Safe-haven property of gold toward multi asset portfolio during Covid-19 Pandemic

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คุณสมบัติความเป็นทรัพย์สินปลอดภัยของทองคำ ต่อพอร์ตการลงทุนในสินทรัพย์ที่หลากหลาย ในช่วงการระบาดของ Covid-19

น.ส.นลัทพร ธรรมธรสิริ

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This study test whether gold has a property of safe-haven asset during the COVID-19 pandemic by performing multivariate time series analysis against multiple asset classes (equity, fixed income, property fund and REIT, and BITCOIN). Dividing testing period into pre- (2015 -2019) and on-going COVID-19 period (2020), the result of long run cointegration test came out that gold is shown to have a cointegrating relationship only during COVID-19 and no cointegration during pre-pandemic. This can be indicated that gold does not have the property of being a hedging instrument over a long run but consider itself to be a hedging asset over the pandemic period. For short run relationship during the COVID-19, the result from impulse response shows gold to be a strong safe-haven asset only against traditional asset class such as equity, fixed income, and real estate, but not for the alternative asset class like BITCOIN as the impact from the shock of S&P500, UST and NAREIT to gold are in the opposite direction compared to pre-pandemic.

Field of Study:	Finance	Student's Signature .....
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1. Introduction

The unique characteristic of COVID-19 pandemic is unlike other crises that happened in world history. This situation provides an opportunity to re-examine the property of gold as the safe-haven asset where it is defined as the asset that provides investors a safe place or non-negative return during market turmoil (Baur & McDermott, 2010). In other words, during the crisis, this safe-haven asset should have a property of no-correlation or negative correlation or non-co-integrated characteristic with other asset classes in the investment portfolio (Yunus, 2020).

Thus, the objective of this paper is to test whether gold has a property of safe-haven asset during the COVID-19 pandemic by performing multivariate time series analysis against multiple asset classes. Dividing testing period into pre- and on-going COVID-19 period, we will employ the cointegration test to measure the safe-haven property of gold in the long run. Then we will perform impulse response function using vector error correction model to further measure the short-run relationship of being safe-haven asset of gold as weak or strong toward portfolio that consists of equity, fixed income, property fund and REIT,

and BITCOIN in order to compare the dynamic of the impact from widespread of COVID-19.

Starting from Hubei Provinces in China in December 2019, this infectious disease spreads to 221 countries with more than 4.8 million deaths and almost 234 million reported cases around the world as of October 2021 (Worldometer, 2021). To tackle this problem, many government policies such as social distancing and country lockdown, are implemented which result in shutting down the international supply chain system (Scott R. Baker, 2020).

This pandemic links both financial and economic turmoil together with the infectious disease that spread the shock to many asset classes globally. Its strong connectivity of the financial markets and the spillover effects is significantly high during this period (Bouri, Cepni, et al., 2020). Table 2 in data descriptive shows the impact of the COVID-19 pandemic on the financial market. During the pre-pandemic period, five years average return of Bitcoin as the alternative asset class showing to be the highest and follow by S&P500, NAREIT, Gold and U.S. Treasury which are traditional asset class, respectively. However, after the existing of this widespread disease, gold average returns largely jump four times from the previous period from 0.02% to 0.09%, which is the highest changed

among traditional asset classes excluding Bitcoin. Also, during this pandemic, the volatility is very high as it shows in the standard deviation of all asset classes that dramatically increase especially gold that its' median largely change from the previous period.

Even though portfolio diversification theoretically decreases some level of loss during the crisis (Jaffe, 1989), the study from (Dornbusch et al., 2000) suggested the contagion effects that there is strong co-movement in financial market during market turbulence from one country to another. In addition, there is a higher correlation between each asset classes as showing in Table 3. During the COVID-19 period in 2020, the correlation of gold, which traditionally perceive as the safe-haven asset, toward other asset classes increase and are positively correlated, while the U.S. Treasury seems to have higher degree of becoming safe-haven asset as it is negatively correlated with other asset classes except for gold.

Moreover, loss aversion framework could lead investors to seek for shelter during the storm. Investors are more concerned and avoid loss than in gaining circumstances (Tversky & Kahneman, 1991). Thus, such a condition motivates the idea in re-visiting the property of gold as it is traditionally perceived as safe-haven asset that positively performs during COVID-19 which in term of investment, it is very significant for

investors to realize an important in the relationship between safe-haven assets and other asset classes in order to rebalance the investment portfolio.

There are three levels of safe-haven definition that most literatures usually use: hedge, weak safe-haven, and strong safe-haven (Baur & McDermott, 2010; Jaffe, 1989; Yunus, 2020). Firstly, Hedge means, on average, the asset does not have the correlation or have negative correlation or do not co-integrated toward others in the portfolio over the long run. This means, the asset that is considered being a hedging asset, which provides diversification benefit, will not be cointegrated and can be excluded from the others in long run relationship. Secondly, Weak safe-haven asset means, during the crisis or market turbulence, the asset is not correlated or receives little impact from shock or does not response by the shock with a high magnitude compared to other asset classes. And finally, Strong safe-haven asset means, during the crisis, the asset is negatively correlated or largely moves in the opposite direction as it is affected by the shock in comparison to other asset classes (Yunus, 2020).

To the best knowledge, there are various studies on gold as hedging asset, but usually analyses against equity during a certain period while there is only a paper study on time series linkage during 1985 until

2017 of gold being safe-haven asset against many asset classes such as stock, fixed income, and real estate (Yunus, 2020). From our objective to revisit the safe-haven property of gold during this pandemic, our hypothesis is that gold should consider being a weak safe-haven asset during the COVID-19 pandemic.

2. Literature Review

Literatures suggest government bonds, cryptocurrency, and commodities specifically gold as one of the asset classes helping to diversify investment portfolios (Baur & McDermott, 2010; Bouri, Shahzad, et al., 2020; Jaffe, 1989). However, focusing on commodity, the degree of gold acting as safe-haven asset is different toward each asset class. Most of the studies analyses gold against individual asset class such as equity as a hedge asset but not so many studies against fixed income and property fund and REITs. Moreover, with the emerging of alternative investment of cryptocurrency, Bitcoin also found to offer diversification properties as its return pattern is different from traditional asset (Baur et al., 2017). Therefore, in term of understanding the diversification properties of gold in the investment portfolio, the academic literature of the relationship between gold and each asset classes (Equity, Fixed income, Property fund and REITs and Bitcoin) is presented as follow.

