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Abstract

Recent literature attract the attention to the issue of whether heterogeneity in stock holding periods has an impact on resulting investor exposures. In this research, we aim to study co-movement dynamics of Islamic equity returns to explain international portfolio diversification opportunities for investors having heterogeneous stock holding periods in the context of Brexit. We employ three recent appropriate methodologies: MGARCH-DCC, Continuous Wavelet Transforms (CWT), and Maximum Overlap Discrete Wavelet Transform (MODWT). The unique contribution of this research is that it is the first study investigating the Brexit effect on Islamic stocks. It would guide Shari'ah investors in their diversification strategies. The results tend to shed light on the effective portfolio diversification benefits in light of shock (Brexit) between UK Islamic stock index and other selected indices varying from country to country depending on investment horizons. This critically confirms the significance of heterogeneity in investment horizons and provides significant implications for portfolio diversification strategies.

Keywords: Brexit, Islamic stock markets, MGARCH-DCC, CWT, MODWT

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Introduction

Through the referendum of June 23, 2016 (Brexit), the United Kingdom people took the momentous decision of breaking its 43-year historical link with the European Union (EU). When the people around the world woke up after the referendum, the decision taken by Britain knocked markets around the world. Before the referendum, there have been numerous surveys indicating remaining in the EU. Most markets around the world did not expect the referendum result in favour of Brexit. It further caused concern about the economic policy uncertainty in the EU. This would affect the decision of investors, businessman, fund managers, basically all the agents of the economy.

The economists are segregated into two, some are saying the shock would remain for long time generating fundamental effects, changing the direction of correlation among stock market returns, others are saying this shock would remain short term and it may create short term volatility in stock market returns, contagion effect for some other countries, then disappear. To assess the impact of the shock in the UK in terms of the diversification strategies of the investors is a major concern of market makers, speculators, hedge funds, portfolio managers, regulators, central bankers, pension and insurance fund managers, etc. It is apparent that the controversy is still ongoing and remains unresolved.

Since the Brexit referendum has taken place recently, there is inadequate literature on the effect of the shock on the diversification strategies. Oehler, Horn, & Wendt, (2017) who conducted an event study analysis to determine the short-term abnormal stock returns following the Brexit referendum found that stocks of firms with higher proportions of domestic sales realized more negative abnormal returns than stocks of firms with more sales abroad. Another study (Adesina, 2017) investigated the volatility persistence under a Brexit-vote structural break and discovered that following the Brexit vote, volatility persistence rose significantly in the stock markets. Schiereck, Kiesel, & Kolaric, (2016) had similar results with (Adesina, 2017) and found that the short-run fall in stock prices due to the Brexit announcement was more conspicuous than the Lehman's bankruptcy, particularly for the EU banks. On the other hand, Springford & Whyte(2014) advocated that the Britain's eurosceptics are right that the City would not collapse in the event of an EU exit and its central role in foreign exchange and securities trading, in insurance and asset management, and in financial law and accountancy services would proceed, as would be its

position as the location of choice for many leading private equity and hedge funds. As it can be seen that there are various arguments going on saying exit affected partially, some expressing it had been worse than the Lehman's bankruptcy, others stating there would be some cost of leaving but advocating Britain could overcome difficulties. It is apparent there is no consensus on the impact of Brexit on stock market which indicates the controversy still remained unresolved.

In the light of the above discussions we would like to address co-movement dynamics of Islamic equity returns to identify international portfolio diversification benefits for the investors having heterogeneous investment horizons in the light of Brexit. There are three techniques employed as follows: MGARCH-DCC (to see dynamic conditional correlations and volatilities), followed by wavelet CWT (to observe these correlations on the different holding periods or investment horizons), then followed by wavelet MODWT (to validate our result as a robustness check). By applying MGARCH-DCC techniques, we will observe the dynamic conditional (time-variant) correlations and volatilities between UK Shari'ah compliant stocks return and others to depict whether there are diversification benefits for the investors or not (MGARCH-DCC), following that we will decompose our data into different holding periods to monitor whether there is a multiscale tendency or not (Wavelet CWT) (these coefficients represent scale-specific betas for each stock index), then further checking our results for robustness (MODWT). The sample period of study is 26 April 2013–13 April 2017.

We have chosen Islamic finance area because it is one of the fastest growing segments of financial industry, not particularly to the specific region but as a whole. Moreover, the literature is lacking of adequate information as compared to its counterpart. The contribution of this research to literature will be as follows: (i) it will guide Shari'ah investors in their diversification strategies in the light of recent shock (Brexit) (ii) the implications of this shock on Islamic stocks could be an example for the future shocks and the investor take into account information provided in this study (iii) to the best of the authors' knowledge, this is the first study investigating the Brexit effect on the Islamic stock markets employing the recently developed appropriate econometric techniques.

We found that the UK Islamic stock market return is highly correlated with the Canadian and US implying a less diversification opportunities for the investors. However, Kuwait and Japan (in the case of Japan, particularly for medium holding periods) offers effective diversification benefits for the investors. Turkey seems to be the most volatile Shari'ah compliant stock, indicating high

fluctuation over the period, but at the same time, shock to volatility is mean reverting as a faster rate than others. However, Malaysian stocks indicate least volatility with the slowest mean-reverting performance. Interestingly, India seems less correlated with UK Islamic stocks, but our wavelet results showing contagion effect for the short term holding periods but in the long run offering diversification benefits. It is worth mentioning that, in wavelet aftermath Brexit (810^{th} trading days), all the patterns seem to show lesser correlation with the UK market in the medium term holding periods. This information could be supported by MGARCH-DCC results.

The structure of this paper is as follows: Section II looks through the theoretical underpinnings in this regard and leading to the literature review in Section III. Methodology is discussed in Section IV followed by data, empirical results and discussion in Section V. Finally, this paper ends with the conclusion and the policy implications of the study in Section VI.

Theoretical Underpinnings

International Portfolio Diversifications

The theoretical foundations of modern portfolio theory have started its journey with stunning work of Markowitz (1959) 'Modern Portfolio Theory' and followed by Grubel (1968) 'International Diversified Portfolios'. Markowitz laid the foundation of modern portfolio theory by driving that the volatility of a portfolio is less than the weighted average of the individual volatilities of the securities that form the portfolio. This is only possible when a portfolio contains securities which are not perfectly correlated among each other in returns. The variance of the expected return on a portfolio can be measured as follows:

$$\sigma_p^2 = (\Sigma W_i^2 \sigma_i^2 + \Sigma\Sigma W_i W_j Cov_{ij})$$

Where σ_i is the standard deviation of expected returns of security i, the sums are over all the securities in the portfolio, W_i is the proportion of the portfolio in security i, lastly Cov_{ij} is the covariance of expected returns of securities of i and j. To explain how diversification diminishes risk is that supposing the covariance is less than one (invariable true), this will lead to having standard deviation less than the weighted average of the standard deviation of the expected returns of the securities.

