Understanding Volatility dependence between MENA Sukuk, GCC Sukuk and Nifty Shariah Index during Covid-19: A C-vine Copula Approach

Saif Siddiqui[1], Ziya Batool Rizvi[1]

[1] Centre for Management Studies, Jamia Millia Islamia (A Central University), New Delhi

Contact the Author: ssiddiqui1@jmi.ac.in

Abstract— **The study aims to identify the dependence between MENA Sukuk, GCC Sukuk, and Nifty 50 Shariah indices. Further, it finds out volatility patterns among the same indices before and during the COVID-19 pandemic. Daily data (April 2017 to November 2020) of the indices are analyzed using the GARCH model and C-Vine Copula approach. It is done by modelling the returns of the indices. The outcomes may provide a prodigious advantage for portfolio makers and stockholders towards investment policies throughout financial catastrophes like the COVID19 pandemic. In the pre-Covid period- C Vine copula shows that the Sukuk have strong dependence while the Shariah index has rather weak dependence, for MENA Sukuk and Nifty Shariah 50 it increased by a great margin in during-COVID 19 periods. GCC Sukuk and Nifty Shariah indices are positively correlated to each other in comparison to the returns of Mena Sukuk. The results of the GARCH model show asymmetrical co movements for losses and gains. Moreover, conditioned on MENA Sukuk, the GCC Sukuk and Nifty Shariah 50 had a higher negative degree of dependence within and throughout the COVID-19 period. The findings show substantial high and low tail dependency among the Sukuk and Shariah markets before Covid19. GCC Sukuk and Nifty Shariah 50 indices are highly positively correlated to each other in returns of MENA Sukuk. We also find negative dependency among the GCC Sukuk and Nifty Shariah 50 during Covid19 with MENA Sukuk. The outcomes are varied due to the time variation copulas that shows dependency diverges over time for all variables. Furthermore, this study would be helpful to find out the significance of ethical finance functions safe havens for world investors by using the copula model.**

Keywords: Covid-19, Dependency, Volatility, Sukuk, Index, Copula, GARCH

I. INTRODUCTION

The outbreak of the pandemic of coronavirus (COVID-19) is a widespread economic challenge and a major influencing factor in the current time. The novel disease has unfolded quickly athwart boundaries with quite 5,049, 497 individuals confirmed the infection and therefore the deaths of 367,230 people in more than 195 countries around the world, carrying an average death rate of 6.07% below 1% mortality from flu (Gormsen & Koijen, 2020; Sherif, 2020), which has affected the Islamic finance market too.

The major contributor to the recent growth of the Islamic finance market is Sukuk, the Islamic bond. These are structured to generate returns for investors without violating Shariah. The Sukuk market has shown remarkable growth in the first half of 2017. It has developed from just $ 200bn in 2003 to projected $ 4 trillion by the year 2030 (Alam & Seifzadeh, 2020). Such exceptional development has been grown up in non-Muslim nations in Asia and Europe (Alam, 2019). This is because of the cultural diversity with enormous numbers of Muslim immigrants (Alam & Seifzadeh, 2020).

Empowered by the above contentions and the possible effect of the current flare-up of the COVID-19 pandemic, this study looks at and gives new proof on the impact of COVID-19 on the S&P Dow Jones MENA Sukuk and GCC Sukuk disparity with the Nifty Shariah 50 record and examines the volatility pattern of the S&P Middle East and North Africa (MENA) Sukuk, Gulf Cooperation Council (GCC) and Nifty Shariah 50 indices.

The key motivation for this research study is to analyze the volatility and dependency structure for Shariah and Sukuk index before and during the Covid-19 pandemic. Shariah market, including Sukuk, is inclined by the situation of financial market circumstances specifically the volatility and returns. The statistic recounts the unrivalled volatility in Sukuk and Shariah indices throughout Covid-19.

This paper also focuses on the factors of coupling and decoupling of Sukuk and Shariah index before and during the pandemic in association with globally perilous issues given joint dependency of return disseminations together in tails (extremes) and the focus.

Additionally, we enhance contribution and originality via associating the volatility of two Sukuk and a Shariah market, which gives a good insight of their comparative upended before and during the pandemic period. These findings provide better perceptions in understanding the volatilities. The outcomes may provide a prodigious advantage for portfolio makers and stockholders towards investment policies throughout financial catastrophes like to COVID19 pandemic. Apart from this, there is a dearth of studies on the S&P Middle East and North Africa (MENA) Sukuk, GCC Sukuk and Nifty Shariah 50 indices together.

This study adopts a copula approach that offers great flexibility in separating the marginal distributions from the dependence structure and in modeling these distributions independently to provide information on average dependence as well as on the probability that two variables jointly experience extreme upwards or downwards movements.

This paper is organized as follows. Section 2 reviews the documents available in the same way and/or related to Islamic funds. Section 3 describes the data source and method used for the current study. Section 4 shows the strong results of the analysis and finally, section 5 concludes the paper by giving the real and strategy suggestions and delineation for future study.

II. LITERATURE REVIEW

The studies that have examined Sukuk indices are few. The empirical studies based on Islamic indices, conducted around the world, collected from various sources, are presented in Appendix 1. From the review of literature, it can be interpreted that the co-integration model is the widely used tool for analyzing Shariah indices, followed by Multivariate GARCH, CAPM and T-test. There are a few articles that have used other tests like Copula, wavelet analysis and GMM. There are a few articles that have used other tests like wavelet analysis and GMM.

This paper subsides the existing literature by investigating the dependency structure among Sukuk and Nifty Shariah. So, we used various copulas which help to find out any variations in dependency structure over time variations. It is notified that most of the outcomes imply that the relationship between Sukuk and Shariah index counterpart by pretentious a continuous and symmetrical collaboration among them, most of the studies reflect the strong dependency between Sukuk and Shariah stocks. In our best information and considering the research gap, there is no research on GCC, MENA Sukuk and Nifty Shariah 50 index based on copula approach. The study intends to find out the modelled return in indexed based investments, primarily in Sukuk before and during COVID-19.

III. METHODOLOGY

3.1 Data and Hypotheses

As stated earlier, the data consists of daily returns of three indices, namely, Dow Jones MENA Sukuk (MS), S&P GCC Sukuk (GS) and Nifty Shariah 50 index (NF). The empirical analysis is conducted on daily data obtained for the period 1st April 2017 to 30th November 2020 for benchmark indices. To examine the link between Sukuk and Nifty Shariah, we consider the daily closing prices of the nearest contract to maturity on the Sukuk and Shariah. We choose data from 2017 to 2020 to analyze the pre and during COVID-19 pandemic situation as it was earlier observed that there was the highest issuance of Sukuk after financial crises.