There are vast of literatures study the safe-haven properties of gold toward common equity. One of the earlier studies is from (Jaffe, 1989). He stated that there is no correlation between gold and equity, and to most asset classes its correlation is low. By constructing multi-asset portfolio including different weights in gold and test the effect of it, the results came out that the higher weight in proportion of gold in the portfolio; sample vary from 5% to 15%; the more increasing in return and lower in risk (Jaffe, 1989). Moreover, the research from (Baur & Lucey, 2010) suggested gold to be safe-haven asset toward equity but for a short period of time after an extreme loses. This provided contradicting resulted from (Yunus, 2020) that gold is integrated with equity in the long run. Furthermore, gold is traditionally seen as the assets that preserve their intrinsic value and usually used as a hedging instrument against common stock in especially developed countries (Baur & McDermott, 2010). However, for some emerging markets, gold represents as a weak safe-haven asset due to differences in investor behavior (Baur & McDermott, 2010). Focusing on COVID-19 situation, it is the crisis that combines many problems together. The revisiting of the gold properties against many indices has been addressed. Commodity future of soybean and gold are resulted to be the safe-haven asset toward equity during this pandemic; evident from US, EU, and China (Ji et al., 2020).

The number of specific studies on gold and bond are relatively lower than equity; especially the study of fixed income during the period of COVID-19 is still rare. The existing studies usually analyze the property of gold in combination of bond and other asset classes. Normally, Treasury bond is also considered as safe asset. It offers fixed income until maturity while gold has not but rather protects investors from currency and default risk (Baur & McDermott, 2016). The study on the hedging role of gold using GARCH process suggested that gold is not a safe-haven asset for fixed income, but it acts as the hedging instrument for German's bond and not for U.S. and U.K. from 1995 to 2005 (Baur & Lucey, 2010). Gold also resulted to show negative relationship with treasury bills but turned out to have no relationship with long term U.S.'s government and corporate bond (Jaffe, 1989). Discussing on the study from (Yunus, 2020), bond and gold are integrated in the long run. This means that on average both are moving in the same direction over 30 years period which resulted in not being a strong hedging asset.

The research on property fund and REITs during the COVID-19 pandemic is also very hard to find. Usually, the relationship between gold and real estate is defined as being an inflation hedge within the portfolio. Many literatures suggest real estate to be an inflation hedging instrument

(Larsen & Mcqueen, 1995; Mull & Soenen, 1997). Gold and REITs mean return is approximately equal, but its correlation to inflation is negative. Also, gold is better performed as an inflation hedge compared to gold stock, stock, and REITs (Larsen & Mcqueen, 1995). By optimizing mean-variance multi-asset portfolio; that consist of bonds, cash, equity, and gold; including international real estate improves the risk-return characteristic (Chua, 1999). In addition, as mentioned before on paper of (Jaffe, 1989) that the relationship of gold and real estate resulted to be similarly low compared to other asset classes. Moreover, gold and real estate are correlated over the long horizon where it shows to reduce the diversification benefit in investing portfolio (Yunus, 2020).

Alternative investment of cryptocurrency, especially Bitcoin have been in the spotlight over the past decade since the introduction of (Nakamoto, 2009). With it unique characteristic induced vast of researchers to study on its role of becoming the safe-haven asset as an idealistically alternative investment of gold in which both asset classes share several common characteristics. Bitcoin and gold are produced by mining with limited supply. Also, regulated by U.S. Commodity Futures Trading Commission (CFTC), both are commodities and do not generate periodic income by themselves (Bouri, Shahzad, et al., 2020). The study

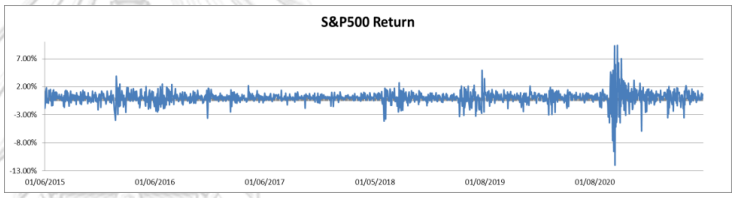
using wavelet coherence approach on the dependency of stock, bond, gold, and Bitcoin suggested Bitcoin to rank the first in term of being safe-haven asset due to the unconnected characteristic to financial market (Bouri, Shahzad, et al., 2020). Moreover, Bitcoin result to be safe-haven asset in short-run during the COVID-19 pandemic (Dwita Mariana et al., 2021). On the contrary, (Conlon et al., 2020) study stated that during the COVID-19 pandemic, Bitcoin is not pronounced to be safe-haven asset against international indices as it increases the portfolio downside risk. This is in line with (Kliber et al., 2019) that Bitcoin shows to be a weak hedging instrument in comparison to equity.

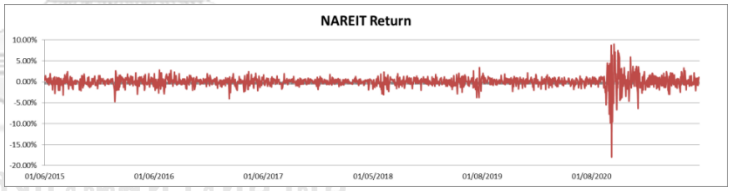
To sum up, there are mixed of result and various studies on gold being a hedging instrument and safe-haven asset, depending on time horizon and portfolio type. But there are less studies on the magnitude of gold being a safe-haven asset in benefiting from diversified investment portfolio during crisis using time series multivariate analysis.

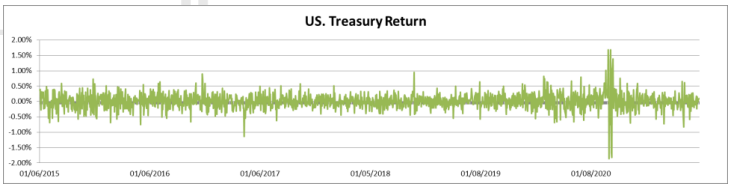
3. Data

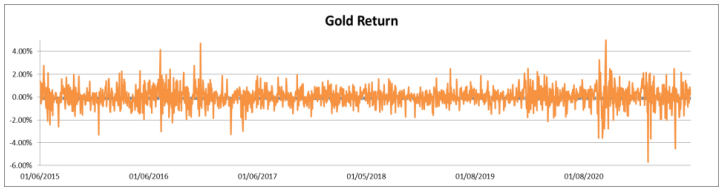
In this paper, there are four asset classes used to test against gold which are Equity, Fixed income, Property fund & REITs, and Cryptocurrency. All this asset classes are available in U.S. and dominated in USD. For equity, we use last price of S&P500 Index to represent U.S.

equity. For fixed income, we use Bloomberg Barclays US Treasury Index as to present fixed income total return dominated in USD issued by U.S. Treasury. Also, last price of FTSE NAREIT U.S. is used to represent U.S. property fund and REITs, which investors can trade on the stock exchange. Finally, we use Bitcoins as the representative of alternative investment category of cryptocurrency and gold using the last spot price (XAU $/Oz). Table 1 show the return and price pattern of all variables during 2015 to 2020.