There has been numerous research conducted subsequent to these papers empirically testing the covariance of asset returns among stock market to explain portfolio diversification opportunities. If there is a high correlation among the asset returns, it will decrease the advantage of diversified investment portfolios (Xiao & Dhesi, 2010). In this research we employ these theoretical bases to study the volatilities and correlation among the Shari'ah compliant stock indices to answer the research question.

The establishment of modern portfolio theory is subsequently followed by the developments in it and took long years to attain its contemporary form. There has been some criticism on the earlier models of portfolio theory, this has led to improvement in the model with the accumulation of knowledge in this field. One of the major assumption was the portfolio variances are constant and normally distributed which did not make sense to some researchers. However, subsequent models have been built which made use of asymmetric and fat tailed distributions that are closer to real world data.

In this paper, one of the recent technique MGARCH-DCC is employed which enable us to adopt a student-*t* distribution of variances. This helps researcher to capture the fat-tailed nature of distribution of index returns (Pesaran & Pesaran, 2007b). Moreover, we utilized wavelet transform to decompose the time series into different holding periods or horizons to illustrate under which circumstances the economic agents take advantage of the diversification benefits.

Diversifying of portfolio is one of the most significant components of investment topics. Most fund manager, investment professionals and investors agree that it does not guarantee against a loss or earning great deal of money but it helps investors to attain long-term financial goals while minimizing risk. This does not necessarily mean that through diversification investor avoid entire risk or reduce risk down to zero.

Self-Features of Islamic Finance

Islamic financial system relies on the fundamentals of Shari'ah, which require investor to earn money in an ethical and socially responsible manner which are in line with the teaching of Shari'ah. Equities traded in the financial market under Shari'ah indices are scrutinized through screening process to ensure they are Shari'ah compliant. There are two types of screening: sector screening and financial screening. In sector screening, the common elements screened for are interest rate, gambling, banned commodities (alcohol pork, etc.), uncertainty and fulfilment of

contractual obligations dictated by Islamic Law of Contracts. The latter financial screening which is also known quantitative screening is to evaluate the extent interest-based financing and interest-based income by using of various ratios and considering the leverage of the company as well. Askari, Iqbal, Krichenne, & Mirakhor, (2011) argue that due to the ethical foundation nature of Islamic stock indices, it has led to the provision of better benefit that could be derived from diversification in comparison with its conventional counterparts. This is mainly due to the fact that the limiting of the interest-based leveraging would lead to a lower systemic risk in the Islamic stock indices, both during an expansion and a recession. Many investors find that the simplest and most efficient way to improve return is to invest in various indices, especially on those Islamic ones which are said and proven to be more transparent with lower risks.

Shari'ah compliant equities serve a wider responsibility to take into consideration the societal goals such as sustainable development. This is reasonable because of the given moral and religious foundation on which Shari'ah compliant financing is based and has requirements to focus on becoming profitable and competitive within the global economy in which it functions.

The values are rooted in Shari'ah compliant finance which are: fairness, justice, equity – are those that will help them not only to survive and be successful in the current crisis but also to endure and grow their presence in the economic cycles. In relation to this, sustainable development is a vital field which can bring a wide range of social benefits that could result in a greatly improved quality of life in the future. Since Islam touches every part of human's life, it comprises of policies and novel funding mechanisms that will reduce negative externalities such as the emissions that may contribute to the climate change and allows us to be well prepared for future economic and environmental disasters. The motivating factor about Shari'ah compliant sustainable investing is that it provides a positive framework for individual and institutional investors who wish to invest their savings in projects that ensure the mitigation of risks and gain benefit from the upside opportunities and most important of all safeguards the environment and achieve social justice.

Literature Review

Even though the Brexit referendum has taken place recently, the literature is getting broader day by day trying to investigate the impacts of it on the economy, financial sector, social life, nature

and so on. In this study, we would like to investigate the impacts of Brexit on different Shari'ah compliant stock indices in terms of correlation and volatilities and show whether there are diversification benefits for the Shari'ah compliant investors, policy makers, fund managers.

Since the literature is still in its infant stage, there are some research examining Brexit implications on various fields. Oehler et al., (2017) examined short-term stock price effects and the impact of firm-level internationalization in the light of Brexit. They found that stocks of firms with higher proportions of domestic sales realized more negative abnormal returns than stocks of firms with more sales abroad supporting the idea of firm-level international diversification seems to be pretty significant factor for country specific risk. Another study analyzed the stock and CDS market reactions around the UK's EU membership referendum ("Brexit") on June 23, 2016, and the Lehman Brothers bankruptcy filing on September 15, 2008. Interestingly they have found the short-run drop in stock prices to the Brexit announcement was more evident than to Lehman's bankruptcy filing, particularly for the EU banks.

Adesina, (2017) models volatility dynamics and explore volatility persistence under a supposed Brexit-vote structural break. They compared volatility persistence in the stock and foreign exchange markets pre and post the Brexit-vote. They have concluded that volatility persistence had risen significantly in the stock markets but declined in the foreign exchange market aftermath of referendum. Another study aims to investigate how market, exchange rate, and excess residual volatility drive investors' sentiment up on a day of extreme choosing Friday June 24, 2016, as a day of extreme. They concluded the capital markets went reverse, and the U.K. political establishment was shocked. Investors' sentiment was particularly high on June 24, 2016 as both FTSE and the pound got hit.

Enlargement and contradiction in Europe may be received as good or bad news may have also some implication in the financial markets. There are quite a lot literature on the enlargement of Europe and its positive effect on attendee countries in terms of economic welfare (Egger, Larch, Pfaffermayr, & Walde, 2008; Zhu & Van Ierland, 2006). The other aspect of it is the negative impacts of exit on the member counties. (Jackowicz, Kozłowskia, & Podgórski, 2016) examined whether the exporters on the Warsaw Stock Exchange suffered the most from Brexit. Unexpectedly, they found out that investors' reactions were mostly identical with regard to the firms' dependence on exports. As it can be observed there is no clear evidence whether Brexit has

negative or positive impact on the different aspects of the economy, it is inconclusive. This is the main motivation as to why we would like to make an humble attempt to investigate how Brexit affected the correlation and volatility among Shari'ah compliant stocks. This will help Shari'ah investors in their diversification strategies.

Methodology

Multivariate GARCH: Conditional Correlation and Volatilities

To apprehend the relationship among the stock markets in terms of risk diversification, we begin our research with the application of Multivariate GARCH (MGARCH-DCC) introduced by (Engle, 2002) to assess the time-varying volatility and correlation. In MGARCH-DCC, the major assumption which is the invariability of means and variances of variables and co-movements over time is relaxed. However, in traditional methods to measure the risk of financial asset relies on the historical covariance matrix. The use of this traditional methods has major weakness that it is time-invariant. In other words, the correlation and variance does not change over time. An improper model may cause inefficient portfolio diversification and inaccurate evaluation of risk exposure. Therefore, it is imperative to know the dynamic behavior of the covariance among the financial assets.