The Dow Jones MENA Sukuk consists of US dollar-denominated investment-grade Sukuk (Islamic bonds) issued in the MENA region, which are Shariah-compliant. The S&P GCC Sukuk consists of US dollar-denominated investment-grade Sukuk from GCC countries of risk. The Nifty Shariah 50 consists of investors with Shariah-compliant investment solutions. The data is taken from the official websites of S&P Dow Jones Indicesand Nifty indices (www.spindices.com and www.niftyindices.com). (See Appendix 1)

Null Hypotheses

For this purpose, two null hypotheses are put as follows:

H01: There is no significant difference in dependency structure among GCC, MENA Sukuk and Nifty Shariah 50 before and during the COVID-19 pandemic is not the same.

H02: There is no significant difference in the volatility in Sukuk and Nifty Shariah 50 before and during COVID-19 pandemic.

This includes various copulas with different tail dependency structures like Student-t (symmetric dependency), Rotated Gumbel 180(Lower and Upper tail dependency), Gaussian (Upper tail dependency) and Frank (symmetric tail dependency). Intended for a better understanding, we analyze two global Sukuk indexes namely, MENA and GCC Sukuk and Nifty Shariah 50 index by considering the data from 1st April'17 to 30th November'20. Outcomes represent that both Sukuk and Nifty Shariah50 indices are highly affected by the pandemic. Additionally, results proposed that Sukuk and Shariah index are sturdily related and inclined to co-move during the Covid19 crisis, which proves the coupling hypothesis of Sukuk from Shariah.

Our outcomes have several significant consequences and proposed some prominent contributions to the existing literature by examining the co-movements of the dependency structure of Shariah and Sukuk market through the Copula approach before and during the COVID-19 pandemic. For explaining the associations among Sukuk and Shariah Index we build a dynamic and static dependency structure through Copula. To our best knowledge, this research is the original one that examines the volatility and dependency among Sukuk (MENA and GCC Sukuk) and Shariah (Nifty 50) index before and throughout the COVID-19 crisis.

TABLE I. DATA SUMMARY

Index	Launch date	First date	Countries considered	Symbols used at levels	Symbols used at first difference
S&P MENA Sukuk Index	September 20, 2013	July 31, 2013	The Middle East and North Africa	MS	RMS
GCC Sukuk	March 22, 2018	December 31, 2012	Bahrain, Kuwait, Oman, Katar, Saudi Arabia, and UAE	GS	RGS
Nifty Shariah 50	February 19, 2008	December 26, 2008	India	NS	RNF

Source: Authors' elaboration

All the data series are considered after computing their log returns using the formula for calculating return:

rt= ln (Pt / P(t-1)).

Here, rt and Pt addresses the everyday return at the business day t individually.

All data series are retrieved from Bloomberg, S&P Dow Jones and Nifty Shariah. The explanation behind using the Dow Jones list is for normalization in the total of indices value. Next, the S&P MENA is used for global Islamic fixed income. The S&P index measures the performance of MENA Sukuk around the world which is involved in the Middle East and African market. Then, the Bloomberg index is used to reflect the GCC Sukuk. GCC Sukuktracks the performance of 6 countries Sovereign Sukuk that are globally traded.

Lastly, Nifty Shariah 50 indices are used for reflecting the uncertainty in Sukuk. This study has divided the observation into the Before-COVID 19 and the During-COVID 19 period to examine the difference between Pre and During COVID-19. World Health Organization (WHO) issued the first Disease Outbreak News Reporting 2019 globally.

Hence, we took the beginning of the COVID-19 from November 2019 as global and defined the 1st November 2019-30th November 2020 as during the COVID-19 period. The period from 1st April 2017 to 31st October 2019 is defined as the before COVID-19 period.

In the methodology part, first, we provided a brief introduction of the models used for the distribution of the margins. Then, a brief description of the approach used for dependence.

Figure 1a-c presents pre COVID-19 and 2a-c during COVID-19-time plots of the price series and Figure 3a-c presents pre COVID-19 and 4a-c during COVID-19 presents the time plot of return series for the three sample indices.
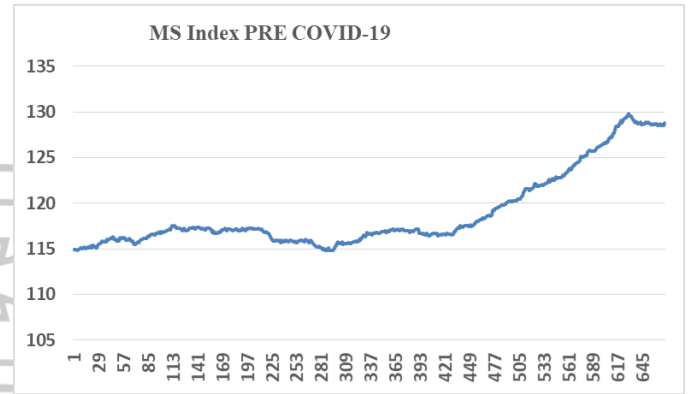

Figure 1a: Price series from 1st April 2017 to 31st October 2019. Source: Authors' elaboration
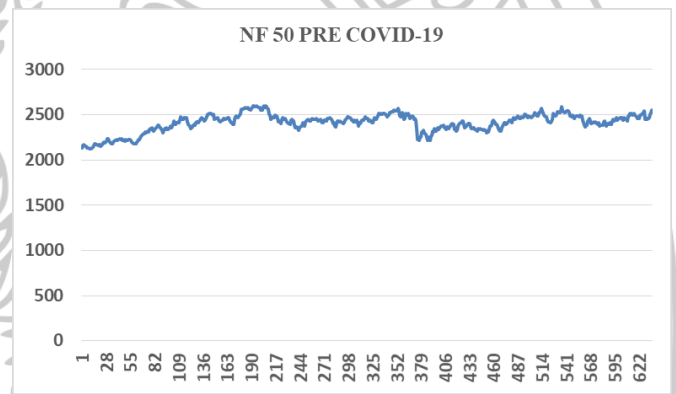

