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Comparison of Correlation for Asia Shariah Indices using DCC-GARCH and Rolling Window Correlation

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ABSTRACT

This paper aims to compare the capability of correlation in capturing the volatility using rolling window correlation and Dynamic Conditional Correlation - Generalized Autoregressive Conditional Heteroscedasticity (DCC-GARCH) approach. This study will perform a DCC-GARCH to estimate the dynamic conditional correlation between the Asian Shariah indices. The Asian Shariah index comprises FTSE SGX Asia Shariah 100, FTSE Bursa Malaysia Emas Shariah Index, FTSE Greater China Shariah Index, and FTSE Stock Exchange of Thailand (SET) Shariah Index. The correlation estimation considers the FTSE SGX Asia Shariah 100 as a proxy. On the 11th of March 2020, The World Health Organization (WHO) has announced the Coronavirus 2019 (COVID-19) as pandemic. Therefore, the data used covers six months before and after 11th March 2020, from 11th September 2019 until 11th September 2020. The output of both effected correlations towards the Covid-19 will be evaluated based on their ability to capture the time-varying changes through graph plotting. The empirical findings show that the DCC-GARCH is better at capturing the highly changes volatility than the rolling window correlation.

Keywords: DCC-GARCH, Rolling Window Correlation, Asian Shariah Indices

1 INTRODUCTION

The tremendous growth potential and profitability of Islamic stock market indices have increased its popularity among the investor [1]. Hence, it showed tremendous support from investors in Islamic finance investments. The distinctive point of Islamic finance is the guidelines provided by Shariah scholar in screening the company either it should be considered as Shariah-compliant or otherwise. To be classified as Shariah-compliant stock, the company should not involve in the unlawful act, which includes the production of liquor, gambling, entertainment, pork-based, tobacco, and riba-based financial institution [2].

Essentially, previous literature shows that the Islamic index is superior than conventional indices in form of less volatile [3], more efficient in terms of informational efficiency [4], and diversification of an Islamic portfolio may be a strong replacement for conventional diversification [5]. Explicitly, there are several Islamic indices in Asian region such as the FTSE Bursa Malaysia Emas Shariah Index for Malaysia Shariah stock, FTSE Greater China Shariah Index for China Shariah stock, FTSE Stock

Exchange of Thailand (SET) Shariah Index for Thailand Shariah stocks. The performance of the top 100 Asia pacific stocks can be monitored through FTSE SGX Asia Shariah 100.

There are different stock market indices response since the announcement of novel coronavirus (COVID-19) declared as the pandemic of World Health Organization (WHO). [6] highlighted that during pandemics, news is important in making investment strategy in which, given the existence of COVID-19, the return predictability of health news is investigated. Besides, [7] showed that financial markets react swiftly to the COVID-19 pandemic, and the response varies depending on where the outbreak is in its phase. Moreover, [8] focused on world economic crisis causes by the pandemic outbreak which resulting the contemporary effect from specific events associated with COVID-19. [9] looked at the March 2020 stock market crash, the performance of the US stock market was examined, and it was discovered that natural gas, food, healthcare, and software stocks reap high positive returns, while equity prices in the petroleum, real estate, entertainment, and hospitality sectors collapse. [10] addressed the conventional financial system is suffering several difficulties. significantly increasing towards COVID-19 pandemic and inventors consider stock returns to be uncertain. Since there has been a little discussion of the impact on the Shariah indices of COVID-19, [10] suggested for other researchers to do more investigation. Consequently, can provide the investigators with information on the fundamental structures and characteristics of Shariah's investment structures and their effect to this current pandemic.

Therefore, this paper will study the how COVID-19 effects on Islamic indices linkages before and after the COVID-19 pandemic. This paper is contributed in two ways. First, this paper contributes to the literature by examining the reaction of Islamic indices in terms of correlation affected by the COVID-19 outbreak. Second, this paper compares the effects of COVID-19 on the correlation based on rolling window correlation and dynamic conditional correlation.

The structure of this paper is as follows: Section 2 digs deeper into the earlier research on DCC-GARCH and rolling window correlation, and the application in a financial network. Then, Section 3 will illustrate the data used for this research. Meanwhile, in Section 4, discusses the methods applied in comparing the FTSE Shariah indices' correlation. The descriptive study and correlation between the indices used are then reported in Section 6. Lastly, the conclusion of the paper are given in Section 7.

2 LITERATURE REVIEW

The literature review section discusses previous work related to correlation analysis between the DCC-GARCH and the rolling window correlation. The section also discusses the application on DCC-GARCH in a financial network for both the conventional and Shariah compliance markets.

2.1 Rolling window correlation and Dynamic Conditional Correlation - Generalized Autoregressive Conditional Heteroscedasticity

An enormous amount of work has been carried out in correlation with financial variables as it can help in financial management tasks, including hedging, portfolio diversification, and integration analysis. In this paper, the rolling window correlation and dynamic conditional correlation are used to compare the correlation's correlation analysis. The previous study by [11] compares the performance between rolling window correlation and DCC-GARCH. The result shows that DCC-

GARCH is better at capturing correlation than the rolling window correlation. One of the drawbacks in the rolling window correlation is where the cross-linking dynamics cannot be accurately captured. Additionally, unusually small, and broad return observation can lead to a leap in correlation estimates when the observation falls out of the estimation window. Besides, [12] implied the DCC-GARCH and rolling windows to examine hedge effectiveness under heterogeneous market expectations.