To overcome this drawback, we have employed Multivariate Generalized Autoregressive Conditional Heteroscedastic (MGARCH-DCC) model utilizing dynamic conditional correlation. In our study, we have tested both normal (Gaussian) distribution and *t*-distribution and have chosen the more efficient distribution for our study. The possible superiority in *t*-distribution is it is better to capture the fat-tailed nature of the distribution of asset returns as in the case of high risk assets such as, stock indices (Pesaran & Pesaran, 2007a). It is also better for risk analysis where the tail properties of return distributions are of most concern.

MGARCH-DCC is very useful technique can be utilized in many ways. As in the case of (Boyer, Kumagai, & Yuan, 2016; Chiang, Jeon, & Li, 2007; Corsetti, Pericoli, & Sbracia, 2005; Syllignakis & Kouretas, 2011), they have investigated the contagion effects due to herding behavior in merging financial markets. Another advantage of MGARCH-DCC is that it estimates correlation coefficients of the standardized residuals and so accounts for heteroscedasticity directly

(Chiang et al., 2007). Since volatility vary overtime by the procedure, the time-variant correlation does not have any bias from the volatility (Celik, 2012). Thus we obtain superior measure for correlation.

We have employed the following equation for the purpose of our test:

$$V(r_{it}|\Omega_{t-1}) = \sigma^2_{i,t-1} = \bar{\sigma}^2_i(1 - \lambda_{1i} - \lambda_{2i}) + \lambda_{1i}\sigma^2_{i,t-2} + \lambda_{2i}r^2_{i,t-1}$$

Where σ_i^2 is the unconditional variance of the ith asset return. λ_{1i}+λ_{2i} represents asset specific volatility parameters (individual asset return volatilities). We have also investigated whether shock to the volatility is mean-reverting or not by estimating (1-λ_{1i}-λ_{2i}). To be brief, we have skip the derivation of model which can be found in (Pesaran & Pesaran, 2007a).

The main objective that we have employed Dynamic Conditional Correlation (DCC), it accounts for variation in the mean as well as variance of the time series. To put it another way, DCC permits the changes in both fist moment (mean) and the second moment (variance). To observe how the correlation and variance vary over time is vital information. It provides clear picture to the investor how variance and correlation changes among different investment classes before they channel their funds to specific financial assets. Therefore, in our case it allows us to account for diversification benefits to the investors.

Wavelet

There are numerous heterogeneous players in the financial market which are market makers, speculators, hedge fund, portfolio managers, regulators or central banks, pension and insurance fund managers, etc. These players in financial market have heterogeneous time scale or investment horizon or stock holding periods such as, 2-4 days, 8-16 days, 16-32 days, etc. Having decomposed time series into different holding periods or horizons leads to true dynamic and Granger (i.e. lead-lag) causal relationship between different markets or different classes of financial assets (In & Kim, 2013).

Every market player operates on their investment horizon. It is the sum of the activities of all the investors who have different investment horizons or stock holding periods that form the final market prices.

Wavelet decomposes time series, say daily stock prices, into different horizons or holding periods in order to measure the contribution of each type of investor to the daily stock prices. For instance, speculator and insurance fund manager have different objectives and investment horizon while they are investing in particular financial assets. Speculator is taking large risk in the hope of making large-short term gains by anticipating the future price movements in the economy. On the other hand, insurance fund managers invest their money for the long term and try to ensure that the maturity schedules of the deposits coincide with the demand for insurance claims. As it can be observed from this example, both of them have different objectives and different horizons (holding periods) which lead to having different betas for different investors.

Wavelet handles the heterogeneity in investment horizons of investor by measuring the contribution of each stock holding periods or investment horizons to the market prices. Hence, every investor in financial markets would be aware of their risk exposures born and makes their investment decision based on their risk exposures.

Continues Wavelet Transform (CWT)

Continues Wavelet Transform is getting popular in area of economics and finance and being utilized by numerous researcher (Chowdhury, Haque, & Masih, 2016; Dewandaru, Rizvi, Masih, Masih, & Alhabshi, 2014; Najeeb, Bacha, & Masih, 2015). The CWT maps the original time series, which is a function of just one variable time separated into functions of two different variables such as time and frequency. The CWT navigate the series correlations in a two-dimensional figure that permits the researcher to easily detect and interpret patterns or hidden information. Wavelet coherence is known as an analysis of correlation between tow CWTs. These figures would illustrate the extent of correlation between two variables with both time and time scale/frequency changing (Najeeb et al., 2015).

(Daubechies, 1992)'s least asymmetric wavelet filter of length L = 8 is employed for both CWT and MODWT, denoted by LA (8), relies on eight nonzero coefficients. Balance between the sample size and the length of the wavelet filter is one of the principal applied in this research by using the Wavelet filter (In & Kim, 2013). It is shown by the previous studies to consider a moderate-length filter such as L=8 for high frequency data to handle the characteristics properties of time series (Gencay, Selcuk, & Whitcher, 2001; In & Kim, 2013). The argument in the literature

support the idea of LA (8) filter creating more smooth wavelet coefficients than other filters such as Haar wavelet filter.

The continuous wavelet transform (CWT) $W_X(u,s)$ is acquired by projecting a mother wavelet ψ onto the analyzed time series $x(t) \in L^2(\mathbb{R})$, that is:

$$W_X(u,s) = \int_{-\infty}^{\infty} x(t) \frac{1}{\sqrt{s}} \psi\left(\frac{t-u}{s}\right) dt$$

The time domain part of wavelet is provided by u, while frequency domain part of wavelet is provided by s. The wavelet transform navigates the original series into function of s and u, provide us related information simultaneously both on time and frequency. In order to study the interaction between two time-series, bivariate framework which is called wavelet coherence should be applied. We will be able to observe how closely two time-series, say X and Y, are connected by a linear transformation. Following is how the wavelet coherence of two time-series is defined:

$$R_n^2(s) = \frac{\left|S(s^{-1}W_n^{xy}(s))\right|^2}{S(s^{-1}|W_n^x(s)|^2 . S(s^{-1}\left|W_n^y(s)\right|^2}$$

Where *s* is a wavelet scale, *S* Is a smoothing operator, is the continuous wavelet transform of the time series X, is the continuous wavelet transform of the time series Y, is a cross wavelet transform of the two time series X and Y (Madaleno & Pinho, 2012). To be brief, the mathematical derivation part is skipped referring (Gencay et al., 2001; In & Kim, 2013; Madaleno & Pinho, 2012).