Figure 1b: Price series from 1st April 2017 to 31st October 2019. Source: Authors' elaboration
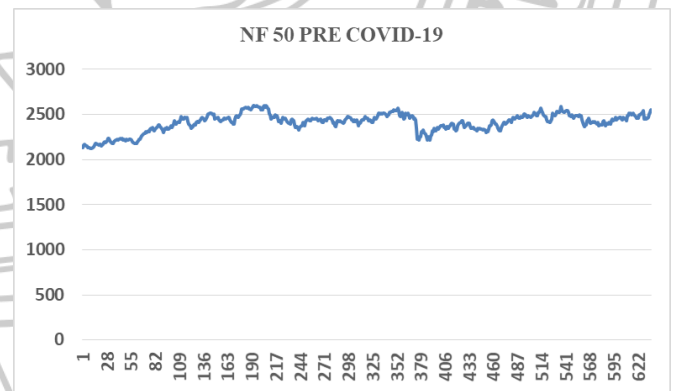

Figure 1c: Price series from 1st April 2017 to 31st October 2019. Source: Authors' elaboration

Figures 1a, 1b and 1c (Pre Covid-19 Period) show that NF was at the level of 2150 as of April 1st, 2017, as it was initiated way before the other two indices. It rose and fell due to America's trade war with China and again rose and finished at the rose level from starting (at increasing rate up to 50 per cent)

after 2.5 years. While, the other two were initiated on April 1st, 2017, at the level of 117.5 and 115. Both GS and MS show a rising trend.

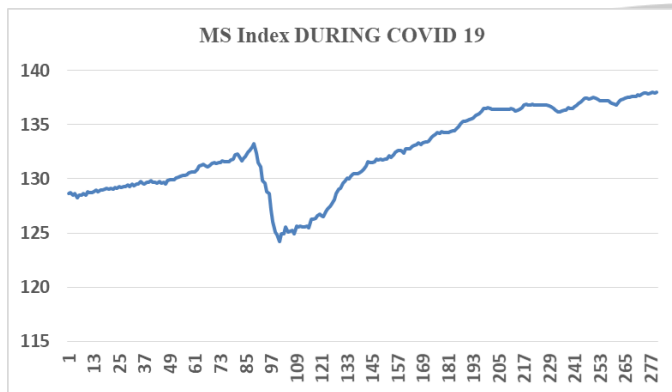## PRICE SERIES DURING COVID-19

Figure 2a: Price series from 1st November 2019 to 30th. Source: Authors' elaboration
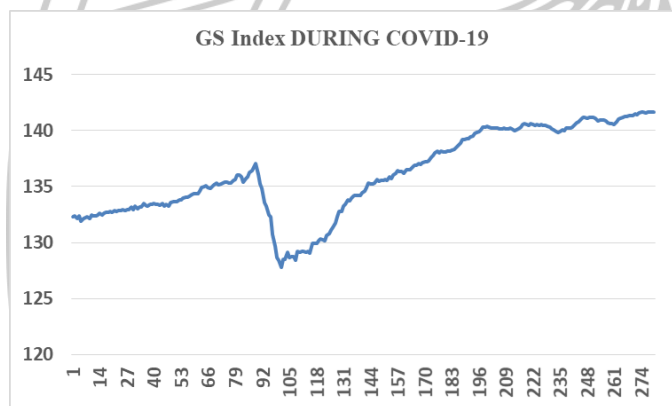

Figure 2b: Price series from 1st November 2019 to 30th November 2020. Source: Authors' elaboration
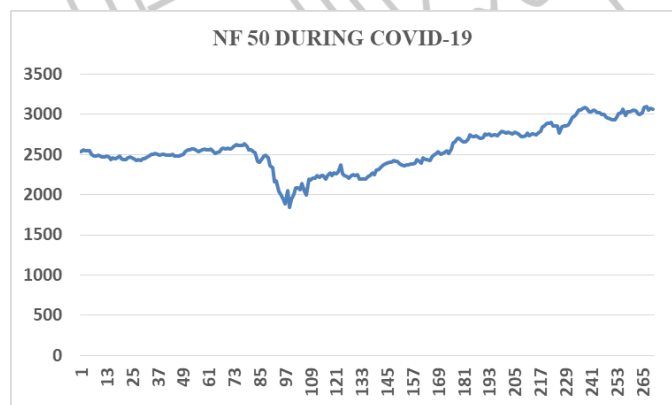

Figure 2c: Price series from 1st November 2019 to 30th November 2020. Source: Authors' elaboration

Figures 2a, 2b and 2c show that NF was at the level of 2500 as of November 1st, 2019, as it was initiated way before the other two indices. It rose and fell due to the Covid-19 pandemic and lockdown situation in the world. Investors do not have the funds to invest in the stock market which affect the global economy but once the lockdown was lifted from the economy and things normalize then again investors invest into the stock market so the price rose and finished more it's starting (increased 20 per cent) level. The other two were initiated i.e., MS and GS on November 1st, 2019, at the level of 128 and 133. Both MS and GS show a rising trend (increase 7.81 and 6.76 per cent).
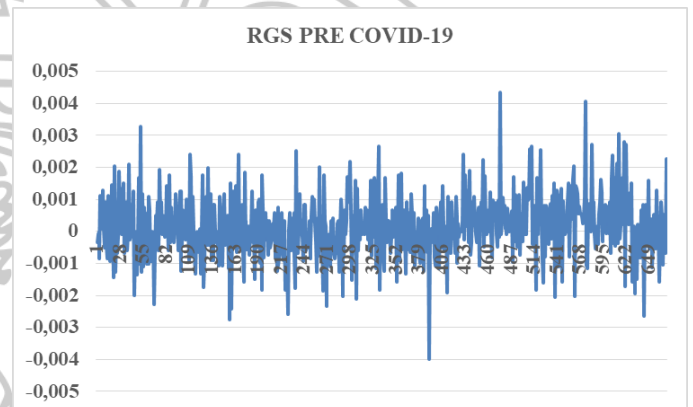
Figure 3: Return series from 1st April 2017 to 31st October 2019. Source: Authors' elaboration