2.2 Dynamic Conditional Correlation - Generalized Autoregressive Conditional Heteroscedasticity in financial market

The DCC-GARCH approach, which first proposed by [13], has the advantage of performing well in capturing a dynamic time-varying correlation and being able to estimate large correlation matrices. The previous studies on Shariah indices using this method was employed by [14] on FTSE Shariah China Index, FTSE Shariah India Index, FTSE Shariah USA Index, and Dow Jones Shariah Index. The DCC-GARCH was used to capture the time-varying mean and variance properties that the changes of correlation could be observed over time. [15] employed DCC-GARCH to identify the dynamic relationship between world oil price change and 5 ASEAN's main stock comprised Indonesia Stock Exchange (IDX) with Indonesia Stock Exchange (IDX) with Composite Stock Price Index (CSPI), Kuala Lumpur Stock Exchange (KLSE) with Kuala Lumpur Composite Index (KLCI), Stock Exchange Thailand (SET) with SET, Singapore Stock Exchange (SSX) with Strait Times and Philippine Stock Exchange (PSE) with PSEi. [15] revealed that the stock market and commodity market's condition affected the correlation of world oil price and the five ASEAN leading stocks. The correlation for some ASEAN countries also experienced shock during stock market and commodity market turbulence. Besides, it was decided that it was not acceptable to apply a static correlation approach, as shocks could occur in the stock market and the commodity market. Moreover, many other research on this DCC-GARCH method have been applied in the conventional index and show a strong correlation between the variables.

To assess the co-movements between emerging markets, [16] applied DCC-GARCH on the total return index of 20 emerging markets. The study covered a period from March 1997 to January 2015. Applying dynamic DCC-GARCH, [16] found that all emerging countries experienced a high correlation between September 2009 caused by the 2008 global financial crisis. Besides, by employing DCC-GARCH, the authors can determine the behaviour of conditional correlations among crypto currencies and four main assets. The result revealed positive correlations among crypto currencies with Ripple and Dash revealed as the most variable correlation.

The recent study on COVID-19 was conducted by [17] to study the best safe-haven asset throughout the epidemic using the DCC-GARCH approach. According to the findings, gold and soybean commodity futures will continue to be strong safe-haven investments during the pandemic.

So far, there was a little discussion regarding the effect of COVID-19 towards Shariah indices using the dynamic conditional approach. The previous closet study on Shariah indices is done by [18] using DCC-GARCH. The authors investigated how the stock market in Turkey (conventional and Islamic) responded to COVID-19 pandemic using the DCC-GARCH model from Feb 10, 2011, to Sep 02, 2020. However, the study on the correlation's the ability of correlation to capture the volatility toward the COVID-19 outbreak for Asian Shariah indices is still unavailable. Therefore, in this research, the effect on the correlation for the Shariah-indices in the Asia-Pacific country towards the declaration of the COVID-19 pandemic will be examined using the DCC-GARCH and rolling window correlation.

3 DATA DESCRIPTION

The analysis was conducted using the four indices in Table 1. The data used covers six months before and after COVID-19 declared pandemic [11], from September 11, 2019, to September 11, 2020. The FTSE SGX Asia Shariah 100 considered the proxy index for this research as it covers Asia Pacific's top 100 stock. The daily indices prices are extracted from Eikon DataStream. The return of the index is then calculated to form the following logarithm return:

$$r_t = ln(p_t) - ln(p_{t-1}) \quad (1)$$

Table 1: Selected indices for study

Index Code	Definition
FTSGS100U	FTSE SGX Asia Shariah 100
KLFTEMSI	FTSE Bursa Malaysia Emas Shariah Index
FTSWGCHIY	FTSE Greater China Shariah Index
FTFSTSH	FTSE Stock Exchange of Thailand (SET) Shariah Index

4 METHODOLOGY

This section presents the procedure to compare the correlation between the FTSE Shariah indices. The first subsection explains the procedure to calculate the rolling window correlation, and the second subsection shows the calculation of Dynamic Conditional Correlation - Generalized Autoregressive Conditional Heteroscedasticity.

4.1 Jarque-Bera test

The Jarque-Bera (JB) test investigates the normality behaviour in the series [19]. The null hypothesis for the test is the assumption that the series have normality behaviour. If the *p*-value is less than the significant level, then this assumption will be rejected. The Jarque-Bera test can be computed as the following equation

$$JB = \frac{n}{6}(s^2 + \frac{(k-3)^2}{4}) \quad (2)$$

such that n is the sample size, s is the skewness and k is the kurtosis.

4.2 Augmented Dickey-Fuller test

Augmented Dickey Fuller (ADF) test is one of the unit root tests for stationarity. The test is used to determine if the stationarity of the series based on the unit root for the polynomial in time series. If the roots are lies between the unit circle, then the series is said to be stationary. If the p-value is less than the significant level, then the stationary assumption for the series will be rejected.

4.3 ARCH- Langrange Multiplier test

Autoregressive Conditional Heteroscedasticity (ARCH) - Langrange Multiplier test is applied to find the existense of heteroscedasticity in the series. In order to use the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model in time series analysis, the presence of time-varying occurrences in conditional volatility should be detected. The null hypothesis for this ARCH effect test considered no existing ARCH in the time series. If the p-value obtained is smaller the significant level, then it is concluded that the series has the ARCH effect.