Maximum Overlap Discrete Wavelet Transformation (MODWT)

The domestic and international stock markets consist of investors having heterogeneous time-scale or investment horizons or stockholding periods (Najeeb et al., 2015). If each investor would like to know their contribution to market price since every one of them has different investment horizon or holding periods, the true dynamic relationship between financial assets could be obtained through decomposing the time series into different scales or investment horizon or holding periods. This analysis can be carried out with the help of the wavelet transforms, such as discrete wavelet

transform (DWT), maximum overlap discrete wavelet transform (MODWT), and continuous wavelet transform (CWT). Since wavelet, in general, is explained and brief information is provided about CWT, we would like to pay more attention to DWT and MODWT. Since MODWT is applied as a robustness checking.

There are four main differences between DWT and MODWT as follows:

1-In MODWT, there is no restriction on sample size, however in DWT, the sample size is restricted to multiple of two.

2-In MODWT, its wavelet and scaling coefficients are shift invariant. That is a shift in the time series results in an equivalent in the transform and hence a shift in time series does not change the pattern of coefficients. However, in the case of DWT, its wavelet and scaling coefficients are not shift invariant.

3-The details at each time scale contain the same number of observation in MODWT, but this is not case in the DWT.

4-Variance of MODWT is more efficient than DWT.

MODWT is applied in this study since its superiority over DWT has been shown (Percival, 1995). In this study, we would be using the MODWT to explain the variation in covariance and correlation of the stock returns over different investment horizon to identify the diversification benefits of Shari'ah compliant investments. We have employed following formula proposed by Whitcher. Definition of wavelet covariance (Xt , Yt)is as follows:

$$\gamma_{XY}(\lambda_j) = \frac{1}{2\lambda_j} Cov(\tilde{\omega}_{X,jt}, \tilde{\omega}_{Y,jt})$$

To be brief, we have omitted the derivation part of the formula. Testing MODWT is quite useful to investigate the financial market with the investors having different types of time resolutions. Since the agents in financial market is quite distinct, it would reflect to the dynamics of interrelation between financial market instrument and the behavior of agents. The cornerstone of such analysis is the risk management at different time-scale and enlighten the investor about different investment strategies.

Data, Empirical Results and Discussions

Data

We have employed Islamic market index for following countries: UK, Turkey, India, Malaysia, Kuwait, US, Canada, Japan. The data was collected from Dow Jones Index. These countries have been chosen because they are the markets growing faster in Islamic finance as compare to counterparts. The sample period of study is 26 April 2013–13 April 2017. Pre-Brexit covers the period of 26 April 2013-23 June 2016; Post Brexit covers the period of 24 June 2016-13 April 2017. Selected indexes for research are provided in Table 1 below.

Table 1:Selected Indices for Research

Symbol		Definition
DUK	(UK)	Dow Jones Islamic UK
DUS	(US)	Dow Jones Islamic U.S.
DJA	(JA)	Dow Jones Islamic Japan
DTU	(TU)	Dow Jones Islamic Turkey
DIN	(IN)	Dow Jones Islamic India
DMY	(MY)	Dow Jones Islamic Malaysia
DCA	(CA)	Dow Jones Islamic Canada
DKU	(KU)	Dow Jones Islamic Kuwait

MGARCH-DCC

The aim of this research is to conduct an exploratory study on diversification strategy to observe whether there has been existence of diversification benefits for Islamic asset managers and mutual funds in UK before Brexit and, if yes, how Brexit influence these diversification benefits aftermath the shock. This information is very crucial for Islamic asset managers and mutual funds to predict the further shocks might happen during the process of exit from European Union and take necessary measure by hedging their funds against risks.

To start our empirical analysis, we first glance at the relationship between UK Shari'ah compliant stocks with other Shari'ah compliant stocks around the world for the purpose of portfolio diversification. To observe this, we applied unconditional correlation and volatilities among Shari'ah compliant stocks. These correlations and volatilities are time-invariant and represents entire sample period.

Table 2 below summarizes the maximum likelihood (ML) estimates of λ_1 and λ_2 for our Shari'ah compliant stock returns, as well as for δ_1 and δ_2. Firstly, we compare the estimates of Gaussian DCC (normal distribution) model with the t-DCC model to observe which one appears to be better. In both estimates, we observed that all return volatility estimates are statistically significant and below the unity (mostly close to unity). This implies that shock to the volatility is mean-reverting not following the I-GARCH. We infer that there is gradual decay under the estimates of Gaussian DCC model and the t-DCC model. The maximized log likelihood value (28631) under t-DCC model is greater than normal distribution value (28472.5). The estimated degrees of freedom is (9.2568), well below the values of 30. This implies that t-distribution is more efficient in capturing the fat-tailed nature of distribution of asset returns. From the t- distribution, it can be observed that shock to volatility is mean reverting as a faster rate than others in the case of Turkish stocks. However, Malaysian stocks indicate the slowest mean-reverting performance.

Table 2: Estimates of λ_1 and λ_2 and Delta

		Normal Distribution		T-Distribution	
	Parameter	Estimate	T Ratio	Estimate	T Ratio
Lambda 1	DUK	0.81478	26.7258	0.83983	21.8357
	DUS	0.79962	21.8235	0.83396	23.2755
	DTU	0.57018	6.0498	0.63762	6.0913
	DMY	0.9455	75.4913	0.9547	73.0223
	DKU	0.84108	31.4962	0.86687	34.7375
	DJA	0.84506	26.5244	0.85134	23.3036
	DIN	0.77352	9.3199	0.86776	17.1127
	DCA	0.93338	57.1494	0.94326	67.5885
Lambda 2	DUK	0.10742	6.7433	0.078456	4.7044
	DUS	0.12222	6.0164	0.10962	5.1366
	DTU	0.12559	3.4284	0.10499	2.9514
	DMY	0.052225	5.0234	0.041911	3.9753
	DKU	0.11611	6.9309	0.10108	6.0482
	DJA	0.10057	5.9675	0.10078	4.8708
	DIN	0.083966	3.6434	0.056566	2.9987
	DCA	0.049867	5.1471	0.044509	5.0896
Delta 1		0.97225	63.5762	0.98614	216.7045
Delta 2		0.0071093	3.6589	0.0053643	4.3835
Max. Log Likelihood		28472.5		28631	
Degrees of freedom				9.2568	11.9684

The unconditional volatility and correlation of returns are provided in Table 3. On-diagonal represents the unconditional volatility, off-diagonal represents the unconditional correlation among assets. Turkey seems to have highest volatility fit risk-lover type investors. However, Malaysia appears to be the least volatile suits risk-averse type investors. Surprisingly Japan has negative correlation with the US providing diversification benefits for the Shari'ah investors. Interestingly, Kuwait has less correlation with the other markets offering diversification benefits for the investors. This point is in line with the study of (Najeeb et al., 2015) found MENA markets (such as Kuwait, Qatar, Saudi Arabia, etc.) offer unique diversification opportunities. Japan has less correlation with all the countries except with India and Malaysia probably because of geographical proximity. This raise the issue of Japan being a one the biggest economy and financial sector could be an alternative to US market. However, checking the long run correlation between these two market, (Zhong, Chang, & Tzeng, 2014) found cointegration that in the long-run they do not provide diversification opportunities. Since our main focus in this study is UK, paper show high correlation with the Canadian and US market that does not give way for diversification. The opposite could be said in the case of Kuwait since it is mentioned having least correlation with almost all markets.