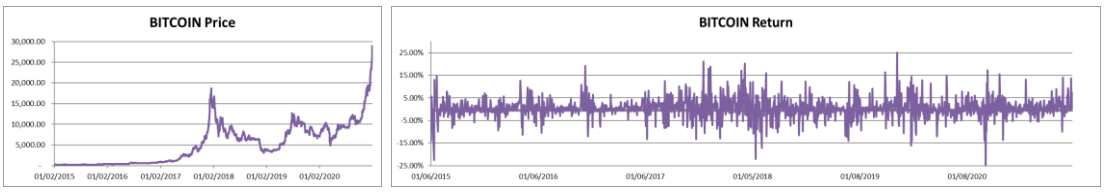


Table 1: Price and Return of each asset class during January 2015 to December 2020 source from Bloomberg.

Since the first infected COVID-19 case in U.S. emerged on January 2020, we would like to divide sample into two periods: pre-COVID-19 period (January 2015 to December 2019) and COVID-19 period (January 2020 to December 2020). All information is collected on daily basis from Bloomberg in which it consists of 1,497 samples for each asset class in total (1,247 samples in pre- and 250 samples during the COVID-19 pandemic).

3.1. Data Descriptive

Pre COVID-19 (2015 -2019)						
	Observations	Mean	Median	Maximum	Minimum	Std. Dev.
BITCOIN	1,247	0.35%	0.25%	25.00%	-22.44%	4.45%
GOLD	1,247	0.02%	0.01%	4.69%	-3.32%	0.79%
NAREIT	1,247	0.02%	0.08%	3.37%	-4.69%	0.91%
S_P500	1,247	0.04%	0.05%	4.96%	-4.10%	0.85%
UST	1,247	0.01%	0.01%	0.95%	-1.14%	0.23%

During COVID-19 (2020)						
	Observations	Mean	Median	Maximum	Minimum	Std. Dev.
BITCOIN	250	0.66%	0.46%	17.16%	-27.19%	4.23%
GOLD	250	0.09%	0.21%	5.09%	-5.69%	1.22%
NAREIT	250	0.01%	0.07%	9.03%	-18.02%	2.68%
S_P500	250	0.08%	0.24%	9.38%	-11.98%	2.18%
UST	250	0.03%	0.03%	1.68%	-1.86%	0.39%

Table 2: Descriptive statistics

The statistical information for pre- and ongoing- COVID19 period from 2015 to 2020 are showed in Table 2 and 3. Data in table 2 are the percentage return of all variables for comparative reason. As mentioned earlier that the average return of BITCOIN during pre-pandemic period show to be the highest and the mean return of gold rank almost the lowest compared to other asset class. However, after COVID-19 emerged, the return of gold jumped up to rank the second after BITCOIN. Moreover, the difference between MAX and MIN of gold from pre- to on-going COVID-19 period does not changed that much compared to BITCOIN, NAREIT and S&P500.

Correlation: Pre COVID-19					
	BITCOIN	GOLD	NAREIT	S_P500	UST
BITCOIN	1				
GOLD	0.031	1			
NAREIT	(0.002)	0.044	1		
S_P500	0.020	(0.170)	0.571	1	
UST	(0.002)	0.438	0.106	(0.359)	1

Correlation: During COVID-19					
	BITCOIN	GOLD	NAREIT	S_P500	UST
BITCOIN	1				
GOLD	0.325	1			
NAREIT	0.358	0.142	1		
S_P500	0.412	0.140	0.887	1	
UST	(0.056)	0.234	(0.381)	(0.427)	1

Table 3: Correlation between each asset classes.

The return correlation in table 3 of gold toward other asset classes during 2015 to 2019 founded to be positive except for S&P500 where Bitcoin NAREIT, and UST are positively increasing correlated with gold, respectively. However, in 2020 where the shock from COVID-19 has emerged, the return correlation of gold and other asset classes became all positive even though the correlation between gold and UST is still positive but decreasing in term of magnitude. Nevertheless, this

correlation is affected by the heteroscedasticity problem where this correlation might consist of other effect rather than only the effect from price movement that we would like to study (Yunus, 2020). So, we will use the more robust statistical method in multivariate time-series model testing on co-integration which will be presented in the following section.

4. Methodology

The objective of this paper is to study the time series relationship and the magnitude of gold as weak or strong safe-haven asset toward multi-asset portfolio during pre- and on-going COVID-19. Therefore, from all the literature review on the gold properties, our hypothesis is gold, would also be the weak safe-haven asset during the COVID-19 pandemic.

There are four steps in this study. First, we will test for stationary properties of each asset class using Augmented Dickey Fuller Test. Then we need to perform the multivariate time series analysis by using co-integration vector from (Johansen, 1994) and (Johansen & Juselius, 1990) for the analysis that has more than two variables. These will be used to examine whether the pandemic have any effect on the co-movement of gold and other asset classes during the testing period. Moreover, this process will help us identify the long run relationship of gold being the safe-haven asset among other asset classes.

By assuming that gold have long run relationship with other asset class in the portfolio, the next step is to use Vector Error Correction Model (VECM) to perform Impulse Response Function (IRF) to be able to explain the short-term relationship of gold movement during pandemic against other asset classes in order to classify as weak or strong safe haven asset.

4.1. Unit Root Testing

The first step is to perform Augmented Dickey Fuller Test to all asset classes in order to test for stationary and if it contains non-stationary property, do the differencing p time in order to solve nonstationary problem that make error term become White noise or its mean equal to zero. This process allows more than one lag in AR regression model. Assume y_t is timeseries data that we would like to test for stationary properties (Dickey & Fuller, 1981). In this case, we will test each variable once at a time where y_t is a series of individual asset classes, including S&P500, UST, NAREIT, Bitcoin and gold.

$$\Delta y_t = \mu + \delta y_{t-i} + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \varepsilon_t \qquad ; (1)$$

Where H_0: $\delta = 0 ; Non - Stationary$

H_1: $\delta < 0 ; Stationary$

For selecting optimal lag, Akaike's Information criterion (AIC) and Bayesian Information Criterion (BIC) will be used in choosing the lowest AIC or BIC to be the optimum lags for the model.