RETURN SERIES DURING COVID-19
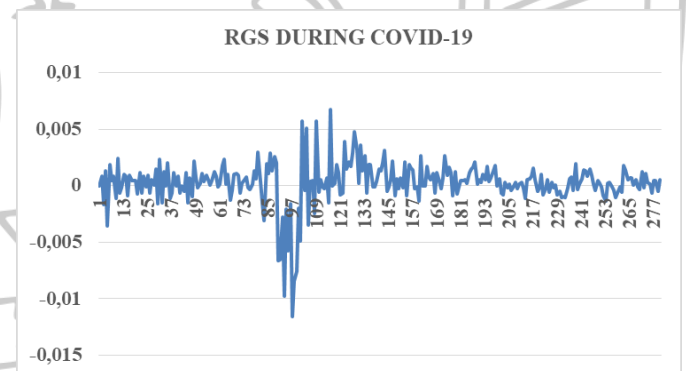
Figure 4a: Return series from 1st November 2019 to 30th November 2020. Source: Authors' elaboration

Figure 3 & 4 shows the return series for the three indices and it can be observed that the return of during Covid-19 of MS (RMS), GS (RGS) and NS (RNF) having higher fluctuations as compared to returns of Pre Covid-19 period of MS (RMS), GS (RGS) and NS (RNF) while, RMS and RGS are leaping around the same path. This was due to the spread of the corona virus pandemic from China into the rest of the world, and the economic shutdown and investors were worried about the impact of the COVID-19. Hence, it can be observed from the graph that NS is the most volatile out of the three indices. Outliers are also visible.

Tables 3 & 4 reports summary statistics for the daily returns of the indices considered as well as statistics testing for normality and independence.

3.2 Preliminary results

Preliminary analysis and results are presented as follows:

Descriptive Statistics before Covid-19

Descriptive statistics of Before Covid-19 period are presented in table 2.

TABLE II. Descriptive statistics before covid period (3ʳᵈ April 2017 – 31ˢᵗ October 2019)

	MS	GS	NF
Mean	0.000173	0.000177	0.000215
Median	0.000171	0.000166	0.000146
Minimum	-0.00403	-0.004	-0.05156
Maximum	0.004697	0.004318	0.027081
Std.Deviation	0.001011	0.000998	0.008275
Skewness	0.153036	0.149481	-0.63146
Kurtosis	4.247265	4.153168	6.588454
Jarque-Bera	46.0444	39.61861	404.0084
Probability	0.000000	0.000000	0.000000
Observation	670	670	670

Source: Authors' elaboration

Table 2 premises the descriptive properties before the Covid-19 period. The sample means are positive for MS, GS, and NF in the Pre Covid-19 period, whereas the standard deviation is lowest for GS (00.09 per cent) and highest for MS (00.10 per cent). Thus, MS is found to be the most volatile index followed by GS and NS.

Skewness and kurtosis indicate that all series are completely skewed except Nifty Shariah 50 it skewed negatively and extremely leptokurtic. The values of skewness and kurtosis reveal that all indices follow the traditional distribution that is other verified by the value of Jarque-Bera datum and prospect value. As higher kurtosis relates to the extremity of outliers, which is highest for NF distribution followed by MS and GS, respectively.

Descriptive Statistics for During Covid-19

Descriptive statistics of During Covid-19 period are presented in table 3.

TABLE III. Descriptive statistics during covid period (1ˢᵗ November 2019 – 30ᵀᴴ november 2020)

	MS	GS	NF
Mean	0.000251	0.000244	0.000683
Median	0.000375	0.000372	0.001353
Minimum	-0.01172	-0.011702	-0.10902
Maximum	0.006651	0.006697	0.089551
Std.Deviation	0.001935	0.001937	0.018286
Skewness	-1.99655	-1.98831	-0.8989
Kurtosis	13.6984	13.67204	13.90106
Jarque-Bera	1515.907	1507.83	1195.223
Probability	0.000000	0.000000	0.000000
Observation	279	279	235

Source: Authors' elaboration

Table 3 summarizes the descriptive properties of the variables during the Covid-19 period. The sample means are positive for MS, GS, and NF during the Covid-19 period, whereas the standard deviation is lowest for MS (00.19 per cent) and highest for NS (01.82 per cent). Thus, NF is found to be the most volatile index followed by GS and MS.

The values of skewness and kurtosis reveal that all indices don't follow the normal distribution. The same is given by Jarque-Bera test. As higher kurtosis relates to the extremity of outliers, which is highest for NS distribution followed by MS and GS, respectively.

After the comparison of Before COVID-19 and During the COVID-19 period, all variables, except MS have a positive return. The volatility of each variable has increased in both periods under study. NS has shown a higher mean return in the COVID-19 period. The maximum and minimum returns during and after the COVID period show the highest peak. Standard deviation is highly volatile during the COVID-19 period in comparison to pre-COVID-19 period. All variables are somewhat asymmetric as shown by their non-zero skewness coefficients.

IV. Results

4.1 GARCH modelling

To comprehend the impulsiveness of the securities market, we will in general allow Exponential GARCH models that area unit broadly utilized in learning the variability of the financial market in money writing have depended on uneven GARCH model developed by Admiral Nelson (1991) recommending the following work of ARMA GARCH model for volatilities (D'Ecclesia & Clementi, 2019). The ARMA approach created by Box and Jenkins (1976) may be a class of random models needed to investigate measurement information considering the ensuing autoregressive moving normal model meant as ARMA (p,q).

$$y_t = \delta + \sum_{i-1}^{p} \phi_i\, y_{t-i} + \sum_{j=1}^{q} \theta_j\, \varepsilon_{t-j} + \varepsilon_t$$

(1)

Where δ may be a constant term, ϕ_i the ith autoregressive constant, θ_j the jth moving average constant, and ε_t error term at time t. p and q are known as the sets of autoregressive and moving normal terms, severally. when the backshift administrator B is applied, Eq. (1) are regularly composed as:

$$\left(1 - \sum_{i=1}^{p} \phi_j\, B^i\right)\left(y_{t-\mu}\right) = \left(1 + \sum_{j=1}^{q} \theta_j\, B^j\right) \varepsilon_t$$

(2)

where $B(y_t - \mu) = y_{t-1} - \mu$ and $B\varepsilon_t = \varepsilon_{t-1}$.

It is used to explore what proportion of Sukuk influenced the market volatility Pre and during the COVID-19 crisis.

In this study, the ARMA-GARCH method is used to assess the parameters of the marginal. The best-fitting model was selected among completely different lag orders (ARMA (0, 0), ARMA (0,1), ARMA (1,0), ARMA (1,1)) with the error term following the traditional, student's t or Generalized Error Distribution (GED).