4.4 Rolling window correlation

Rolling window correlation between the asset i and j can be computed as the following equation:

$$\rho_{t,i,j} = \frac{\sum_{t=1}^{T=30}(r_{t,i} - \bar{r}_{t,i})\,(r_{t,j} - \bar{r}_{t,j})}{\left(\sum_{t=1}^{T=30}(r_{t,i} - \bar{r}_{t,i})^2\right)^{1/2}\left(\sum_{t=1}^{T=30}(r_{t,j} - \bar{r}_{t,j})^2\right)^{1/2}} \quad (3)$$

where $r_{t,j}$ and $r_{t,i}$ denote the stocks and the proxy stock returns on the day t, respectively, and the notations $\bar{r}_{t,i}$and $\bar{r}_{t,j}$ denoted as the mean of the stock return and the proxy stock's mean from day one until the day t. The correlation will be computed for every 30 days since the length of a window $T = 30$ in which the next correlation will be drifted by one day forward.

4.5 Multivariate GARCH model and Dynamic Conditional Correlations (DCC)

[13] proposed a Dynamic Conditional Correlation Generalized Autoregressive Conditional Heteroscedasticity Dynamic Conditional Correlation (DCC-GARCH) model as a generalization of Bollerslev's constant conditional correlation estimator [20]. The computational of dynamic conditional correlation involved two steps procedures. First, a univariate GARCH model is employed to compute the conditional variances for each price index. Second, the time-varying correlation matrix will be determined based on the normalized residuals from the first step.

Firstly the following univariate GARCH (p,q) model, given n numbers of price index returns, are employed to compute the conditional variances of each equity index:

$$h_{it} = \omega_i + \sum_{x=1}^{p_i} \alpha_{ix} r_{it-x}^2 + \sum_{y=1}^{q_i} \beta_{iy} h_{it-y}, \qquad \text{for } i = 1,2,\ldots,n \quad (4)$$

where $\omega_i > 0$, $\alpha_{ix} \geq 0$, $\beta_{iy} \geq 0$ and $\sum_{x=1}^{p_i} \alpha_{ix} + \sum_{y=1}^{q_i} \beta_{iy} < 1$; h_{it} denotes as the estimated conditional variance of the individual index.

Secondly, by estimating DCC-GARCH equation parameters, a time-varying correlation matrix will be computed using standardized residuals ε_t as an input obtained from the first step. Following [13], the conditional covariance matrix H_t can be decomposed as :

$$H_t = D_t R_t D_t \tag{5}$$

where D_t is a diagonal matrix of conditional time-varying standardized residuals is computed from the univariate GARCH models and R_t denotes the time-varying correlation matrix (off-diagonal elements).

R_t consists of the following conditional correlation coefficients:

$$\boldsymbol{R}_t = (\text{diag}\,\mathbf{Q}_t)^{-\frac{1}{2}}\boldsymbol{Q}_t(\text{diag}\,\mathbf{Q}_t)^{-\frac{1}{2}}, \tag{6}$$

where $\mathbf{Q}_t$ denotes as the time the time-varying covariance matrix of the standardized residual $\varepsilon_i = (\varepsilon_{1,t},...,\varepsilon_{n,t})$ given by

$$\boldsymbol{Q}_t = (1-\alpha-\beta)\bar{\boldsymbol{Q}} + \alpha\varepsilon_{t-1}\varepsilon'_{t-1} + \beta\boldsymbol{Q}_{t-1}, \tag{7}$$

in which both α and β are non-negative scalar parameters and fulfil the condition $\alpha+\beta<1$. The scalar α, capturing the previous shocks, and the scalar β captures previous dynamic conditional correlations on the current dynamic correlation. $\bar{\mathbf{Q}}$ indicates the $n\times n$ unconditional variance matrix of ε_t.

The following shows likelihood of the DCC-GARCH estimator stated by [13] :

$$L = -\frac{1}{2}\sum_{t=1}^{T}(k\,log(2\pi) + 2\,log(|D_t|) + log(|R_t|) + \varepsilon'_t R_t^{-1}\varepsilon_t), \tag{8}$$

The estimation of the likelihood process is obtained in two steps as the volatility (D_t) and the correlation (R_t) components may be varied.

5 RESULTS AND DISCUSSION

This section presents the descriptive analysis and the correlation between the Islamic indices and demonstrates the correlation. The FTSG100U will be used as the proxy index as it contains the top 100 stocks traded in the Asia Pacific. The correlation will be calculated between the proxy index and the other indices.

5.1 Descriptive Statistic of the returns and diagnostic check

Table 2 shows the descriptive statistic of the Shariah indices before COVID-19 was declared as a pandemic. From Table 2, the daily mean return is negative for all indices, with the lowest mean is from the FTSGS100U with a value of -0.000017, and the highest value is -0.002686 by the FTFSTSH. The standard deviations for all the indices are significantly small, ranging from 0.007835 (KLFTEMSI) to 0.015091 (FTFSTSH), indicating that each index's values are close to the other. All of the indices show a negative skewness, designating that all the indices are left-skewed distribution. Moreover, none of the indices gives the values of kurtosis that are approximately or close to 3, which means none of these indices is normally distributed.

Furthermore, based on the Jaque-Bera test results, all indices reject the null hypothesis at a 1% significance level, confirming a non-normal behaviour. Besides, the Autoregressive Conditional Heteroscedasticity-Lagrange Multiplier (*ARCH-LM*) test results show a highly significant result suggesting a heteroskedastic effect for all indices. Therefore, the GARCH model estimation is appropriate to employ for capturing ARCH effects in the indices. Also, from Table 2, the result from the unit root test using the Augmented Dickey-Fuller (ADF) test rejects the null hypothesis which indicates a non-stationary process for all the return of price indices.

