflation, the results are achieved from VAR model). The number in the table is obtained from Chi-square test. *** indicates 1 percent significant level

Panel A: Townhouse and Inflation	
The null hypothesis	**Chi-square (X^2)**
Inflation does not "Granger" cause the price of townhouse	5.9680
The price of townhouse does not "Granger" cause inflation	1.9488
Panel B: Condominium and Inflation	
The null hypothesis	**Chi-square (X^2)**
Inflation does not "Granger" cause the price of condominium	3.5316
The price of condominium does not "Granger" cause inflation	39.0580***
Panel C: SETPREIT and Inflation	
The null hypothesis	**Chi-square (X^2)**
Inflation does not "Granger" cause the price of SETPREIT	4.6402
The price of SETPREIT does not "Granger" cause inflation	38.7936***
Panel D: Single-house and Inflation	
The null hypothesis	**Chi-square (X^2)**
Inflation does not "Granger" cause the price of single-house	2.1388
The price of single-house does not "Granger" cause inflation	1.6687

Table 7 represents the causality tests that obtained by using VEC model (in case of Single-house by using VAR model). The results in panel A and panel D show that the price of single-house and townhouse are not Granger caused by inflation, and inflation is also not Granger caused by the price of single-house and townhouse as well, therefore, these results indicate that there is no causality relationship between the price of single-house and townhouse, and inflation. In other word this analysis provides the evidence that the price of the price of single-house and townhouse have no influence on inflation, while inflation have no effect on the price of single-house and townhouse as well. Then, the past information of single-house and townhouse has no ability to forecast an inflation.

On the other hand, for panel B, it can be seen that the direction of causality is from the price of condominium to inflation, since the estimated chi-square is significant at the 1% significant level. However, there is no reverse causation from inflation to price of condominium. Similarly, the price of SETPREIT Granger cause inflation at 1% significant level, and there is no reverse causation from inflation to price of SETPREIT as well. From these results, These results imply that the inflation can be predicted by considering the past information about the price of condominium and SETPREIT.

the obtained results of this study are consistent with the study of (Le Moigne & Viveiros, 2020), which outlined that the direction of Granger causality from total and appreciation returns of real estate assets to inflation as well. (Le Moigne & Viveiros, 2020) made a point that real estate assets have been widely accepted as a hedge of inflation from the perspectives of investors, therefore when inflation is existed, investors will start to allocate their capitals into real estate investment. Therefore, the ability of real estate assets as an inflation hedging will be enacted through the appreciation in the value and return from real estate. In addition, the study from (Buehler, 2016), it also emphasized and made the additional point that the movements in price of the real estate can be applied to forecast and understand about the variations of macroeconomics variables. It indicates that the price of real estate assets is thought to have an influence in forecasting, and also illustrating the inflation.

In summary, with the finding from (Le Moigne & Viveiros, 2020), reporting that real estate accounts for a part of component of the CPI, and the study of (Buehler, 2016),

in the short run the price of real estate assets, including condominium and SETPREIT can be used to predict inflation rates, or in other word in Thailand the price of those types of real estate can be considered as a leading indicator of inflation rates.

5.3 Impulse response function and variance decomposition

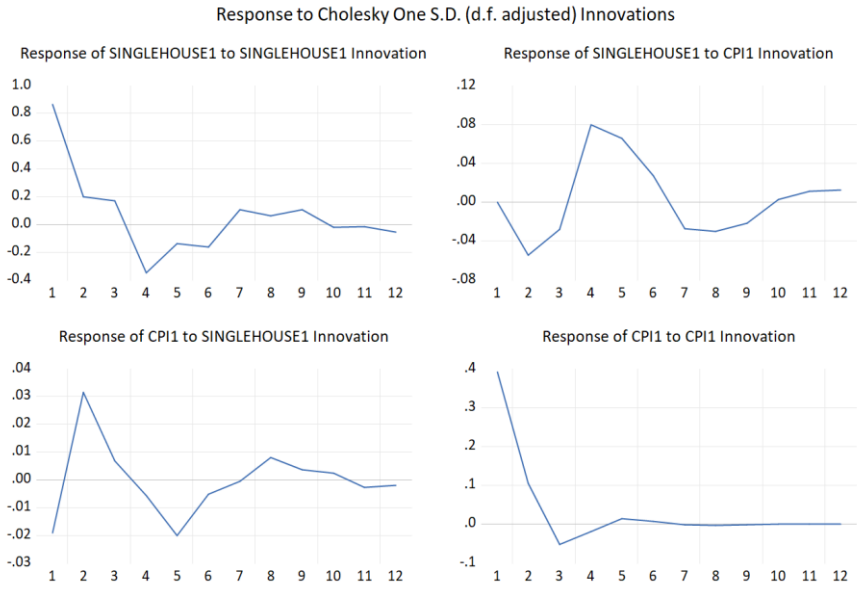
Beside from using VECM (or in case of single-house is VAR) to examine the short-run relationship, adjustment coefficient, and Granger causality, the VECM (or VAR) model can also be employed to see the movement of inflation and price of real estate, corresponding to the shock and also analyze the proportion of the variation effected by shocks as well. To further examine dynamic relationships in the price of real estate assets and inflation, the results of Impulse response function and variance decomposition are illustrated in Figure 3 and Table 8.