4.2. Multivariate Time series analysis

Then, if the data tested to be nonstationary, it might be the case that they might be cointegrated and they will have a long-run relationship. For that reason, the co-integration analysis by (Johansen, 1994) and (Johansen & Juselius, 1990) will be used to evaluate the co-movement of gold and other asset classes. Johansen and Juselius's model usually use with the model that have more than two variables by constructing the co-integration vectors where all variables can be dependent or independent variable. With the optimal lag, we will find the amount of co-integration vector or rank of π by testing co-integration that analyses from the Maximum Eigenvalue Test or Trace Test. Johansen co-integration starting from modeling the first order of Vector Autoregressive (VAR) given by

$$\boldsymbol{x_t} = \mu + A_1\boldsymbol{x}_{t-1} + \ldots + A_k\boldsymbol{x}_{t-k} + \varepsilon_t \quad ; (2)$$

Then transform it into first different form.

$$\Delta\boldsymbol{x_t} = \mu + \pi\boldsymbol{x}_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta\boldsymbol{x}_{t-i} + \varepsilon_t \quad ; (3)$$

Where $\boldsymbol{x_t}$ = (5 x1) variables vector (there are five variables in this model: S&P500, UST, NAREIT, Bitcoin and Gold)

μ = matrix of all interceptions

A_t = (5 x 5) matrix of coefficients

ε_t = (5 x1) error term vector

k = lag length

Γ_i = (5 x 5) coefficient matrix which i = 1 to k-1

$\pi = \sum_{i=1}^{k} A_i - I$ which is the (5 x 5) matrix that its rank represents the amount of co-integration vectors in the model.

There are two test statistics that Johansen proposed to identify the rank of matrix π or the cointegration vector: The Trace Test (λ_{Trace}) *and the Maximum Eigenvalue Test* (λ_{Max}). This can be used similarly to a critical value to identify the appropriate amount of co-integration vectors; where T = number of observations, $\lambda_i =$ *highest eigenvalues in matrix* π ,and r = number of co-integration vector (Osterwald-Lenum, 1992).

λ_{Trace} $: \lambda_{Trace}(r) = -T \sum_{i=r+1}^{n} \ln (1 - \hat{\lambda}_i)$; (4)

H_0: *Amount of cointegration vectors* $\leq r$, H_1 : *Amount of cointegration vectors* $> r$

λ_{Max} $: \lambda_{Max}\ (r, r+1) = -T\ x \ln (1 - \hat{\lambda}_{r+1})$; (5)

H_0: $Amount\ of\ cointegration\ vectors$

$\leq r, \quad H_1 : Amount\ of\ \ cointegration\ vectors > r + 1$

The result of this test will present the amount of co-integration from zero to T-1 with its critical value. If the test statistic is greater than the critical value from Johansen's statistical tables, then we will reject the H_0 that there are r cointegrating vectors.

In our case if the result tests to have no co-integration where we do not reject r $\leq$ 0, it means gold has a diversification property and is considered to be hedging asset in the long run toward other asset class during the testing period.

On the other hand, if the amount of cointegrating relationship is > 0, an exclusion test will be conducted. As the cointegration test will tell only the amount of cointegrating relationship and do not have any implication about causation, also it does not tell which asset class is part of this relationship. Thus, we will exclude gold from the analysis and run the Johansen cointegration test again, then compare it with the result from five variables to examine the change in cointegration vector (Yunus, 2020). If excluding gold provides less cointegrating relationship compared to the result from including all asset classes, it means gold

cannot be excludable from the long term cointegration and is not considered being a hedging asset over the long run.

In addition, we can only interpret that gold do not have hedging property for the entire period but cannot specify it as weak or strong safe haven asset as this method do not provide the direction of relationship between asset classes.

4.3. Vector Error Correction Model (VECM)

If gold shows to have some co-integration, which we believe it might have a very high chance to be co-integrated as we have many variables in our model. Then the Johansen co-integration will only tell how many long run relationships under the system that we create, but do not exactly show the detail of the shock in the short run. So, the next step is to perform Vector Error Correction (VECM) that better examine the short-term movement which will be captured through the coefficients in the system (Eryiğit, 2017). This model will include the error correction term in VAR equation where it shows the short-term relationship between gold and other asset classes in the portfolio (Shiva & Sethi, 2015).

$$\Delta \boldsymbol{x_t} = \mu + \gamma \hat{e}_{t-1} + \sum_{i=1}^{k} \Gamma_i \, \Delta \boldsymbol{x}_{t-i} + \boldsymbol{\varepsilon}_t \qquad ; (6)$$

Where $\boldsymbol{x_t}$ = the (5 x1) variables vector (the same five variable vectors including Gold, UST, NAREIT, Bitcoin and S&P500).

$\hat{e}_{t-1}$ = the value measures the deviation out of the long run relationship from the previous period which came from the cointegration equation of all x_t that $\hat{e}_t = x_t - \hat{\mu} - \sum_{i=1}^{k} \hat{\Gamma}_i \Delta x_{t-i}$.

But if there is no co-integration, we will use VAR model in equation (3) to perform impulse response instead.

4.4. Impulse Response Function (IRF)

The next step is to use the VECM equation to perform the Impulse response function (Barigozzi et al., 2021; Khan, 2014; Tarak Nath Sahu, 2013). This analysis pictures one Standard Deviation of innovations/ shocks of each asset class toward the others in 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 take time to get back to equilibrium again. In addition, it visualizes the dynamic of magnitude, duration, persistency and direction or the sign of relationship, whether it is negative or positive from the shock (Yunus, 2020).

In this case we compare between two testing period; before and after the first COVID-19 case have been announced in U.S. during January 2020. From the definition of safe-haven asset, if the direction of

relationship of gold toward others are positive or going in the same direction in comparison between two periods, this mean gold gets less impact from the shock compared to other asset classes. Then its' safe-haven property will be characterized as weak (Yunus, 2020). On the other hand, if there is a large movement of gold going in the opposite direction or the sign of relationship is negative compared to pre COVID-19 period, it will consider being strong safe-haven asset during the pandemic.