Table 3: Estimated Unconditional Volatility & Correlation Matrix for the Indices

	DUK	DUS	DTU	DMY	DKU	DJA	DIN	DCA
DUK	0.0048538	0.49809	0.41275	0.36103	0.13287	0.15205	0.36536	0.56009
DUS	0.49809	0.0035945	0.25341	0.21984	0.051861	-0.01112	0.27002	0.56433
DTU	0.41275	0.25341	0.0066238	0.34322	0.13111	0.14047	0.27383	0.35454
DMY	0.36103	0.21984	0.34322	0.003565	0.21591	0.24605	0.39217	0.29355
DKU	0.13287	0.051861	0.13111	0.21591	0.003794	0.10928	0.14542	0.080199
DJA	0.15205	-0.01112	0.14047	0.24605	0.10928	0.005107	0.22779	0.095015
DIN	0.36536	0.27002	0.27383	0.39217	0.14542	0.22779	0.003992	0.23851
DCA	0.56009	0.56433	0.35454	0.29355	0.080199	0.095015	0.23851	0.005133

In figure 1, it presents the chart of dynamic conditional volatilities plotted during the entire period of study indicating the time-variant volatilities among markets. As we move along the horizon, all the markets appear stable and moving together except Turkey's market being more volatile as compare to others. The bad effect of referendum results on UK market can be easily observable in the graph illustrating that the volatility hit a peak 24 June 2016 and reverted back to normal over the long run. It seems the decision of British people influence all the markets. Notice that Turkey's

volatility reached its peak just after Brexit but it does not indicate the influence of break in Europe. It is the effect of political turmoil which Turkey has experienced failed military coup attempt following the 15 July. It is imperative to mention that even though Kuwait is shown one of the stable market in the earlier result but in 2014 the volatility reached its peak. This is because stock markets in the energy-rich Gulf states dived in the fourth quarter in 2014 due to the slump in oil prices in the red amid a wave of panic sell-offs after oil lost about 50 percent of its value because of weak demand and this could be obviously observable in the case of Kuwait. Overall the markets are following same path and it seems UK market reverted back to its own path indicating short-term impact of Brexit. This is results are in line with unconditional volatility results presented earlier.

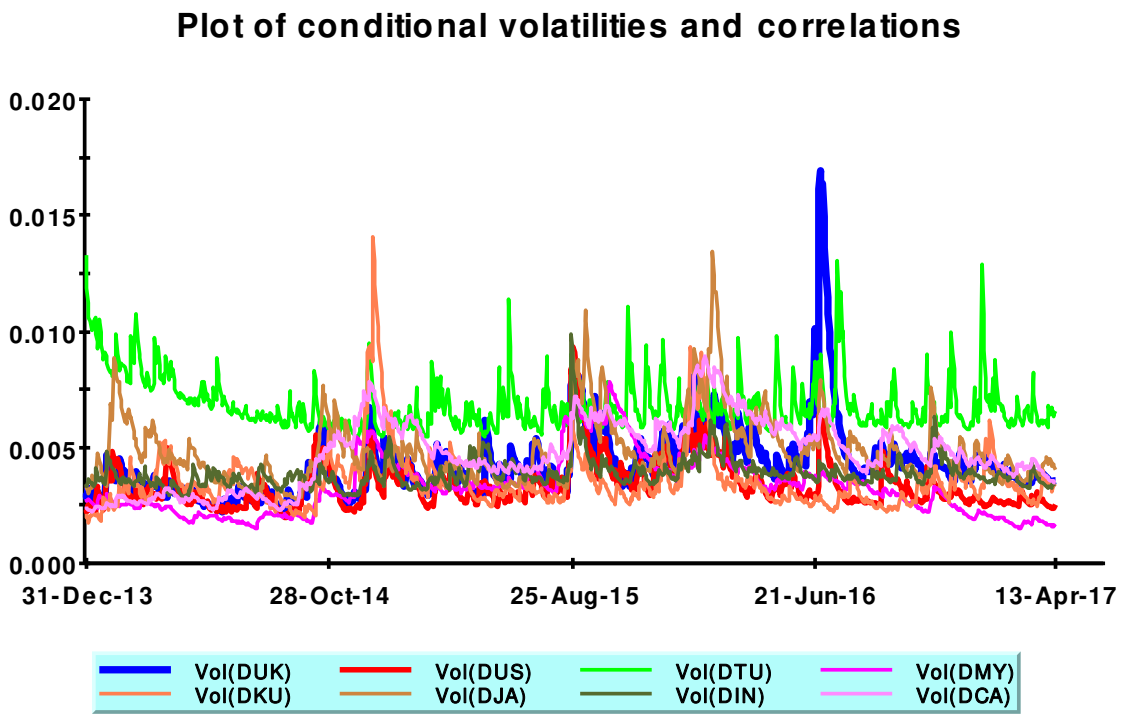


Figure 1:Plot of Conditional Volatilities

Following figure 2 provides information about dynamic conditional correlation (time-variant correlation) between UK and other stock markets. This is one of the significant result shed lights on the diversification opportunities for Shari'ah investors in UK. The chart enables us to monitor

the direction of correlation before and after Brexit. We will be able to read whether Brexit had impacts on the correlation of stock market returns.

As it can be monitored, the highest correlation of UK Shari'ah compliant stock index is with Canadian and US Shari'ah compliant stocks. This high correlation among these stock market returns eradicates diversification opportunities for the Shari'ah compliant investor in UK. It is imperative to mention that the correlation has declining trend aftermath of Brexit, probably indicating the shock to the market affected more negatively UK than the other markets. On the other hand, Kuwait has the least correlation with UK offering diversification benefits. Even the correlation trend has fluctuating along the horizon line getting negative and close to zero over periods. As it was discussed earlier report, the chart supports the result of Japan which offers diversification opportunities to UK investor since the correlation is fluctuating around zero. Interestingly, following Brexit, the correlation has declined as in the case of Canadian and US stock markets return until the beginning of 2017 and reverted back to usual trend following the drop. For the rest of markets there is an obvious diminishing trend following the referendum.

To sum, our MGARCH-DCC result shows that there exists not much variation over the period but it is obvious that after the referendum result, correlation among stock market returns have a

declining trend.