Table 2: Descriptive statistic of FTSE Shariah indices returns before COVID-19 declare as pandemic

	FTSGS100U	KLFTEMSI	FTSWGCHIY	FTFSTSH
Mean	-0.000017	-0.000984	-0.000257	-0.002686
Variance	0.000075	0.000061	0.000192	0.000228
Std Dev	0.008651	0.007835	0.013843	0.015091
Skewness	-0.850939	-2.952289	-1.759174	-3.607424
Kurtosis	1.343644	16.070668	6.546150	22.160737
Jarque-Bera	24.107 [a]	1473.5 [a]	279.21 [a]	2726.9 [a]
ARCH LM	32.187 [a]	17.573 [a]	33.723 [a]	55.913 [a]
ADF	-4.3925 [a]	-0.1667 [a]	-5.6841 [a]	1.1547 [a]

[a] denotes significance at the 1% level

Table 3 shows the descriptive statistic of the Shariah indices after COVID-19 was declared as a pandemic. The daily mean is positive for all indices, with the lowest mean of 0.000866 (FTFSTSH) and the highest 0.001517 (FTSWGCHIY). The standard deviation of the indices ranges from 0.015711 (KLFTEMSI) to 0.023846 (FTFSTSH). Although the values are small, they are slightly higher than the standard deviation before the pandemic is declared in Table 2. For the skewness, all the indices show a negative skewness value except for FTSGS100U. It means that all the indices have a left-skewed distribution, but not for FTSGS100U.

On the other hand, it clearly showed that all indices are non-normally distributed based on kurtosis values. It has been confirmed by the Jaque-Bera test results, where all indices reject the null hypothesis at a 1% significance level, showing a non-normal behaviour. Besides, all indices reject the null hypothesis of at a 1% significance level, suggesting a heteroskedastic effect for all indices through the ARCH LM test results. Therefore, the GARCH model estimation is appropriate to employ for capturing ARCH effects for the indices. Lastly, similar to Table 2, for the Augmented Dickey-Fuller (ADF) test, all the values obtained in Table 3 leads to the null hypothesis to be rejected which indicates a non-stationary process for all the indices.

Table 3: Descriptive statistic of FTSE Shariah indices returns after COVID-19 declare as pandemic

	FTSGS100U	KLFTEMSI	FTSWGCHIY	FTFSTSH
Mean	0.001495	0.001474	0.001517	0.000866
Variance	0.000302	0.000247	0.000337	0.000569
Std Dev	0.017368	0.015711	0.018358	0.023846
Skewness	0.254539	-0.322978	-0.163889	-0.744091
Kurtosis	1.897214	2.195897	2.328589	7.310377
Jarque-Bera	19.646 [a]	26.471 [a]	27.959 [a]	272.91 [a]
ARCH	22.098 [a]	15.545 [a]	36.993 [a]	62.7 [a]
ADF	-6.5937 [a]	-5.3452 [a]	-5.5751 [a]	-1.5009 [a]

[a] denotes significance at the 1% level

5.2 Daily Price Return

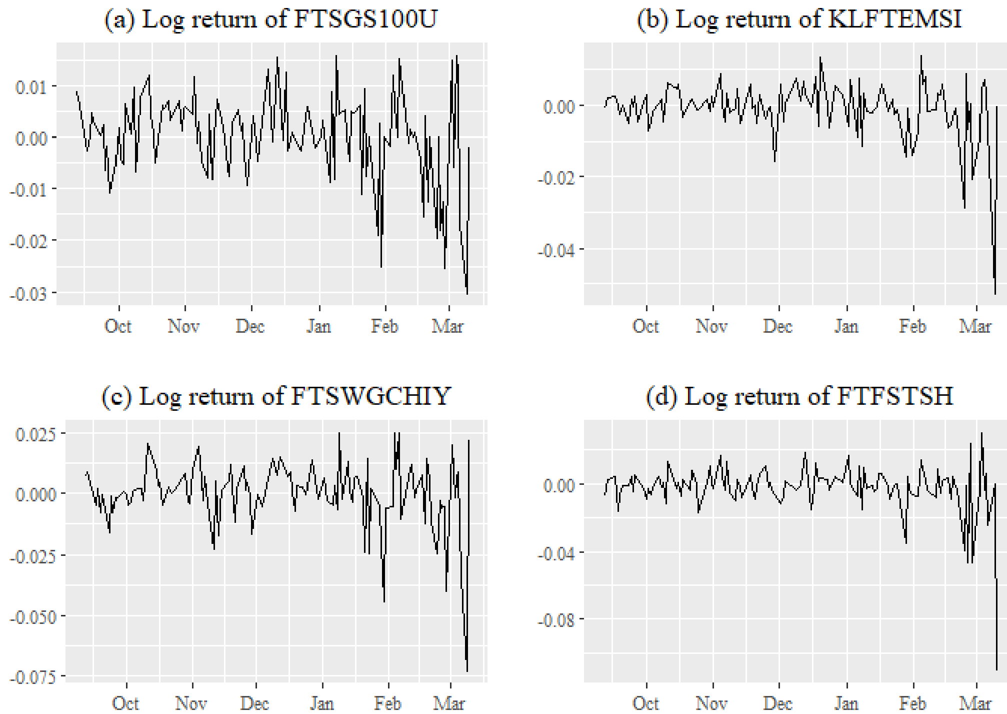

Figure 1: Log return of daily price indices for FTSE Shariah before COVID-19 declare as pandemic.