5. Empirical Results

5.1 Unit Root Test

In order to test for cointegration, the data should stationary at the first order or I(1). So first examine unit root by conducting the Augmented Dickey Fuller test for both pre and during COVID-19 data. The results in table 4 observed result to be non-stationary at levels for both periods, where we do not reject the Null hypothesis at the 1, 5 and 10 percent significant level. Then repeat the process again by using their first differences. The result came out to reject the Null hypothesis that all variables are stationary for the first differences at 99% confident interval.

Variables	t-statistic				Order of integration
	Pre COVID-19		During COVID-19		
	Level	1th Difference	Level	1th Difference	
Gold	0.855041	-35.9584***	1.171115	-8.96985***	I(1)
S_P500	1.93601	-13.49885***	0.3175	-4.121241***	I(1)
UST	1.322956	-15.8405***	1.506681	-6.620086***	I(1)
NAREIT	0.539151	-13.15830***	-0.479038	-4.514112***	I(1)
BITCOIN	-0.940089	-8.849885***	2.986223	-6.548210***	I(1)

*** 99% Confident Interval
** 95% Confident Interval
* 90% Confident Interval

Table 4: Result of Augmented Dickey Fuller test

5.2 Optimal lag length

In choosing the optimal lag, we would like to include the number of lags that well explained the variation in the forecasted variable or y in which the information criterion will help determine the proper lag length before doing the cointegration analysis in accordance with Johansen since the autoregressive model is sensitive to the selection of appropriate lag length. Also, this process will eliminate serial correlation of the residuals in the model.

The resulted in table 5 present the optimal lag based on three criterions: Akaike information criterion (AIC), Schwarz information criterion (SC) and Hannan-Quinn information criterion (HQ). For pre COVID-19 data, all information criterions suggested the lowest lag of 1. While the AIC criteria for during COVID-19 data found to have the highest lag length of 8 and SC and HQ criteria proposed only 1 lag. Since

choosing too higher lags will make the model lose too many degrees of freedom and might cause the result to not be significant. Therefore, the lower lag of 1 that SC and HQ criteria suggested is preferred as the optimal lag for during COVID-19 data.

Pre COVID-19			
Lag	AIC	SC	HQ
0	62.91701	62.93767	62.92478
1	42.33490*	42.45884*	42.38151*
2	42.34468	42.5719	42.43013
3	42.35025	42.68076	42.47455
4	42.36363	42.79742	42.52677
5	42.37279	42.90987	42.57478
6	42.38377	43.02413	42.6246
7	42.40469	43.14834	42.68437
8	42.41682	43.26375	42.73534

During COVID-19			
Lag	AIC	SC	HQ
0	63.72418	63.79606	63.75313
1	49.36472	49.79596*	49.53842*
2	49.2761	50.06671	49.59455
3	49.24845	50.39843	49.71165
4	49.32047	50.82981	49.92842
5	49.25487	51.12358	50.00757
6	49.26567	51.49376	50.16312
7	49.28694	51.87439	50.32914
8	49.13924*	52.08606	50.32619

* indicates lag order selected by the criterion
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 5: Optimal lag length for Pre COVID-19 data

5.3 Johansen Cointegration Test

Since the data for both period tests to be non-stationary at levels and being stationary at first difference, this provide us high chance that our variables are cointegrated in long run. From our calculation, the result of Trace test and Maximum Eigenvalue test for Gold, S&P500, US treasury, NAREIT and Bitcoin for pre COVID-19 data and during COVID-19 data are provided in table 6 and 7.

As mentioned before, the null hypothesis is $Amount\ of\ cointegration\ vectors \leq r$. But for Trace test, alternative hypothesis is $Amount\ of\ cointegration\ vectors > r$, where the Maximum Eigenvalue alternative hypothesis is $Amount\ of\ cointegration\ vectors > r + 1$. Moreover, the way to reject null hypothesis is Trace test and Maximum Eigenvalue test must be greater than 5 percent critical value in which the null hypothesis of no cointegration is to not reject $r \leq 0$ at 5 percent significant level.

From table 6, the pre COVID-19 period value of Trace test statistic for r = 0 is 66.01244, where it is greater than 5 percent critical value of 60.06141. Also, the Maximum Eigenvalue test statistic at r = 0 is 33.21362 which is greater than 5 percent critical value of 30.4396. On the other hand, value of Trace test and Maximum Eigenvalue test for r =1 are 32.79882 and 16.5453 respectively, where it is less than 5 percent critical value of 40.17493 and 24.15921. Thus, we reject the null hypothesis of $r \leq 0$ but do not reject the null hypothesis of $r \leq 1$. This mean there is at least one cointegration vector at 5 percent significant level for the pre COVID-19 period.

Pre COVID-19				
	H0	**H1**	**Test-Statistic**	**0.05 Critical Value**
Trace Test	r = 0	r > 0	66.01244*	60.06141
	r ≤ 1	r > 1	32.79882	40.17493
	r ≤ 2	r > 2	16.25346	24.27596
	r ≤ 3	r > 3	6.529673	12.32090
	r ≤ 4	r > 4	1.016692	4.12991
	H0	**H1**	**Test-Statistic**	**0.05 Critical Value**
Maximum Eigenvalue Test	r = 0	r = 1	33.21362*	30.43961
	r = 1	r = 2	16.54537	24.15921
	r = 2	r = 3	9.723783	17.79730
	r = 3	r = 4	5.512981	11.22480
	r = 4	r = 5	1.016692	4.12991

* denotes rejection of the hypothesis at the 0.05 level

Table 6: Result of Johansen cointegration test (Pre COVID-19 period)

For during COVID-19 period, Trace test statistic of r =0 is 72.7497 which is greater than 5 percent critical value of 60.06141. And the Maximum Eigenvalue test of r = 0 is 36.17008 that is greater than 30.43961 5 percent critical value. On the contrary, the Trace and Maximum Eigenvalue test of r = 1 are 37.57962 and 21.60264 respectively that are less than 5 percent critical value of 40.17493 and 24.15921. Therefore, we reject the null hypothesis of $r \leq 0$, while we do not reject the null hypothesis of $r \leq 1$, this mean there is at least one cointegration vector at 5 percent significant level for during COVID-19 period.