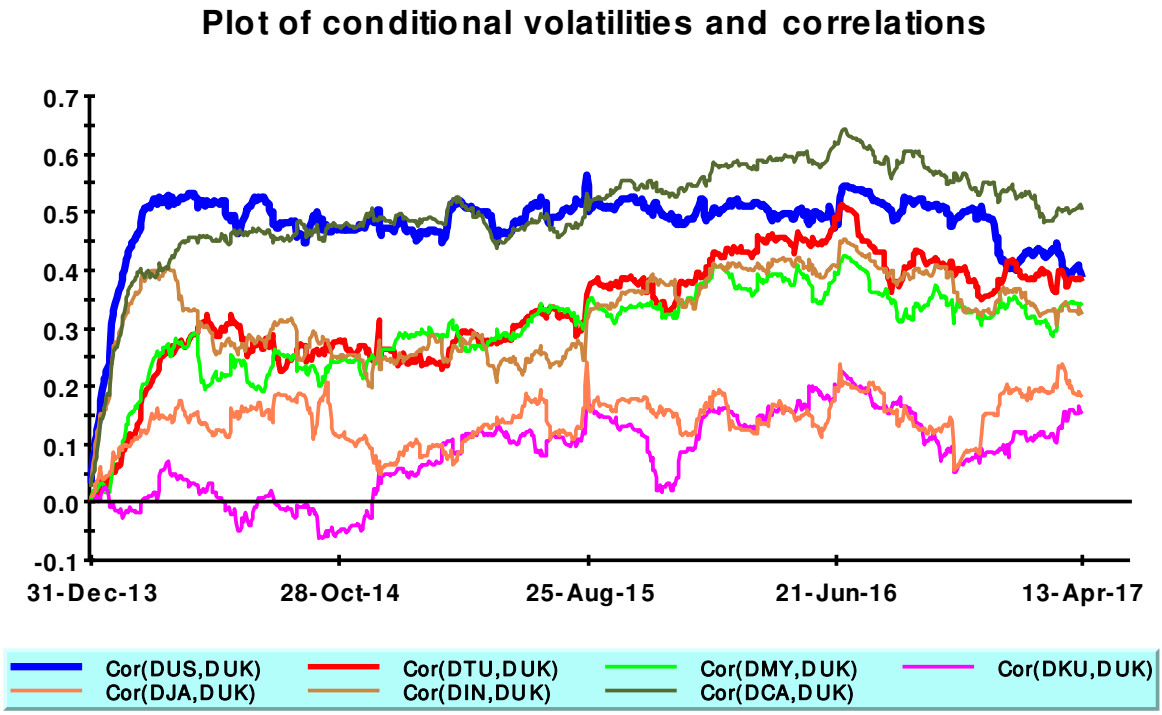


Figure 2: Plot of Conditional Correlations

Continues Wavelet Transformations (CWT) Results

Wavelet decomposes time series, say daily stock prices, into different horizons or holding periods in order to measure the contribution of each type of investor to the daily stock prices Following figures present the estimated wavelet coherence and phase difference of UK Shari'ah compliant stock returns with other market returns from scale 1 (one day) up to scale 8 (roughly one market years) employing continues wavelet transformations (CWT). The reason we have implemented this technique to decompose our Shari'ah compliant stock returns into different investment horizons or holding periods to measure what is the contribution of each type of investor, say speculator, mutual fund, hedge fund and so on. Time is shown on the horizontal axis in terms of number of trading days throughout sample years April 2013-April 2017, while vertical axis refers to investment horizon or holding periods (e.g., two to four days, four to eight days, eight to sixteen days, etc.). The curved line represents the 5 percent significant level which is estimated employing Monte Carlo simulations. The areas beyond this curved line are not statistically significant for interpretation at 95 percent confidence level. There are color codes as depicted on the right side of each figures with power ranges from blue to red correlations. Blue color indicates low correlation

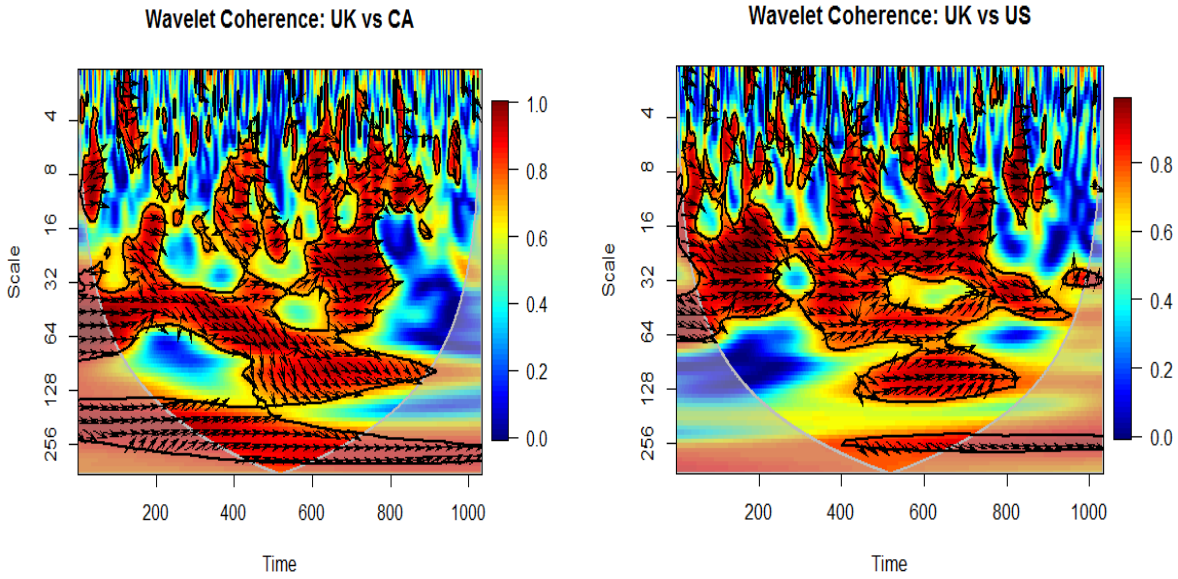
which represents weak relationship between two time-series, while red color indicates high correlation which represents strong relationship between the two time-series. If two time-series in phase, it implies positive relationship between two CWT and arrows point to the right side. If two time-series are in anti-phase, they are negatively correlated and arrows point to the left side. If the arrows are showing upwards, it refers the second time series leads. If the arrows are indicating downwards, it means the first time series leads.