The estimated parameters for the select models are reported in Tables 4 & 5.

TABLE IV.   ESTIMATES OF MARGINAL DISTRIBUTIONS – BEFORE COVID-19

	MS	GS	NF
	GED	GED	GED
μ	0.00014***	0.00178***	0.000237
	(0.000046)	(0.0000)	(0.32956)
λ	-0.146645***	-0.149879***	0.053997
	(0.000054)	(0.000136)	(0.21395)
δ	-	-	-
	-	-	-

	MS	GS	NF
ω	0.000000	0.000000	0.000004***
	(0.958645)	(0.845614)	(0.00000)
α	0.025792***	0.033352***	0.048261***
	(0.002054)	(0.001945)	(0.00000)
β	0.961937***	0.950449***	0.896015***
	(0.00000)	(0.00000)	(0.00000)
Shape	1.378927***	1.387345	1.238533***
	(0.00000)	(0.518705)	(0.00000)

Source: Authors' elaboration

* The table gives the constraint estimations of marginal distribution function along with standard error and p-value of GARCH test for the suitability of distribution function. The constraints of peripheral distribution function are given in eq. (1&2). For GARCH testing, p-values which are lesser than 0.05 shows that null hypothesis is rejected. ∗, ∗∗, ∗∗∗ shows statistical consequence at 10%, 5% and 1% level correspondingly.

TABLE V.   ESTIMATES OF MARGINAL DISTRIBUTIONS – DURING COVID-19

	MS	GS	NF
	STD	STD	STD
M	0.000329***	0.000313***	0.001102***
	(0.002897)	(0.004982)	(0.0000)
Λ	0.856217***	0.856441***	0.397966***
	(0.00000)	(0.00000)	(0.00000)
Δ	0.730880***	-0.730492***	-0.343426***
	(0.00000)	(0.0000)	(0.0000)
Ω	0.000000	0.000000	0.000007
	(0.955101)	(0.958515)	(0.513746)
α	0.140091**	0.138502**	0.147472*
	(0.015616)	(0.018440)	(0.077205)
β	0.829632***	0.833673***	0.818538***
	(0.00000)	(0.00000)	(0.00000)

	MS	GS	NF
Shape	8.602566 **	8.456019 **	0.988159 ***
	0.023592)	(0.021254)	(0.00000)

* The table gives the constraint estimations of marginal distribution function along with standard error and p-value of GARCH test for the suitability of distribution function. The Constraints of peripheral distribution function are given in eq. (1&2). For GARCH testing, p-values which are lesser than 0.05 shows that null hypothesis is rejected. *, **, *** shows statistical consequence at 10%, 5% and 1% level correspondingly.

As shown in the above Tables, all the return series are best captured either by the GED or student t distribution based on AIC. The Autoregressive and Moving Average (ARMA) terms are statistically significant for the selected variables. The ARCH coefficients represented by α, exhibits the influence of past squared residuals. On the other hand, the GARCH coefficient represented by β shows the impact of lagged forecasted variance. All coefficients are statistically significant at 1% for all series.

Further, the sum of ARCH and GARCH coefficients is closer to unity which showing that the shocks are persistent. Shape parameters are statistically significant indicating that the return series was asymmetric.

Lastly, the diagnostic tests could not reject the null hypothesis of no ARCH effect and no serial correlation.

4.2 C-vine Copula Approach

A Copula is a variable accumulative distribution operate of which marginal distribution is uniform on the interval [0,1] and it captures the dependence structure of a variable distribution. (Rüschendorf, 2009). Multi-data distribution methods have high flexibility as a result of it permits scholars to shape the marginal CDFs aboard a dependable structure expressed in Copula's work. In alternative words, through Copula, we will split the combined allocation operation Fxy into a phase that explains the reciprocity among the random variables X and Y and also the classes solely describe a marginal behaviour.

According to Sklar's Theorem, there exists a copula perform C (.) such for all x,y$\in [-a, a]$:

$$F_{XY}(x,y) = C\left(F_X(x), F_Y(y)\right) \quad (3)$$

Where Fx (x) and Fy(y) denote the marginal distribution functions

The theory additionally states that joint distribution is given Fxy performance; copula is exclusive for Fx × range Fy range, which may be a set of the ranges of the marginal CDFs. This suggests that the verb is going to be distinctive on the off chance that the marginal Fx and Fy are persistent. Depending on the formulation, copula could be used to connect marginal to a multivariate of distribution functions, which could also

deteriorate into its univariate minimal appropriation and copula catches the reliance structure.

On account of bivariate appropriation incorporates a thickness Fxy (x,y), and this is accessible, further:

$$F_{XY}(x,y) = C\left(F_X(x), F_Y(y)\right) \cdot f_X(x) \cdot f_Y(y) \quad (4)$$

Where c(.) is the depth of the copula.

A necessary property of the copula is that it provides important details associated with the mean dependence referenced and tail dependence (excessive dependence), that tests the chance of the two markets can collectively together expertise extreme top or drawback worth movements. Unsurprisingly, the higher tail dependence suggests the relative quantity of size inside the higher (lower) portion of the quartile distribution.

Attained from copula, higher and smaller tail Dependency processes area unit given as:

$$\lambda_U = Pr\left[X \geq F_X^{-1}(u) \mid Y \geq F_Y^{-1}(u)\right] = \lim_{u \to 1} \frac{(1 - 2u + C(u,u))}{1 - u} \quad (5)$$

$$\lambda_L = Pr\left[X \leq F_X^{-1}(u) \mid Y \leq F_Y^{-1}(u)\right] = \lim_{u \to 0} \frac{C(u,u)}{u} \quad (6)$$

where $0 \leq u \leq 1$, $0 \leq \lambda_u, \lambda_u \leq 1$. If $\lambda_L > 0$ ($\lambda_L > 0$), then variables X and Y will in general be lower (upper) tail subordinate. This suggests a non-zero likelihood of noticing a tiny (huge) esteem for one arrangement with a minuscule (enormous) esteem for another arrangement (Mensi, Hammoudeh, Shahzad, & Shahbaz, 2017).

Further, different copula families are used to study the dependence between the variables. Therefore, standard residuals from the GARCH models are transformed into uniform distribution using ECDF.