Figure 1 and Figure 2 show the daily price plot for the log returns for each index. All the indices return shows a sideways trend before the pandemic declaration in the range between -0.0109 and 0.0157 for FTSGS100U, -0.0156 and 0.0134 and KLFTEMSI, -0.0229 and 0.0247 for FTSWGCHIY, and 0.0187 and -0.0172 for FTFSTSH. Around early February and the middle of March, the return shows a downtrend pattern with the lowest return of -0.0304 for FTSGS100U, -0.0528974 for KLFTEMSI, -0.0733 for FTSWGCHIY, and -0.111 for FTFSTSH. Surprisingly, the FTSE Shariah indices' range of return is significantly higher after the pandemic declaration period. Moreover, from both figures, they are clearly show that the high volatility presents around March and April due to the pandemic declaration. In addition, Figure 2 apparently show that the outstanding value of the return also increased during that period where the return jumps towards the new high of 0.05628 for FTSGS100U, 0.0579 for KLFTEMSI, 0.0629 for FTSWGCHIY, and 0.0970 for FTFSTSH. After that, the return trend continues with a new sideway trend with a higher range between -0.0326 and 0.0381 for FTSGS100U, -0.0326 and 0.0302 for KLFTEMSI, -0.0386 and 0.0278 for FTSWGCHIY, -0.0226 and 0.0247 for FTFSTSH.

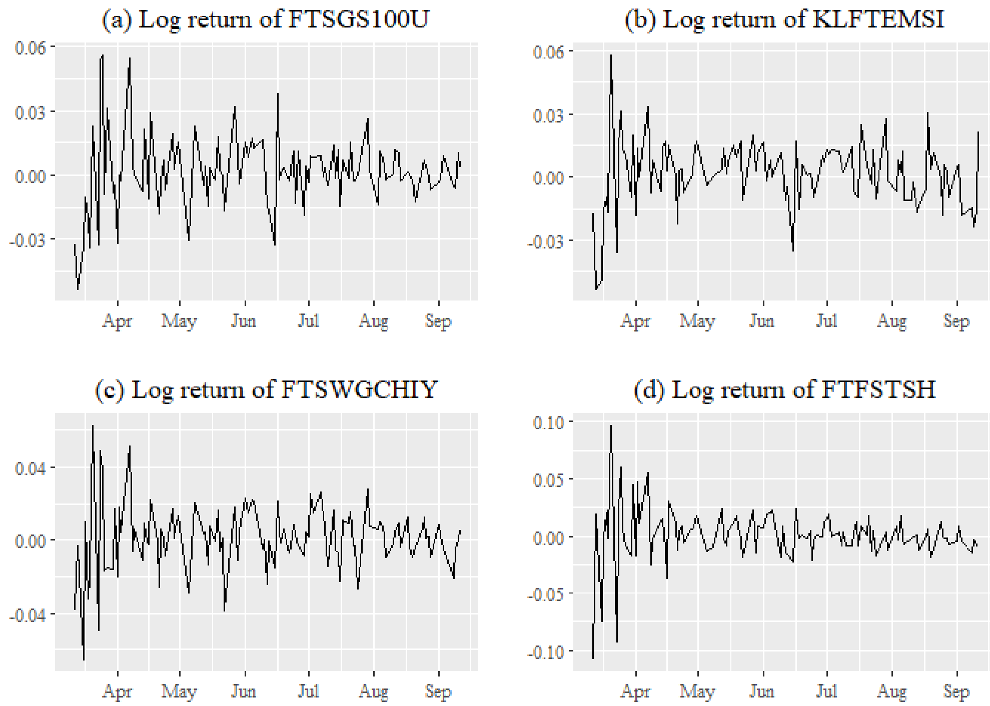

Figure 2: Log return of daily price indices for FTSE Shariah after COVID-19 declare as pandemic

5.3 Rolling window correlation

Results illustrated in Figure 3 show the correlation matrix of FTSE Shariah indices before COVID-19 declared a pandemic by using rolling window correlation. All the FTSE Shariah indices show a positive correlation between each other, showing that any change of return occurs in one index, the other returns will follow in the same direction. The strongest positive correlation exists between FTSGS100U and FTWGCHIY, with a value of 0.74. The strong positive correlation between these two indices suggests that any changes in the indices' return will highly affect the other indices in the same direction. Meanwhile, the lowest positive correlation coefficient presents between FTFSTSH and FTWGCHIY with a value of 0.19. It suggests a weaker positive correlation exists between the two indices. Any changes in the indices' return will slightly be affected by the other indices in the same direction.

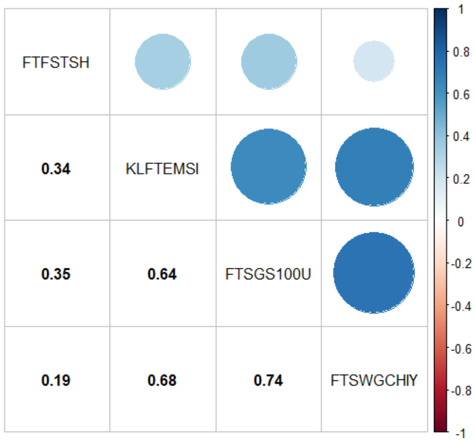

Figure 3: Rolling window correlation coefficient of FTSE Shariah indices return before COVID-19 declare as pandemic