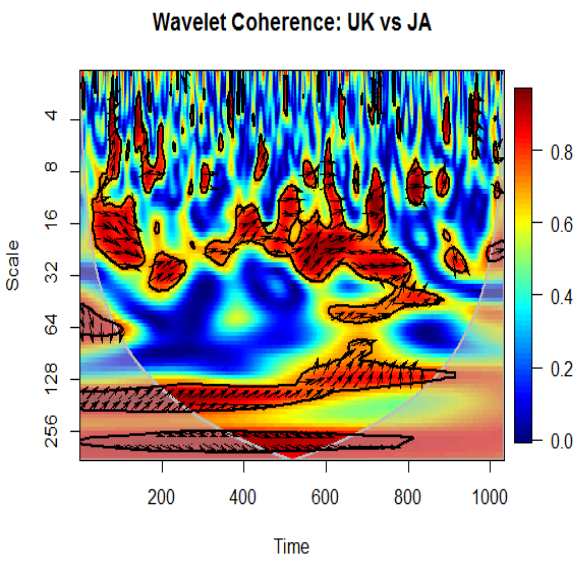
At first glance instantly confirms the strong correlation of the UK stock market returns with the US and Canada as evident by the large area of red spots on the coherence diagram. This is in line with the previous MGARCH-DCC results interpreted. More specifically, we found out that UK correlation with Canada is significant almost at each scale, but interestingly the red spots getting lesser specifically at 16 to 128 holding periods in 810^{th} (indicating the time of Brexit) trading days, thus offering effective portfolio diversification opportunities. This is confirmed with the result of MGARCH-DCC showed that the correlation gets weaker following the Brexit. However, this is not the case for the UK and US relationship. The time series are in-phase for both figures that arrows show right side indicating the positive relationship between stock market returns. It is a bit difficult to draw a conclusion about lead-lag relationship between them since they are dynamic and changing over the scales. As for correlation between Malaysia and UK depicts almost similar pattern in the case of US and Canada with a bit lesser red spots, except offering diversification benefits for the long term investment holding periods consisting of 128-256. The direction arrows draw our attention here that mostly they are right down implying UK is the leading market among two time-series. Similar patterns can be observable on the coherence diagram of Turkey as well indicating high correlation across the horizons. Turkey seems having positive correlation and following UK market since arrow showing right up. Overall we infer that there is less chance of having portfolio diversifications.

As for the coherence between Kuwait and UK, it is obvious that the coherence diagram is covered mostly blue indicating less correlation between two time-series. For investment horizon consisting of two-four, four-eight, we found the correlation is lower implying even no contagion effect between these two market. Meaning that sudden shock in UK does not have series impact on Kuwait at short time scale. But it seems just before the shock (Brexit), there has been diversification opportunities for medium term investment horizons consisting of 32-64 and 64-126

days. Interestingly, India seems less correlated with UK market from medium term investment horizon to the long horizon consisting of 32-64 and onwards offering diversification benefits for long time diversifiers, however in the short run fluctuations, two markets seem to have correlation in short holding periods indicating there is a contagion effect between these two market. As to the correlation between Japan and UK, the coherence diagram shows strong correlation for investment horizon consisting of 8-16 and 16-32 days, however, offering a diversification benefits for medium term investment horizon confirming the MGARCH-DCC result. Moreover, arrows mostly show upward indicating Japan market is leading to UK market.

It is worthwhile mentioning that we would like to draw the attention of our reader to the point that after Brexit, all the patterns seem to show lesser correlation with UK market for medium investment horizons. This declining relationship can be also seen in MGARCH-DCC.




Wavelet Coherence: UK vs JA
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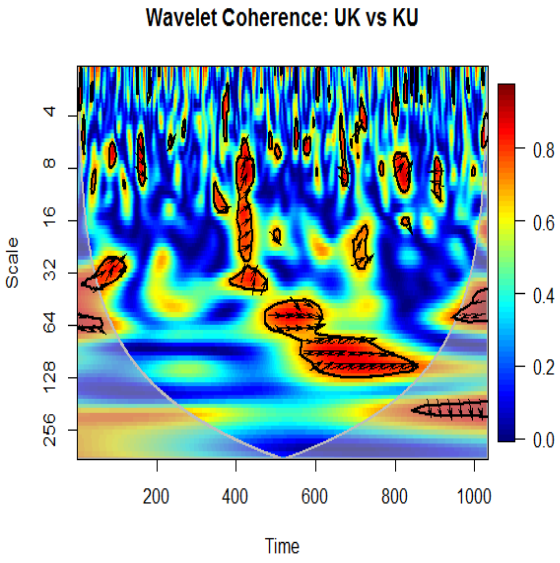
Wavelet Coherence: UK vs KU
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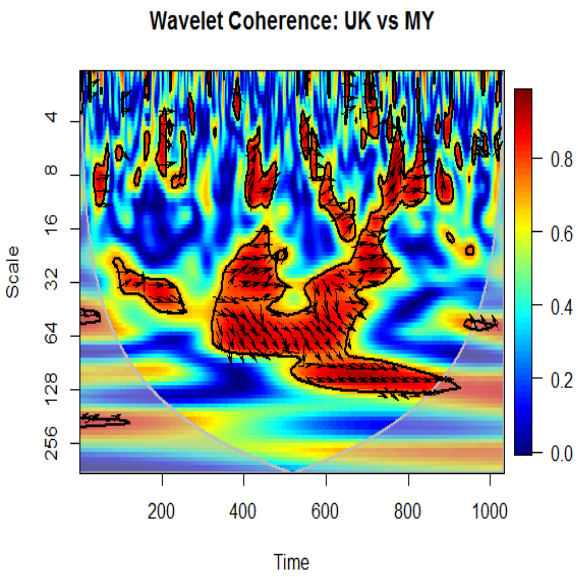
Wavelet Coherence: UK vs MY
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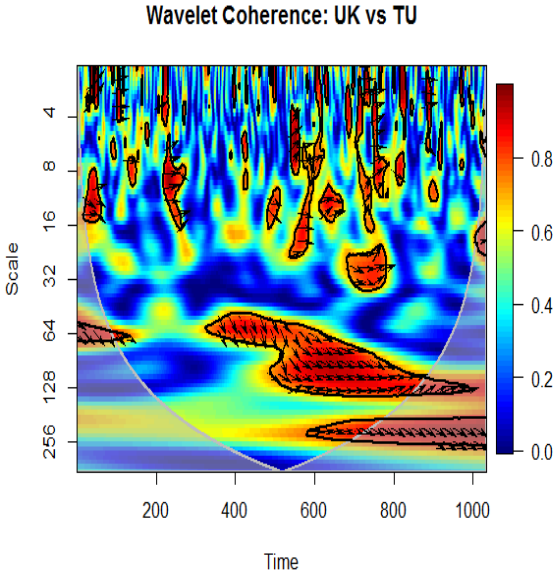
Wavelet Coherence: UK vs TU
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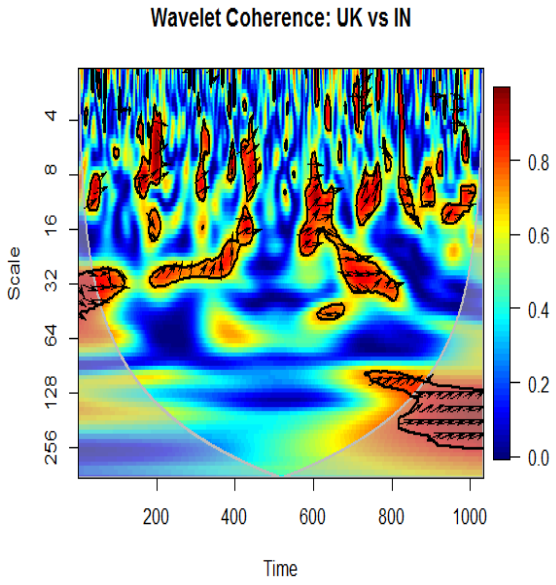