During COVID-19				
	H0	**H1**	**Test-Statistic**	**0.05 Critical Value**
Trace Test	r = 0	r > 0	72.7497*	60.06141
	r ≤ 1	r > 1	37.57962	40.17493
	r ≤ 2	r > 2	15.97697	24.27596
	r ≤ 3	r > 3	6.930192	12.32090
	r ≤ 4	r > 4	0.092552	4.12991
	H0	**H1**	**Test-Statistic**	**0.05 Critical Value**
Maximum Eigenvalue Test	r = 0	r = 1	35.17008*	30.43961
	r = 1	r = 2	21.60264	24.15921
	r = 2	r = 3	9.046783	17.79730
	r = 3	r = 4	6.83764	11.22480
	r = 4	r = 5	0.092552	4.12991

* denotes rejection of the hypothesis at the 0.05 level

Table 7: Result of Johansen cointegration test (During COVID-19 period)

The result of cointegrating relationship cannot specify which asset classes are cointegrated in which we cannot fully conclude whether gold is a hedging instrument. So, the exclusion test of gold will be conducted to further examine the hedging property of gold toward other asset classes. We compare the amount of cointegration between all asset classes and all asset classes excluding gold. If the amount of cointegrating relationship of the analysis from excluding gold is less than the one consists of all asset classes, this mean gold is cointegrated with some other asset and do not provide the diversification relationship in long run. But if the amount of cointegrating relationship remain unchanged, it means gold might not be the asset in the cointegrating relationship and can be exclude from the long-term relationship.

Pre COVID-19 (Gold exclusion)				
	H0	H1	Test-Statistic	0.05 Critical Value
Trace Test	r = 0	r > 0	46.44302	47.85613
	r ≤ 1	r > 1	19.8653	29.79707
	r ≤ 2	r > 2	4.842461	15.49471
	r ≤ 3	r > 3	0.060883	3.841466
	H0	H1	Test-Statistic	0.05 Critical Value
Maximum Eigenvalue Test	r = 0	r = 0	26.57773	27.58434
	r = 1	r = 1	15.02284	21.13162
	r = 2	r = 2	4.781578	14.2646
	r = 3	r = 3	0.060883	3.841466

During COVID-19 (Gold exclusion)				
	H0	H1	Test-Statistic	0.05 Critical Value
Trace Test	r = 0	r > 0	59.80613*	47.85613
	r ≤ 1	r > 1	28.74095	29.79707
	r ≤ 2	r > 2	10.83081	15.49471
	r ≤ 3	r > 3	1.991881	3.841466
	H0	H1	Test-Statistic	0.05 Critical Value
Maximum Eigenvalue Test	r = 0	r = 0	31.06519*	27.58434
	r = 1	r = 1	17.91013	21.13162
	r = 2	r = 2	8.838934	14.2646
	r = 3	r = 3	1.991881	3.841466

* denotes rejection of the hypothesis at the 0.05 level

Table 8: Result of Johansen cointegration test (Gold exclusion)

Table 8 shows the result of the Johansen cointegration test which consists of four variables including S&P 500, UST, NAREIT and BITCOIN and excluding gold. The result of pre COVID-19 period when excluding gold out shows to have no cointegration between each asset class. But when compared to the cointegration result that includes all variables, there is at least one cointegration. The interpretation is gold does not serve as hedging instrument over the long run during pre-COVID-19 period in which it is in line with the study form (Yunus, 2020) that there existed the long term cointegration between gold and other asset classes, and suggested gold not to be hedging asset during the pre-crisis period.

However, the result from the COVID-19 period found that even if we exclude gold from the system, there is still at least one cointegration which is equal to the result from including all five variables in the previous analysis. So, these can be interpreted that during the COVID-19

period, gold does not have the cointegrating relationship with another asset class and might serve as the hedging asset as it can be excludable from the long run relationship and the cointegration vector still remains unchanged.

However, only cointegration test cannot be able to analyses gold as weak or strong safe haven during market turbulence. It only specifies the amount of cointegrating linkage for the entire testing period, not the sign of direction between asset class that we used to classify its type. As the linkage between asset classes increase due to the spillover effect from external shock. Thus, to further examine the safe-haven property, the impulse response function is employed.

5.4 Impulse Response Function

From the fact that the emerged of COVID-19 is a sudden shock that effected market in short run, also the cointegration test do not provide classification meaning of gold safe-haven type during crisis. Thus, the impulse response function will be used to analyses only COVID-19 period in order to evaluate safe-haven asset type of gold and examine short run relationship of it against other asset classes.

As stated earlier, the weak safe haven is an asset that, during the crisis, received small impacted by the shock or the sign of response to the

shock do not change. Whereby strong safe-haven asset is the asset that react to shock in the reverse or opposite direction from normal period. From these, the impulse response function is conducted to picture the sign of relationship that we used to classify safe haven asset type. Table 9 to 13 show the result of impulse response to one standard deviation of innovation in all variables for 20 days' time horizon during pre- and ongoing- COVID-19, respectively.

For pre COVID-19 during 2015 to 2019, the response of gold to one standard deviation shock in rates of return of S&P500, US treasury, NAREIT, BITCOIN and gold itself are positive. This means the increase in other variable return will affect gold return in positive direction. Moreover, when the shock exists, the response of gold to others started response in second period. And the magnitude of response except response from itself during first 20 period is between 0 to 2 where US treasury and NAREIT jump from 0 to 1 and incrementally increase through time.

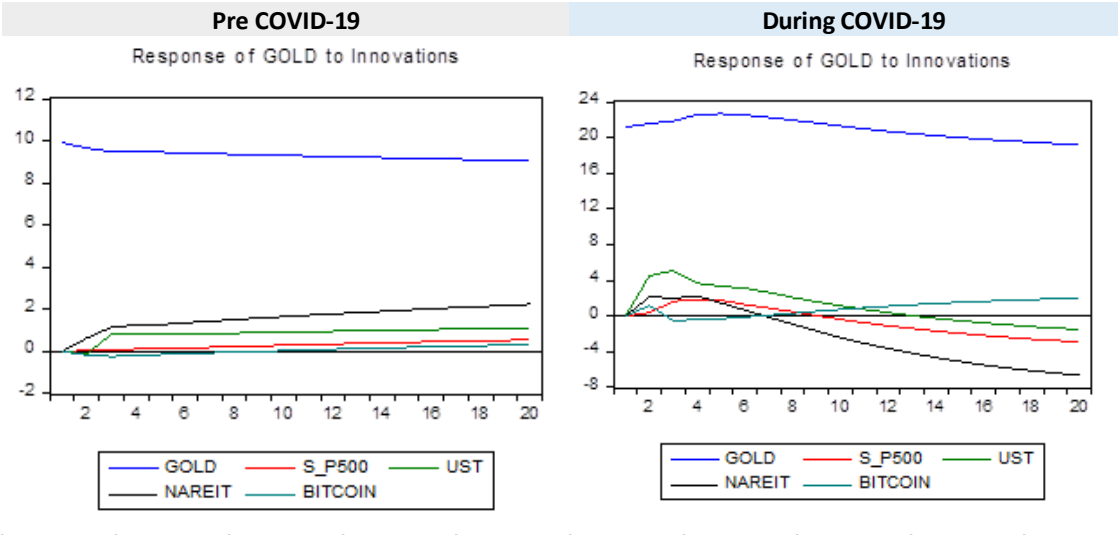


Table 9: Impulse Response Function of Gold (pre- and during COVID-19 period)