5.3.1 Impulse response function

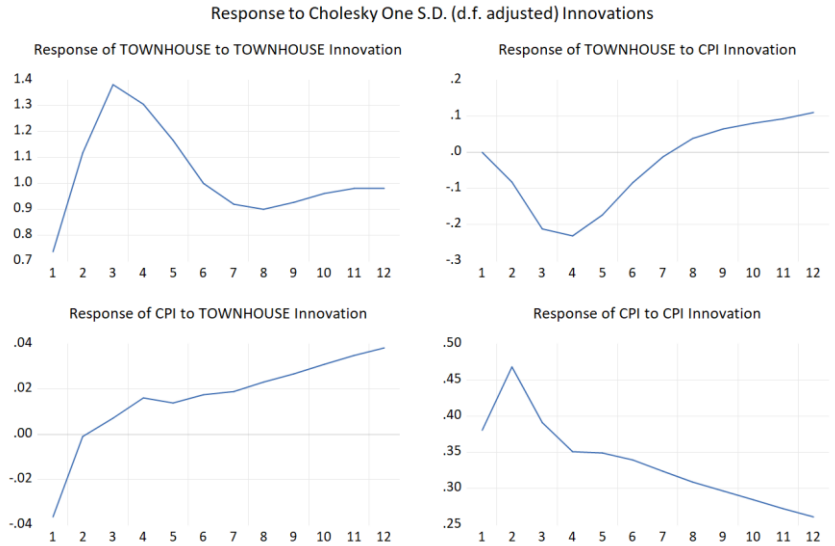
Impulse response function is employed to access the relation between real estate investment and inflation over time through the impulse response analysis in the VECM (or VAR) model. Impulse response function performs the dynamic impact analysis among variables in the system by measuring how a standard deviation shock to a variable in the system is transferred to the other. Residual one standard deviation is used as a method for decomposition setting the impulses to one standard deviation of the residuals.

Figure 3: Impulse response function

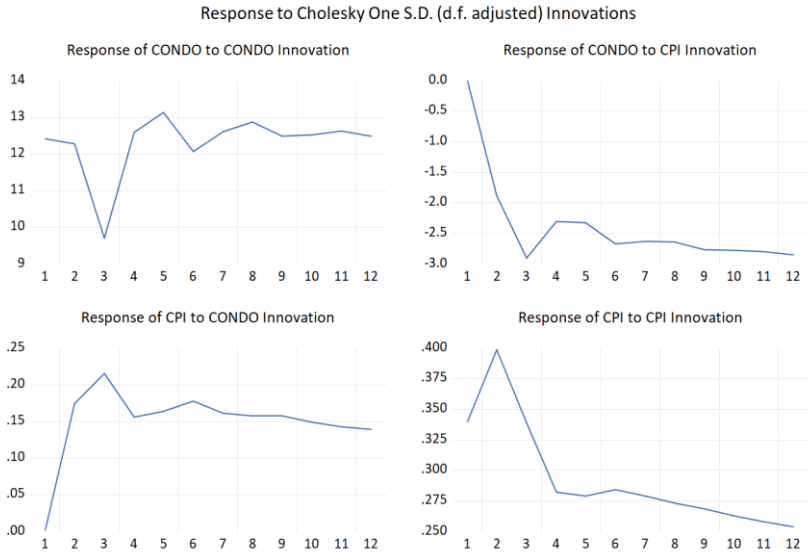
Panel A: Impulse response function for Single-house & Inflation