4.2.1 Copula Functions

This paper uses a varied family of copula functions that have exceptional dependency structures. It includes Student-t (symmetric dependency), Rotated Gumbel 180(Lower and Upper tail dependency), Gaussian (Upper tail dependency) and Frank (symmetric tail dependency). The characteristics of these Copulas are specified below:

The rotated Gumbel copula has an only a lower tail dependency.

CRG(u1, u2; δ) = u1+ u2 − 1 + CG(1 − u1, 1 − u2; δ). (7)

Student t-Copula shows only symmetric tail dependency.

$$Cn.p\ (u,v) = \int_{-\infty}^{t^{-1}(u)} . n \int_{-\infty}^{t_n^{-1}(v)} . \frac{1}{2\pi(1-p2)1/2} exp \left\{1 + \frac{s^2 - 2pst + t^2}{n(1-p^2)}\right\}^{\frac{-n+2}{2}} dsdt \quad (8)$$

$$\lambda L = \lambda U = 2 + [1 - tn - 1\sqrt{(n+1)}\,(1 + p, (1 - P))]$$
(9)

Gaussian Copula has only Upper tail dependency.
$$C_R^{Gauss}(u) = \phi_R\left(\phi^{-1}(u_1)\dots\phi^{-1}(u_d)\right)$$
(10)

Frank copula has only symmetric tail dependency.
$$-\frac{1}{\theta}\log\left[1 + \frac{(\exp^{(-\theta)}-1)(\exp(-\theta u)-1)}{\exp(-\theta)-1}\right]$$
(11)

Another phase is to identify a sequence of the variables in the C-Vine Copula structure. Here, MS is placed in the first place in the order of the variables. For the rest of the variables, this study has used the method proposed by (Panagiotelis, Czado, & Joe, 2012)for identifying the maximal tree spanning by arranging the variables following their sum of absolute pairwise estimated Kendall's tau $\hat{S}_i = \sum_{j=1}^{d} |\hat{T}_{i,j}|$ The variable with the highest dependency is placed at the next sequence and so on.

By this method, the order of the variable is decided as MS, GS, and NF. This sequence applies to the Pre and during COVID 19 periods datasets both.

Figure 5: Pairwise Scatter Plot (Before Covid 19). Source: Authors' elaboration

Figure 6: Pairwise Scatter Plot (During Covid 19). Source: Authors' elaboration

Figures 5 and 6 show Kendall's τ (above the diagonal) and pairwise scatter plot (below the diagonal) of the copula data. From the graph, it is evident that MS has strong dependence while NF has rather weak dependence on other indices. From the estimated Kendall's τ, MS is the highest dependent variable with the rest of the variables as it has the greatest sum of Kendall's tau, which labels it as the second variable.

The next step involves choosing a suitable copula family for each pair and estimating their parameters accordingly. Tables 7 and 8 summarize the results of parameters estimated for the GED copula structure. The first tree reflects the degree and structure of dependence between MS and two other indices- GS and NF. The estimated Kendall's tau evidenced that the degree of dependence has increased between MS and the other two indices the COVID-19 period. This implies that GS and NS are more positively correlated with the movements in the returns of MS.

The dependence structure between GS and NF is shifted from rotated Gumbel 180 degrees to Frank copula. Though, both the copulas measure the lower tail dependence suggesting the downward movements in the index's returns are more correlated than upward movements.

In the view of symmetric tail dependency Student-t, Gaussian, rotated Gumbel and Frank copulas shows the dependency among Sukuk and Nifty Shariah index is optimistic and substantial, opposing the view towards the Sukuk as to be used as hedger and instrument of risk diversification in the risky market situation also. Additionally, the proof of optimistic symmetric upper and lower tail dependency given by Student- t copula suggests that Sukuk and Nifty Shariah index markets change collectively but at different periods before and during Covid19. For GCC and MENA Sukuk, there is a sign of optimistic dependency, even the tail dependency is lower, which shows the optimistic collective response towards the before Covid19 situation. For GS and NF, the symmetric copulas offer the sign of optimistic dependency by supportive sign of upper and lower tail dependency. Though, for GS and NF, we discover a sign of negative lower tail dependency with MS. So, with the features of oblique copulas, it gives the benefit for the diversified portfolio and managing the risk before the crisis.

Next, in the second tree, we tend to explore the dependence between GS and NF conditional on MS. Given the returns of MS, the worth of Kendall's tau between MS and NS increased by a positive margin duringCOVID-19 period. Also, the dependence degree of MS and NF is highest among all the pairs. It is is to be noticed that there are asymmetrical co-movements as extreme losses are more correlated than extreme gains depicted through lower tail dependence. Furthermore, conditioned on MS,GS and NF had a higher negative degree of dependence during the COVID-19 period. The increased negative dependence could be due to high volatility in the index (during the COVID period).
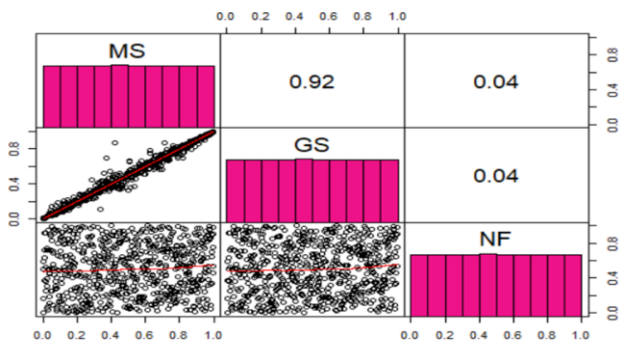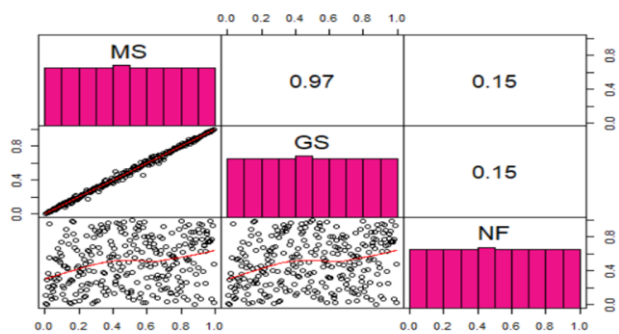
Table 8. During Covid-19 period (1st Nov 2019 -30th Nov 2020)							
	Pairs	Copula	Par1	Par2	λ_L	λ_u	Kendall's tau
Tree 1	MS-GS	Student t	0.9979992	2.83224	0.9536992	0.9536992	0.9597219
	MS-NF	Rotated Gumbel 180	1.161558	-	0.1838131	0	0.1390873
Tree 2	GS-NF⏐ MS	Frank	-0.101906	-	0	0	-0.0113283
Source: Authors' elaboration							

For GS and MS, there is a sign of optimistic dependency, with symmetric upper and lower tail dependency, that shows the optimistic collective response towards the during Covid19 situation. For MS and NF, the symmetric copulas offer the sign of optimistic dependency by supportive sign of high lower tail dependency. Though, for GS and NF, the symmetric copula gives the sign of negative dependence with a higher and lower tail dependency with MS. It illustrates that dependency with globally risky issues changed but asymmetrical due to Covid19.