On the other hand, during the ongoing COVID-19 period during 2020, the impulse response of gold to one standard deviation of other asset classes are volatile and more dynamic than the previous period. Since day one, gold response to the shock from others and itself in positive direction where US Treasury have the highest impact on the gold response. But after period 6 onward, its response turns to become negative for NAREIT, S&P500 and US Treasury while the response from BITCOIN become positive and gradually increasing during the period. Additionally, the magnitude of the response compared to pre COVID-19 period is larger ranging from approximately 4.5 to -8 during this 20-period excluding response from gold itself.

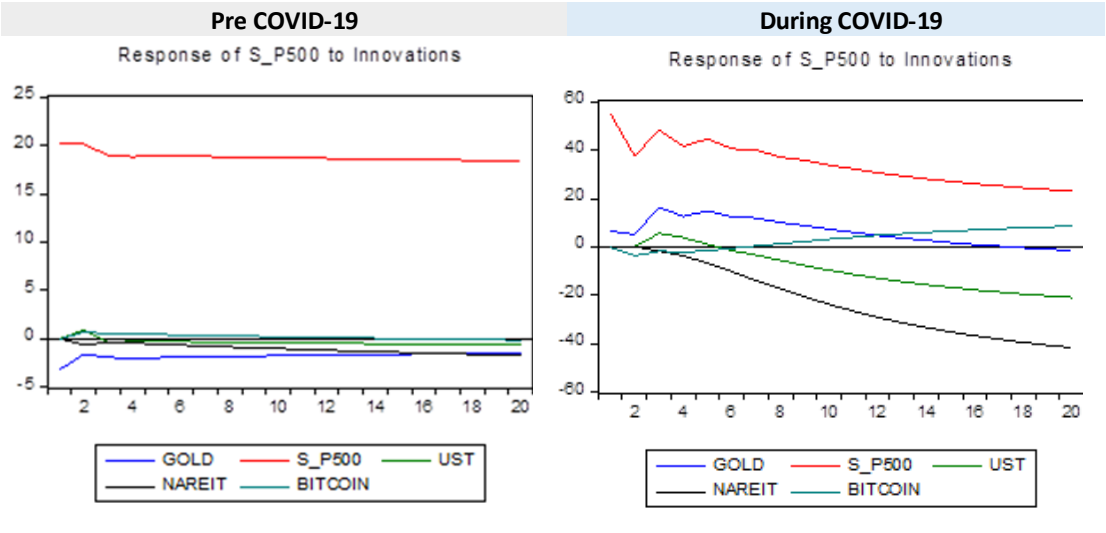


Table 10: Impulse Response Function of S&P500 (pre- and during COVID-19 period)

From the analysis, during pre- COVID-19, the response of all variables is not fluctuated and steady for the entire testing period even the magnitude of response is difference. This indicated that gold, S&P500, US Treasury, NAREIT and BITCOIN cannot be the safe-haven asset during pre-pandemic period in which this is in line with the result from cointegration test that gold does not serve as hedging instrument during that period of time.

However, in comparison between two period, the response of each asset class from shocks to other variables are difference and more volatile during COVID-19 period. This can be evidenced from the huge change in magnitude range, the change in response direction, and the faster reaction from the shock. The response of gold to innovation from U.S. Treasury, S&P500 and NAREIT during COVID-19 compared to previous period

are clearly negative except the response from BITCOIN that remain unchanged. This suggests gold become strong safe-haven asset toward traditional asset class but not for alternative asset class like BITCOIN. Besides gold, the response of NAREIT and BITCOIN to the shock from other asset classes are negative as well. Especially BITCOIN, all impulse response lines during COVID-19 goes in opposite direction from the previous period which indicate a strong property of being safe-asset during the market turbulence.

In addition, the result of NAREIT in this study indicated that it provides the property of being safe-haven asset during COVID-19, but there is no study suggested it to be safe asset especially during COVID-19. Unlike BITCOIN that there is various study of this type of asset class as one of being safe-haven asset during market turmoil. Our study resulted for BITCOIN also have the safe-haven property that is in line with (Bouri, Shahzad, et al., 2020; Dwita Mariana et al., 2021) where BITCOIN is not correlated to financial market and is pronounced to be safe-haven asset during COVID-19.

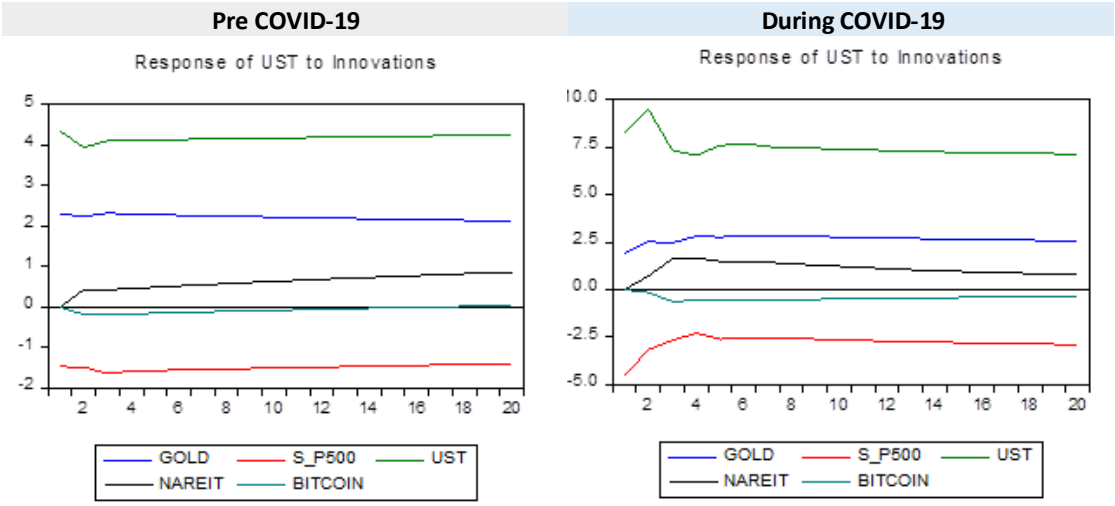


Table 11: Impulse Response Function of US Treasury (pre- and during COVID-19 period)

Thus, the short run analysis suggest not only gold, but also NAREIT and BITCOIN to be considered as strong safe-haven asset during COVID-19 pandemic as the sign of response go into the opposite direction from pre COVID-19 period. The result of this study is consistent with the study from (Baur & Lucey, 2010) that considered gold to have safe-haven properties in the short run after the crisis. In addition, the research from (Ji et al., 2020) also supports that during the COVID-19 period, gold is observed to be one of the safe-haven assets.