Figure 3: Continuous Wavelet Transforms

Robustness and Validation of Results -MODWT

To further reassure our result from MGARCH-DCC and Wavelet CWT, we have applied a maximum overlap discrete transform (MODWT) to our return series. We split our data into two parts, one represents Pre-Brexit and other represent Post-Brexit. Pre-Brexit covers the period of 26 April 2013-23 June 2016; Post Brexit covers the period of 24 June 2016-13 April 2017. Then we have applied MODWT to two of the time series separately. Unlike CWT, an MODWT requires the researcher to specify time scales for the returns. We determined our scale as six scales consisting of (2–4 days, 4–8 days, 8–16 days, 16–32 days, 32–64 days, and 64–128 days). Employing the recent technique MODWT, we investigate the correlations between the UK Islamic stock market returns and other chosen index returns. The results are shown in Table 4 and 5:

The Pre-Brexit results are considerably consistent with the results provided by earlier CWT analysis. According to result, there is not much room for the UK investor to diversify their portfolio with US and Canada across the time-scale. However, Kuwait is one the potential market for UK investor to diversify their risk away. Japan offers diversification opportunities for short term scale consisting 2-4 days and 4-8 days. Surprisingly, Japan has negative correlation with UK for the very short term holding periods providing good opportunities for the UK investors.

Table 4: Correlations of UK Islamic Stock Market Returns vis-a-vis Other Selected Islamic Stock Market Returns: MODWT Transformations for Pre-Brexit

PreBrexit	UKvsCA	UKvsUS	UKvsJA	UKvsMY	UKvsTU	UKvsKU	UKvsIN
d1(2-4)	44.7%	30.5%	-2.1%	20.3%	39.7%	7.7%	31.9%
d2(4-8)	63.1%	56.8%	26.1%	42.6%	42.6%	10.8%	31.3%
d3(8-16)	75.5%	74.0%	49.2%	41.7%	54.1%	18.9%	47.6%
d4(16-32)	80.2%	87.3%	69.9%	56.3%	46.5%	36.3%	47.4%
d5(32-64)	80.8%	84.7%	49.4%	68.0%	17.7%	23.6%	43.5%
d6(64-128)	67.6%	69.3%	23.3%	48.2%	36.5%	26.3%	30.2%

The Post-Brexit result does not show remarkable differences than the Pre-Brexit with one major changes in the long term investment horizons. Basically this results imply that even though there are some opportunities for diversifiers in the short term horizons, it would disappear in the long term horizons indicating all the markets would be integrated in the long run. It is quite interesting for investors to observe the direction of correlation aftermath Brexit and this result may enlighten investor how the Brexit has made an impact on the direction of correlation for different holding periods of stock markets. However, this result contradicts with our MGARCH-DCC and wavelet CWT result, this might be limitation of relatively shortness of data for our Post-Brexit time series. Robustness check could be done in the further years to validate the information provided by Post-Brexit MODWT.

Table 5:Correlations of UK Islamic Stock Market Returns vis-a-vis Other Selected Islamic Stock Market Returns: MODWT Transformations for Post-Brexit

PostBrexit	UKvsCA	UKvsUS	UKvsJA	UKvsMY	UKvsTU	UKvsKU	UKvsIN
d1(2-4)	49.6%	34.9%	-0.1%	26.8%	44.0%	12.5%	40.4%
d2(4-8)	62.3%	59.0%	23.7%	45.0%	44.8%	17.5%	38.8%
d3(8-16)	74.2%	68.2%	51.6%	50.6%	50.3%	14.5%	52.7%
d4(16-32)	79.3%	81.4%	59.0%	67.3%	40.2%	21.3%	53.6%
d5(32-64)	74.4%	80.0%	64.8%	19.8%	22.0%	50.8%	41.1%
d6(64-128)	82.9%	71.6%	97.0%	50.7%	63.5%	94.1%	82.0%

Conclusion and Policy Implications

In this study, we aim to address co-movement dynamics of Islamic equity returns to identify international portfolio diversification benefits for investors having heterogeneous investment horizons in the light of Brexit. Firstly, MGARCH-DCC was applied to monitor dynamic conditional correlations and volatilities between UK Islamic stock market returns and other selected Islamic market returns. It was followed by decomposition of data into different horizons or holding periods to look into whether time series depicts multiscale tendency or not. Last but not the least we have checked our results for robustness by segregating our time series into two Pre-Brexit and Post-Brexit, then applied MODWT.

We discovered that there is a high correlation between UK Islamic stock market return with the Canadian and US implying less diversification benefits for the investors. However, our results significantly tend to indicate that UK Islamic stock market investors who have allocated their investment in Kuwait and Japan (in the case of Japan, particularly for medium holding periods) have enjoyed diversification benefits. Turkey seems to be the most volatile stock over the period appealing risk-lover investor to gain from price up and down, but at the same time, when the shock occurs in the financial sector, volatility is mean reverting faster than other markets. On the other hand, Malaysia appears to have the least volatility implying stable financial sector as compared to others and the shock to the volatility is mean-reverting as a slower rate than others. Interestingly, India seems moderately correlated with UK Islamic stocks, but this is valid for the short term holding periods. Because our wavelet results indicate contagion effect in the short term horizon but the correlation seems to disappear in the medium and long term horizon implying investor can enjoy effective diversification benefits.

It is worth mentioning that our MGARCH-DCC results indicate that in general, there is a declining correlation between UK Islamic stock markets and other selected markets aftermath Brexit. It can be monitored and confirmed by our wavelet CWT results showing all the patterns seem to indicate lesser correlation with UK stock market after Brexit (810^{th} trading days) for medium term investment horizon. This information is in line with our MODWT (Pre-Brexit and Post-Brexit) results (with one exception) segregating time series into two (Pre-Brexit and Post-Brexit) and investigating the correlation between UK Islamic stock market with other chosen market in

different holding periods. The exception is that Post-Brexit result shows high correlation in the d6 (higher scale) implying integration among the stock markets in the higher scale.

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