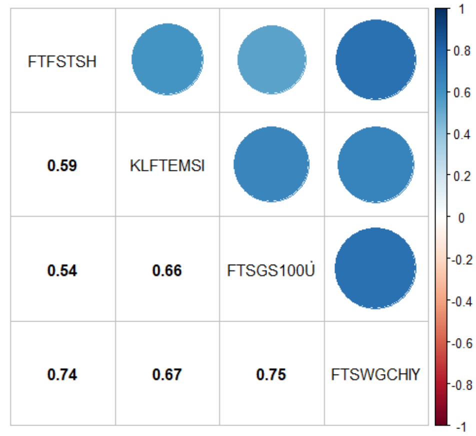

Figure 4: Rolling window correlation coefficient of FTSE Shariah indices return after COVID-19 declare as pandemic

The correlation matrix based on rolling window correlation for FTSE Shariah indices after COVID-19 declared as an outbreak is illustrated in Figure 4. Figure 4 exhibits that all the FTSE Shariah have a positive correlation, demonstrating that any change will affect others' changes in the same direction. As compared to Figure 3, the value for the correlations between all the indices is slightly higher. Therefore, it notifies that the indices have a slightly strong positive correlation after the pandemic was declared. Moreover, the strongest positive correlation remained with the same indices, between FTSGS100U and FTWGCHIY, with a value of 0.75. Meanwhile, the lowest value for the correlation after the pandemic is also relatively high, which is 0.54 between FTFSTSH and FTSGS100U.

Therefore, from Figure 3 and Figure 4, COVID-19 declaration as a pandemic. does not affect the positive direction of the correlation between the indices in either timeline. Unexpectedly, all the correlation value increases after the pandemic declaration except for the correlation between KLFTEMSI and FTSWGCHIY. The value of the correlation between indices changes such that 73.52% increase between FTFSTSH and KLFTEMSI, 50% increase between FTFSTSH and FTSGS100U, 3.13% increase between KLFTEMSI and FTSGS100U, 289.47% increase between FTFSTSH and FTSWGCHIY, 1.47% decrease between KLFTEMSI and FTSWGCHIY, and 1.35% increase between FTSGS100U and FTSWGCHIY.

5.4 Maximum Likelihood Estimates of the Gaussian DCC-GARCH (1,1) on FTSE Shariah indices

The Jarque-Bera test results in Table 2 and Table 3, for all the indices, show the non-normal behaviour distributions. Therefore, this study employs the Gaussian DCC-GARCH (1,1) model to compute the conditional correlation. The maximum likelihood estimates of the Gaussian DCC-GARCH (1,1) on the return of FTSE Shariah indices are shown in Table 4 and Table 5. The estimated parameters for all indices except the parameter α for FTSGS100U are statistically significant before the outbreak. However, most of the estimated parameters show the insignificant result after the crisis. This suggested that persistence in the correlations is very high and past shocks in the markets does not affect the conditional correlation [18]. Following [13], the estimates parameter rounded to three decimals places, leading to the summation of α and β to one for all indices showing that the correlation is nearly integrated. Besides, the high significant volatility parameters β in DCC (1,1) after the declaration of the disease ensuring the high volatility of the return [21]. The expression form for all the indices, either before or after the pandemic was declared, can be formed by plug in the values of the parameters obtained into equation 4.

Table 4: Maximum Likelihood Estimates of the Gaussian DCC-GARCH (1,1) on FTSE Shariah indices daily returns before COVID-19 declares as pandemic

Indices	Parameter	Estimate	T-value (Probability)
FTSGS100U	μ	0.000845	1.332965
	ω	0.000001	0.059808
	α	0.118099	0.305602
	β	0.880901	2.030784 [a]
KLFTEMSI	μ	-0.000271	-0.568661
	ω	0.000001	0.214847
	α	0.095619	3.337815 [a]
	β	0.903381	12.402342 [a]
FTSWGCHIY	μ	0.001065	0.901451
	ω	0.000009	1.067131
	α	0.221633	1.951642 [a]
	β	0.777367	5.897103 [a]
FTFSTSH	μ	-0.001454	-1.711635
	ω	0.000006	0.944620
	α	0.133703	3.355822 [a]
	β	0.865297	13.864176 [a]
DCC-GARCH (1,1)	α	0.027924	0.710292
	β	0.000001	0.000003
AIC		-27.696	
BIC		-27.103	

[a] denotes significance at the 1% level

Table 5: Maximum Likelihood Estimates of the Gaussian DCC-GARCH (1,1) on FTSE Shariah indices daily returns after COVID-19 declare as pandemic

Indices	Parameter	Estimate	T-value (Probability)
FTSGS100U	μ	0.001867	1.700869
	ω	0.000001	0.045675
	α	0.092129	0.312515
	β	0.885870	3.159003 [a]
KLFTEMSI	μ	0.003542	1.979967 [a]
	ω	0.000029	1.161337
	α	0.222453	0.953791
	β	0.640165	2.513643
FTSWGCHIY	μ	0.001543	1.142944
	ω	0.000011	2.652409 [a]
	α	0.095461	3.005204 [a]
	β	0.842562	16.454017 [a]
FTFSTSH	μ	-0.000250	-0.006569
	ω	0.000008	0.011129
	α	0.124611	0.038576
	β	0.807640	0.585865
DCC-GARCH (1,1)	α	0.028273	1.095380
	β	0.840356	16.359150 [a]
AIC		-23.499	
BIC		-22.893	