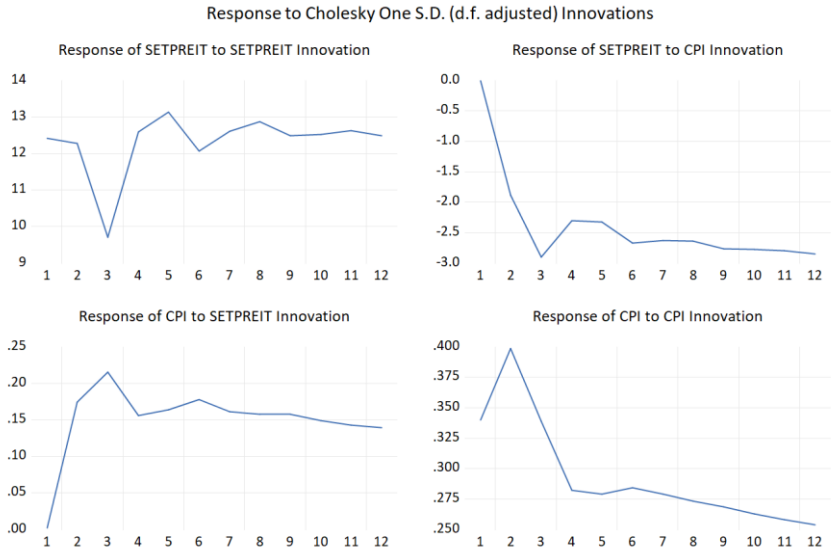
Panel B: Impulse response function for Townhouse & Inflation



Panel C: Impulse response function for condominium & Inflation



Panel D: Impulse response function for SETPREIT & Inflation



The results of the impulse response function analysis are shown in Figure 3, which provide the evidence, related to the ability of past values of the price of real estate assets to forecast the future dynamics of CPI index and vice versa. Overall, the results suggest that the price of real estate assets and inflation of all real estate assets majorly respond to their own shock.

The variations in the price of townhouse, condominium, and SETPREIT have a positive impact on CPI. In other word, the shock in the price of townhouse, condominium, and SETPREIT have an influence in explain the movement of inflation.

5.3.2 Variance decompositions

Variance decompositions are employed to demonstrate the percentage of the forecasting error of variable over time due to a specific shock. In other words, variance decompositions display how much of the variability in the dependent variable is explained by its own shocks versus the shocks in the other variables in the system. In variance decompositions, the Choleski decomposition is used to conduct the innovation accounting. The ordering in the Choleski decomposition might remarkably have an impact on the results due to the first order might end up has the higher proportion of the variation. Therefore, during conducting the test, we decided to switch the Choleski ordering to see whether there is an existence of any difference. However, the achieved results are quite similar. It can briefly conclude that the order biased was not presence in this case.

In the analysis, variance decompositions are investigated up to 24 lag periods. The results show that the forecast error variance, which is explained by its own variance gradually decrease as time pass by. At the same time, the results also suggest that there is an increasing effect of the other.

In panel A and B of table 9, the movement in the price of single-house and townhouse and CPI are explained by their own shocks. In other word, for Single-house and townhouse, share of long-term forecast error variance are explained by its own variance, and CPI is also explained by its own variance as well. So, we can conclude that the price of single-house and townhouse were fail to make significant impacts on CPI index, and the past values of the price of single-house and townhouse have no ability to predict the movement of CPI index. At the same time, CPI index also had no influence on the price of single-house and townhouse, and cannot be employed to forecast the variation of the price of single-house and townhouse as well.

On the other hand, in panel C and panel D of table 9 show that the shock to the price of condominium and SETPREIT had a significant effect on the CPI index. From these results, we can conclude that the price of condominium and SETPREIT had an

important in predicting and explaining CPI index. In other word, these results once again show that the past information of condominium and SETPREIT have an ability to predict an inflation.

Table 8: Estimates of Variance Decomposition

Variance decomposition derived from VECM (or VAR for single-house &CPI), using Choleski ordering shows the proportion of the variation effected by shocks of price of real estate and inflation (CPI). The number in table shows the magnitudes of the forecast error variances that are demonstrated by shocks of each other.

Panel A: Variance decomposition for Single-House and CPI		
Lags (n)	**Percentage of movement in Single-House explained by shocks to:**	
	Single-House	**CPI**
1	99.77%	0.23%
2	99.26%	0.74%
3	99.12%	0.88%
6	97.70%	2.30%
10	97.48%	2.52%
12	97.46%	2.54%
15	97.45%	2.55%
18	97.45%	2.55%
20	97.45%	2.55%
22	97.45%	2.55%
24	97.45%	2.55%
Lags (n)	**Percentage of movement in CPI explained by shocks to:**	
	Single-House	**CPI**
1	0.23%	99.77%
2	0.82%	99.18%
3	0.83%	99.17%
6	1.10%	98.90%
10	1.15%	98.85%
12	1.15%	98.85%
15	1.16%	98.84%
18	1.16%	98.84%
20	1.16%	98.84%
22	1.16%	98.84%
24	1.16%	98.84%
Panel B: Variance decomposition for Townhouse and CPI		
Lags (n)	**Percentage of movement in Townhouse explained by shocks to:**	
	Townhouse	**CPI**
1	99.09%	0.91%
2	97.76%	2.24%
3	95.80%	4.20%
6	95.00%	5.00%
10	96.41%	3.59%
12	96.93%	3.07%
15	97.38%	2.62%
18	97.48%	2.52%
20	97.41%	2.59%
22	97.26%	2.74%