V. CONCLUSIONS

The prodigious possible development and low apparently susceptibility of Nifty Shariah index as compared to Sukuk throughout the strained financial situation. It attracts the curiosity of Muslims, Conventional stockholders as well as portfolio managers globally. Due to the Covid19 pandemic, the relationship between Sukuk and Shariah index is analysed and concurrence rises on the basis of literature related to the dependency among Islamic finance and another index market, specifically in the risky market situation.

We examine the volatility and dependency among the GCC and MENA Sukuk, and Nifty Shariah 50 index market by using the varied family of copula methods having different dependency structures with different periods i.e., 1st April'17 to 31st Oct'19 as before Covid19 and 1st Nov'19 to 30th Nov'20, the practical outcomes show substantial high and low tail dependency among the Sukuk and Shariah market before Covid19.

GS and NF indices are highly positively correlated to each other in returns of MS. We also find negative dependency among the GS and NS during Covid19 with MS. The outcomes are varied due to the time variation copulas that shows dependency diverges over time for all variables.

We find that Sukuk has consistent tail reliance as Bahrain, Oman, and Abu Dhabi; these discoveries counsel that these Gulf markets area unit getting constant direction and the same magnitude throughout the Covid-19 era additionally as these three also. There are asymmetrical co movements for losses and gains. Moreover, conditioned on MS, the GS and NF had a higher negative degree of dependence within and throughout the COVID-19 period. The enhanced negative dependence may be because of high volatility in the index (throughout the COVID period).

Hereafter, H01 was rejected because there is higher and lower tail dependency shown in Sukuk and Nifty Shariah 50 before Covid-19 and during COVID-19 but GS and NF indices are highly positively correlated and dependent to each other in returns of MS during COVID-19.

H02 was rejected because before COVID-19 Sukuk and Nifty Shariah 50 indices are less volatile due to the news effect but highly volatile during COVID-19. Sukuk and Nifty Shariah 50 stock market are Conditioned on MS, the GS and NF show high volatility in index.

Lastly, the outcome indicates some consequences and implications for portfolio managers and global stakeholders seeking interest to invest in the ethical stock market. Meanwhile, the ethical stock market is pessimistically impacted by discriminating dread, tension and concern in the conventional stock market, the hedging assets and hedging strategies seem to be safe in the ethical stock market. Furthermore, this study would be helpful to find out the significance of ethical finance functions safe havens for world investors by using the copula model.

Table 7 Pre Covid-19 period (3rd April 2017-31st Oct 2019)							
	Pairs	Copula	Par1	Par2	λ_L	λ_u	Kendall's tau
Tree 1	MS-GS	Student t	0.992768	2.0001	0.923475	0.923475	0.9233846
	MS-NF	Rotated Gumbel 180	1.045677	-	0.0596446	0	0.043679
Tree 2	GS-NF⏐ MS	Gaussian	-0.03402	-	0	0	-0.021667
Source: Authors' elaboration							

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Followed Appendix A.

APPENDIX A. REVIEW OF THE LITERATURE

S. No	Authors (year)	Conceptual/ Data (Index and time period)	Methodology	Findings
1	Irfan (2020)	SENSEX, NIFTY (2010-2012)	Beta (CAPM), CAGR, Correlation, T-test	There is no difference between Shariah index and benchmark indices Return and conjointly in Shariah index and customary index. It found that equity primarily based Shariah index is social accountable to invest in investors especially small and private investors.
2	Sherif (2020)	UK Dow Jones index, FTSE100 index. Time period is from January'20 to May 20.	Regression	A well-structured and important statistical correlation among the COVID-19 epidemic and the performance of a general stock market indices. It has shown a negative impact compared to the market indicator of complaints. It has co-examined the effect of COVID-19 on the performing of UK 10 sector clusters. The IT revenues of the IT sector have done much better than the market. return of shares in the field of consumer understanding,
3	Grassa & Miniaoui (2018)	88 Sukuk and 287 conventional bonds of GCC countries were taken. The time period is from 2000 to 2015 (15 years)	Correlation, GMM	Prefer Sukuk in the issuance of large debt and long tenor, because it gives negative correlation in terms of credit rating.
4	Aloui, Hammoudeh, & Hamida, (2015)	GCC Shariah stocks and Sukuk. The time period is from 2008-2013 (6 years)	Markov, univariate and multivariate EGARCH	It propounds changes in sukuk price index having a considerable impact on chance of transmission across regime. It has many economic and managerial implications for Islamic portfolio managers, Islamic hedge funds, stock market regulators, and policy makers
5	Bhuiyan, Rahman, Saiti, & Ghani (2019)	Bond index (US, UK, Australia, Canada, Germany and Japan) and Malaysia sukuk index. The time period is from 2010 to 2015 (5 years)	Wavelet coherence, multivariate GARCH	Developed market shown lower co movement of returns between bond and Malaysian sukuk. Malaysian Sukuk shown negative correlation with bond market, good sign of diversification. It divulges alluring opportunity with credit quality to invest in fixed securities.
6	Dharani, Narayanamoorthy, & Natarajan(2011)	Nifty Shariah Index, Nifty Index 2007 to 2010 (4 years)	Sharpe, Treynor, Jensen and T- test	It was found that Nifty Shariah underperformed throughout sample period. Each were underperforming and consistent with respect to risk free return. Nifty shariah is less volatile as compared to Nifty index.