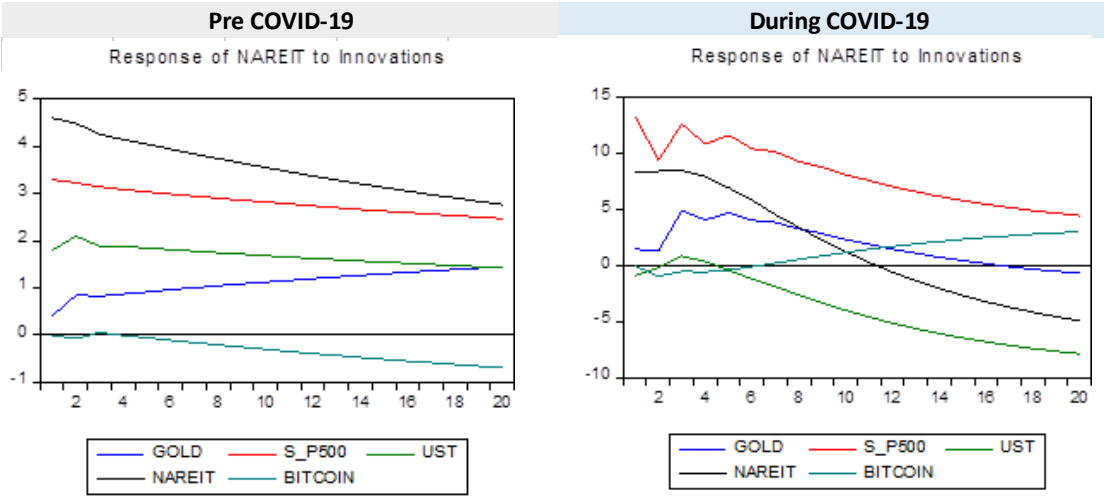


Table 12: Impulse Response Function of NAREIT (pre- and during COVID-19 period)

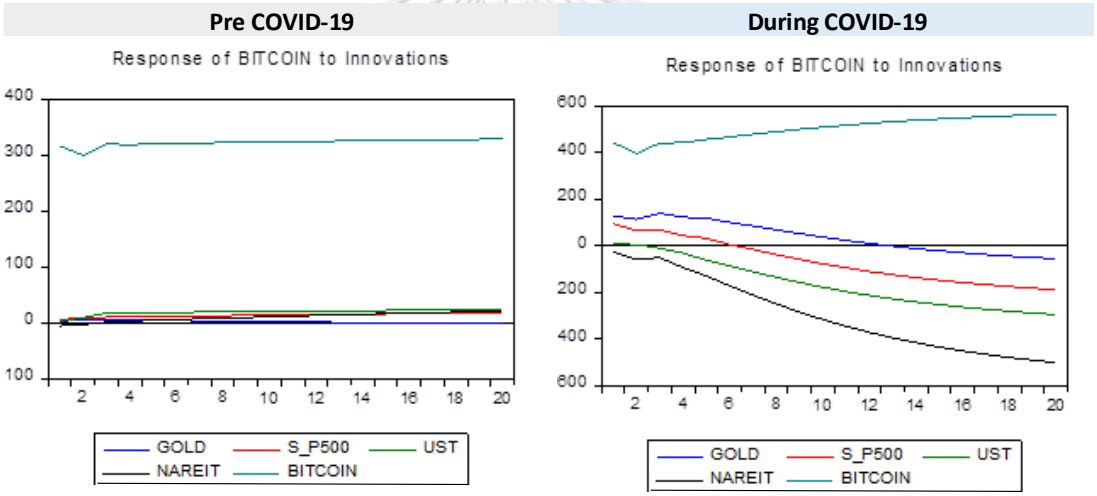


Table 13: Impulse Response Function of BITCOIN (pre- and during COVID-19 period)

6. Conclusion

Under the present of COVID-19 epidemic, looking for safe-haven assets is a crucial and vital topic. Investors all across the world have suffered significant losses as a result of this situation, making the demand for safe-haven asset become even more important in which gold is one of

traditional safe-haven asset that usually been perceived in the literature. Therefore, this study re-examines the safe-haven property of gold against multiple asset classes by using multivariate timeseries analysis during 2015 to 2019 as a pre-COVID-19 period, and 2020 as an ongoing of the widespread of COVID-19 pandemic.

The study summarized that there exist a long run cointegration between gold and other asset classes including equity (S&P500), fixed income (U.S. Treasury), real estate (NAREIT) and alternative investment (BITCOIN) in both during pre- and ongoing COVID-19 period. However, the exclusion test of gold is shown to have a cointegrating relationship only during COVID-19 and no cointegration during pre-pandemic. This can be indicated that gold does not have the property of being a hedging instrument over a long run as it co-moving with others only during pre-pandemic. But consider gold to be a hedging asset over the pandemic period as the cointegrating relationship when excluding gold remains unchanged.

In addition, focusing on the short run relationship during the COVID-19, the result from impulse response shows gold to be a strong safe-haven asset only against traditional asset class such as equity, fixed income, and real estate, but not for the alternative asset class such as

cryptocurrency like BITCOIN as the impact from the shock of S&P500, UST and NAREIT to gold are in the opposite direction compared to pre-pandemic. Moreover, not only gold that is considered to be strong safe haven during pandemic, the finding of this study also shows NAREIT and BITCOIN to be a strong safe haven asset as the direction of its response to the shock reverse from the pre pandemic period.

The result of this study offers an interesting implication for asset allocation strategy. During crisis or a period of uncertainly, investor's portfolio become volatile and the asset class that provide a safe-haven property is preferable. Therefore, the result of this study confirms that the traditional asset class like gold still can be served as strong safe-haven asset during pandemic in which to investors, this will be useful for them to reallocate some part of their investment into gold during market turmoil.

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