[a] denotes significance at the 1% level

5.5 FTSE Shariah indices dynamic conditional correlation and rolling window correlation return

Figure 5 and Figure 6 illustrate the rolling window correlation and DCC-GARCH for FTSGS100U with the other FTSE Shariah indices. The figure reveals the fluctuations of correlation over time, either using DCC-GARCH or rolling window correlation. The rolling window correlation is illustrated as the blue lines, while the DCC-GARCH is illustrated as the red line. The DCC-GARCH shows a lower value compared to the rolling correlation throughout the period. The correlation plot pattern for rolling window correlation has resembled the DCC-GARCH plot, but the rolling correlation behaviour is more erratic. The conditional correlation value between the indices after the pandemic declaration is higher after COVID-19 was declared a pandemic. From Figure 1 and Figure 2, the high volatility exists between March to April; however, in Figure 5 and Figure 6, the graphs demonstrate that the DCC-GARCH excellently captures the time-varying changes compared to the rolling window correlation. Meanwhile, the dynamic conditional correlation between FTSGS100U and FTSWGCHIY is less volatile than other indices representing a strong correlation relationship between them. FTSGS100U and KLFTEMSI show a lower correlation after the declaration of a pandemic. The same with FTSGS100U and FTSWGCHIY, the graph shows a lower correlation after the pandemic. FTSGS100U and FTFSTSH show an increase in the correlation after the declaration of the pandemic. Therefore, from all the graph, either before or after the pandemic announcement, the DCC-GARCH is outperformed in capturing the in time-varying volatility. Hence, the findings are significantly important to the investor to find the diversification benefits from the indices.

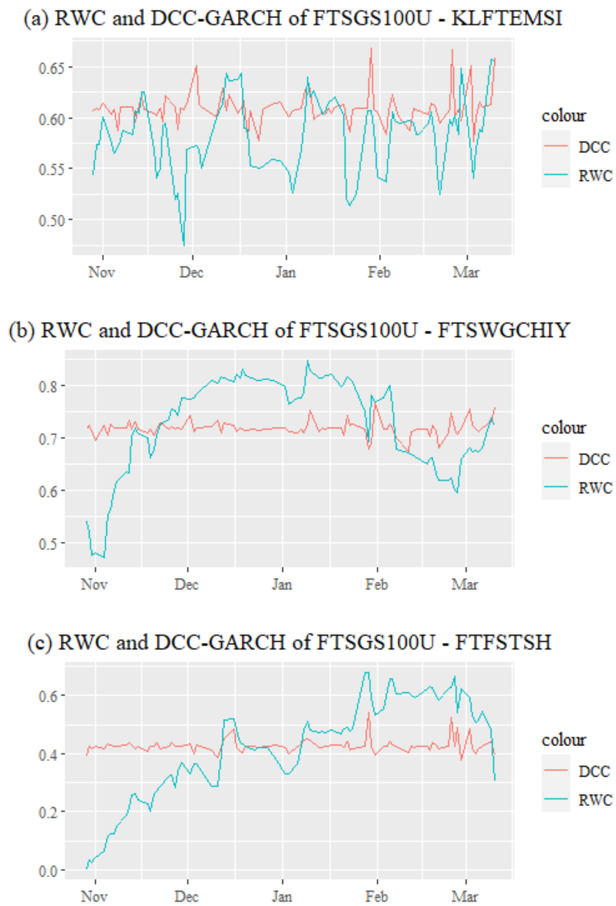

Figure 5: FTSE Shariah indices DCC-GARCH and rolling window correlation return before COVID-19 declare as pandemic

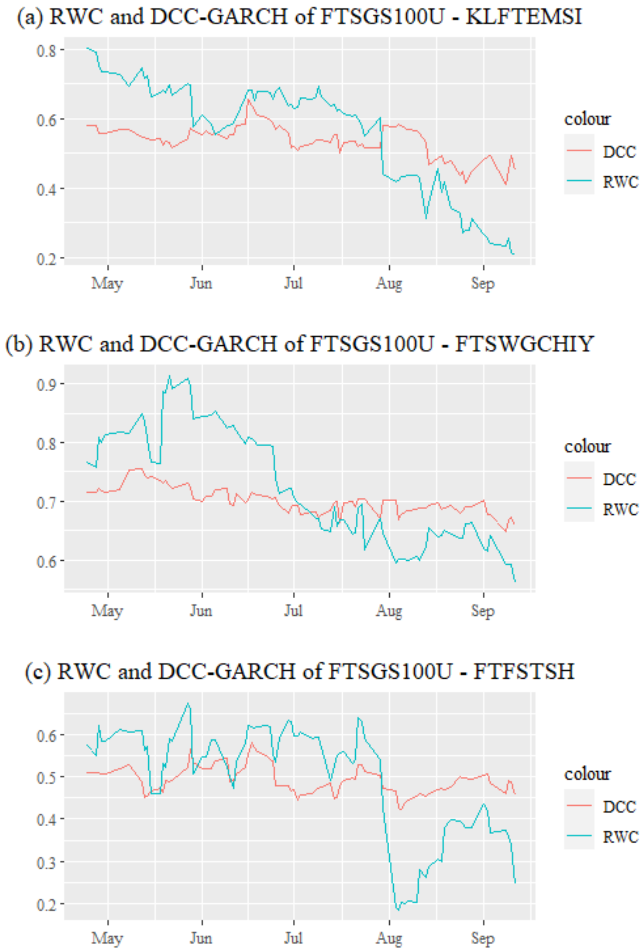

Figure 6**:** FTSE Shariah indices DCC-GARCH and rolling window correlation return after COVID-19 declare as pandemic

6 CONCLUSION

Since COVID-19 declares as a pandemic, economic growth has been significantly affected. This paper employs rolling window correlation and DCC-GARCH to investigate the ability of correlation in capturing the volatility for the Asian Shariah indices before and after the COVID-19 declare as a pandemic. This research finds that those indices' return range is significantly higher, and the return values has increase after the outbreak. On the other hand, their eagerness to detect time-diversity will be compared using the graph presentation. The market participant should rely on the time varying correlation to see the relationship between the indices before making an asset allocation strategy.