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7	Aloui, Hammoudeh, & Hamida, (2015a)	GCC Sukuk indices and Shariah stocks. Daily data of 240 days.	Wavelet, VaR	It was found that there is strong dependency between shariah stocks and sukuk index. Portfolio diversifications also vary with frequencies and time.
8	Bhuiyan, Puspa, Saiti, & Ghani, (2020)	Sukuk and Bond indices. The time period is from 2010-2015 (6years)	VaR	It analyses that VaR amount of sukuk indices is way under VaR of bond indices. Sukuk index with bond indices can cut back the VaR portfolio by 30-50%
9	Abadi & Silva, (2020)	MENA Region 2007-2015 (8 years)	Sharpe ratio, Multifactor Model	Performance measure and period of analysis affects the performance of Islamic and non-Islamic portfolios. Each portfolio found to be underperforming against the benchmark. Islamic portfolios underperformed in global financial crisis. non-Islamic counterparts throughout the Arab Spring their performance was at par
10	Jawad & Faris, (2019)	Mena region, S &P Sukuk and Bond index	GARCH, EGARCH, ARCH-LM	It founds that Sukuk reacts lesser to shocks in comparison to bond. Sukuk are more stable and have less risk.
11	Ali, (2020)	Mena Sukuk, Mena Bond	ADRL, DCC GARCH, Copula	It founds that Mena Sukuk is correlated with Mena equity and Mena bond in short run and in long run it is correlated only with Mena.
12	Boujlil, Hassan, & Grassa, (2020)	143 Sukuk and 602 conventional sovereign bonds of 16 OIC countries were taken. The time period is from 2000 to the year 2015 (15 years)	Correlation and Logit model	National, financial, and macroeconomic indicators decide about the governments' choice of sovereign debt. Countries with developed financial markets, could issue sovereign Sukuk than sovereign bonds, to diversify their monetary markets with new debt products.
13	Kumar & Sahu, (2017)	India region Shariah indices and stock market. The time period is from 2006 to 2015. (9.5 years)	VECM, Granger, VAR, Johansen's	Long run equilibrium relation between Dow Jones index and macroeconomic indicators. In short run, unidirectional causality between Dow Jones index and money supply. Indian Islamic capital market is inefficient due to Co-integration between stock return and macroeconomic indicators.
14	El-Khatib & Samet, (2020)	45 emerging countries stock market index	GARCH	It shows harshly struck and sharp decrease in stock market indices. It causes a growth in volatility levels on sovereign credit default.
15	Ashraf & Marashdeh, (2018)	Shariah Indices from Kuwait, Oman, Qatar, Bahrain, Saudi Arabia and the United Arab Emirates, 5 years 6 months	Breusch Godfrey LM test, KPSS test and GPH (Geweke Porter Hudak) test	It was noticed in this study that during the study period, the returns of all GCC Equity Shariah were not informationally economical however fractionally integrated.
16	Siddiqui &	Nifty 50 Shariah,	Correlation test,	It was seen from the analysis that the returns of

		Nifty 500 Shariah, Nifty 50 and Nifty 500, 9 years	Cointegration test, Granger Causality test, GMM and 3SLS	Shariah Indices are better, and it is less risky as compared to underlying indices.
	Sheikh, (2016)			
19	Reddy & Fu (2014)	Shariah and conventional stocks for companies listed on the Australian Stock Exchange (ASX), 13 years	Risk adjusted. return, Sharpe rating, Treynor rating, Jensen alpha rating, and Multiple Reduction Test	The study shows that Shariah based indices are better investment options while both indexes have a tendency towards act in the same way.
20	El Khamlichi, Sarkar, Arouri, & Teulon, (2014)	Islamic Indices and conventional benchmarks of Dow Jones (12 years 2 months), Financial Times (3 years 4 months), Standard & Poor's (4 years 2 months) and Morgan Stanley (3 years 2 months)	Cointegration test and Variance ratio test	The study concluded that Shariah guidelines work other than in the case of MSCI and FTSE. Whereas the Islamic Indices and conventional indices of Dow Jones and S&P are found to be integrated and hence, provide opportunity of investment diversification.
21	Akguc & Al Rahahleh, (2018)	Standard and Poor Compustat global database of GCC region. The time period is from 2000 to 2014	Multi variate regression analysis	Shariah firms are more profitable than Non Shariah firms
24	Al-Khazali, Lean, & Samet, (2014)	Nine Dow Jones indices, 17 years	Correlation, Capital Asset Pricing Model (CAPM) statistic and Davidson–Duclos (DD) tests	The results indicate that traditional indexes overshadow Shariah index all markets with the exception of European market. Whereas Islamic indices for world, European and US markets overlook their traditional equivalents.
26	Tyagi & Rizwan, (2012)	BSE Tasis Shariah and Sensex, 1 year 6 months	Graphical method	The study revealed that Sensex and Tasis Shariah behaved similarly for the period under study.
27	Natarajan & Dharani, (2012)	Nifty Shariah index, Nifty index and BSE Sensex index, 5 years	t-test, CAPM to estimate beta, and correlation Matrix	It was determined that the median yields of the sharia Compliant Stocks and benchmark index were comparable. The returns from the sharia index were just like the returns attained from the common index. Thus, sharia Compliant investment is taken into account a viable and ethical investment opportunity.
28	Munusamy & Natarajan, (2011)	Nifty Shariah index and Nifty index, 4 years	T-test	No difference was found between average day-wise returns of the Nifty Shariah index and Nifty Index during the period of study. The effect of Ramazan was also observed in the Indian stock market. Also, seasonal variation exists in the Shariah Index.

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29	Mansor & Bhatti, (2011)	Malayasian Shariah Mutual Fund and traditional portfolios, 13 years 4 months	T-test and Correlation analysis	The results revealed that Shariah portfolio earns less returns in regard of traditional equivalents and riskier than conventional one.
30	Hassan & Girard, (2011)	Dow Jones Islamic Market Index (DJIM) and their non-Islamic counterparts, 10 years	Sharpe, Treynor, Jensen and Fama's selectivity, four-factor pricing models and cointegration test	No distinction was found among Islamic and non-Islamic files. The Dow Jones Islamic lists surpass their ordinary partners from 1996 to 2000 and fail to meet expectations them from 2001 to 2005. Generally, comparable award to hazard and enhancement edges exists for each the Islamic and regular lists.
31	Sadeghi, (2008)	Daily stock prices, bid ask to spread and volume of trade for 188 publicly traded companies on Shariah Index of Bursa Malaysia, 7 years	Event Study Methodology	The results showed that the introduction of Shariah index had a positive impact on the performance of financial performances of stock included in the study.