24	97.03%	2.97%
Lags (n)	**Percentage of movement in CPI explained by shocks to:**	
	Townhouse	**CPI**
1	0.91%	99.09%
2	0.36%	99.64%
3	0.27%	99.73%
6	0.24%	99.76%
10	0.37%	99.63%
12	0.53%	99.47%
15	0.83%	99.17%
18	1.21%	98.79%
20	1.51%	98.49%
22	1.83%	98.17%
24	2.19%	97.81%
Panel C: Variance decomposition for Condominium and CPI		
Lags (n)	**Percentage of movement in Condominium explained by shocks to:**	
	Condominium	**CPI**
1	99.99%	0.01%
2	98.96%	1.04%
3	97.27%	2.73%
6	96.93%	3.07%
10	96.50%	3.50%
12	96.33%	3.67%
15	96.08%	3.92%
18	95.85%	4.15%
20	95.70%	4.30%
22	95.55%	4.45%
24	95.41%	4.59%
Lags (n)	**Percentage of movement in CPI explained by shocks to:**	
	Condominium	**CPI**
1	0.01%	99.99%
2	9.94%	90.06%
3	16.48%	83.52%
6	20.30%	79.70%
10	21.87%	78.13%
12	22.05%	77.95%
15	21.97%	78.03%
18	21.66%	78.34%
20	21.38%	78.62%
22	21.06%	78.94%
24	20.72%	79.28%
Panel D: Variance decomposition for SETPREIT and CPI		
Lags (n)	**Percentage of movement in Condominium explained by shocks to:**	
	Condominium	**CPI**
1	99.99%	0.01%
2	98.96%	1.04%
3	97.27%	2.73%
6	96.93%	3.07%
10	96.50%	3.50%
12	96.33%	3.67%
15	96.08%	3.92%

18	95.85%	4.15%
20	95.70%	4.30%
22	95.55%	4.45%
24	95.41%	4.59%
Lags (n)	**Percentage of movement in CPI explained by shocks to:**	
	Condominium	**CPI**
1	0.01%	99.99%
2	9.94%	90.06%
3	16.48%	83.52%
6	20.30%	79.70%
10	21.87%	78.13%
12	22.05%	77.95%
15	21.97%	78.03%
18	21.66%	78.34%
20	21.38%	78.62%
22	21.06%	78.94%
24	20.72%	79.28%

6. Conclusion

This study examined the relationship in the long-term and short-term dynamics between real estate assets in Thailand and inflation (derived from CPI index). The period of the study was from April 2009 to Sep 2021. The Johansen cointegration test, Vector Error Correction Model (VECM), as well as causality tests, impulse response functions, and variance decompositions were applied to investigate the inflation hedging ability of properties.

The result suggests that there is a long-term relationship between rate of inflation and the price of real estate assets, which are townhouse, condominium, and SETPREIT, which is consistent with (Gunasekarage, 2008), in Canada by (Le Moigne & Viveiros, 2020). However, in case of single-house the cointegration is not found, therefore single-house and inflation do not exhibit the long-term relationship. With the exhibition of the long-term relationships between the price of townhouse, condominium, and SETPREIT, and inflation, it can imply that in the long-run townhouse, condominium, and SETPREIT can be used as a hedge against inflation. In the short-term, the dynamic relationships with inflation rate are found in condominium and SETPREIT, which correlate with (Taderera, 2019). So, condominium and SETPREIT have a short-term relationship with inflation. Besides, in the short-run the single-house does not have a relationship with inflation rate as well. Therefore, we can conclude that single- house does not have a relationship with inflation in both short-term and long-term.

The results from the Granger causality also shows that the inflation rates can be predicted by considering the lagged price of condominium and SETPREIT, but there is no existence of the reverse causation from inflation rates to the price of condominium and SETPREIT. Besides, there is no causality between the price of single-house & townhouse and inflation. These findings suggest that in the short-run price of real estate assets, including condominium and SETPREIT have a significant impact on inflation, which is relevant with (Le Moigne & Viveiros, 2020). Therefore, the past values of real estate assets, which are condominium and SETPREIT can be considered to forecast an inflation in Thailand in the short-term.

In summary, the results from this study suggest that Thai real estate assets have a superior hedging ability against inflation in the long run. These results support the findings of previous literature, which suggest that real estate assets are the good hedge of inflation as well. Besides, this study also illustrates that in the short-run the price of condominium and SETPREIT have an influence in explaining the dynamics of inflation rates.

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