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REFERENCES

[1] M. K. Hassan and E. Girard, "Faith-Based Ethical Investing: The Case of Dow Jones Islamic Indexes," *SSRN Electron. J.*, 2012, doi: 10.2139/ssrn.1808853.

[2] C. S. F. Ho, N. A. Abd Rahman, N. H. M. Yusuf, and Z. Zamzamin, "Performance of global Islamic versus conventional share indices: International evidence," *Pacific Basin Financ. J.*, 2014, doi: 10.1016/j.pacfin.2013.09.002.

[3] M. Abduh, "Volatility of Malaysian conventional and Islamic indices: does financial crisis matter?," *J. Islam. Account. Bus. Res.*, vol. 11, no. 1, pp. 1–11, Jan. 2020, doi: 10.1108/JIABR-07-2017-0103.

[4] A. Ben Rejeb and M. Arfaoui, "Do Islamic stock indexes outperform conventional stock indexes? A state space modeling approach," *Eur. J. Manag. Bus. Econ.*, vol. 28, no. 3, pp. 301–322, Oct. 2019, doi: 10.1108/EJMBE-08-2018-0088.

[5] S. Bahloul, M. Mroua, and N. Naifar, "Further evidence on international Islamic and conventional portfolios diversification under regime switching," *Appl. Econ.*, vol. 49, no. 39, pp. 3959–3978, Aug. 2017, doi: 10.1080/00036846.2016.1273496.

[6] A. A. Salisu and X. V. Vo, "Predicting stock returns in the presence of COVID-19 pandemic: The role of health news," *Int. Rev. Financ. Anal.*, vol. 71, p. 101546, Oct. 2020, doi: 10.1016/j.irfa.2020.101546.

[7] B. N. Ashraf, "Stock markets' reaction to COVID-19: Cases or fatalities?," *Res. Int. Bus. Financ.*, vol. 54, p. 101249, Dec. 2020, doi: 10.1016/j.ribaf.2020.101249.

[8] D. H. B. Phan and P. K. Narayan, "Country Responses and the Reaction of the Stock Market to COVID-19—a Preliminary Exposition," *Emerg. Mark. Financ. Trade*, 2020, doi: 10.1080/1540496X.2020.1784719.

[9] M. Mazur, M. Dang, and M. Vega, "COVID-19 and the march 2020 stock market crash. Evidence from S&P1500," *Financ. Res. Lett.*, 2021, doi: 10.1016/j.frl.2020.101690.

[10] M. Sherif, "The impact of Coronavirus (COVID-19) outbreak on faith-based investments: An original analysis," *J. Behav. Exp. Financ.*, 2020, doi: 10.1016/j.jbef.2020.100403.

[11] M. Andersson, E. Krylova, and S. Vähämaa, "Why does the correlation between stock and bond returns vary over time?," *Appl. Financ. Econ.*, 2008, doi: 10.1080/09603100601057854.

[12] N. Raza, S. Ali, S. J. H. Shahzad, and S. A. Raza, "Do commodities effectively hedge real estate risk? A multi-scale asymmetric DCC approach," *Resour. Policy*, 2018, doi:

10.1016/j.resourpol.2018.01.001.

[13] R. Engle, "Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models," *J. Bus. Econ. Stat.*, vol. 20, no. 3, pp. 339–350, 2002, doi: 10.1198/073500102288618487.

[14] B. Saiti, O. I. Bacha, and M. Masih, "Estimation of Dynamic Conditional Correlations of Shariah-Compliant Stock Indices through the Application of Multivariate GARCH Approach," *Aust. ournal Basic Appl. Sci.*, vol. 7, no. 7, pp. 259–267, 2013.

[15] R. Robiyanto, "The Dynamic Correlation between ASEAN-5 Stock Markets and World Oil Prices," *J. Keuang. dan Perbank.*, vol. 22, no. 2, pp. 198–210, 2018, doi: 10.26905/jkdp.v22i2.1688.

[16] N. A. Boamah, J. O. Akotey, and G. Aaawaar, "Economic engagement and within emerging markets integration," *Res. Int. Bus. Financ.*, 2020, doi: 10.1016/j.ribaf.2019.101106.

[17] Q. Ji, D. Zhang, and Y. Zhao, "Searching for safe-haven assets during the COVID-19 pandemic," *Int. Rev. Financ. Anal.*, 2020, doi: 10.1016/j.irfa.2020.101526.

[18] S. Erdogan, A. Gedikli and E. I. Cevik, "The Effects of the Covid-19 Pandemic on Conventional and Islamic Stock Markets in Turkey," *Bilimname*, 2020.

[19] T. Thadewald and H. Büning, "Jarque-Bera test and its competitors for testing normality - A power comparison," *J. Appl. Stat.*, 2007, doi: 10.1080/02664760600994539.

[20] T. Bollerslev, "Modelling the Coherence in Short-Run Nominal Exchange Rates: A Multivariate Generalized Arch Model," *Rev. Econ. Stat.*, 1990, doi: 10.2307/2109358.

[21] M. Naseri and A. M. M. Masih, "Integration and comovement of developed and emerging Islamic stock markets: a case study of Malaysia," *Munich Pers. RePEc Arch.*, 2014.