

Research Article

Vulnerability of Sustainable Islamic Stock Returns to Implied Market Volatilities: An Asymmetric Approach

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Received 13 May 2022; Revised 21 June 2022; Accepted 23 June 2022; Published 19 July 2022

Academic Editor: Stefan Cristian Gherghina

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There has been increasing interests in the sustainable way of investing as enjoined by several sustainability initiatives. However, investors require effective portfolio diversification at various market conditions (stress, benign, and boom) and would consider sustainable equities to the extent that they aid in the minimisation of portfolio risks. As a result, a better way investors can mitigate portfolio risk is by forming portfolios with relevant volatility indices as enshrined in extant literature. It becomes necessary to investigate the susceptibility of Islamic stocks in a sustainable way to shocks from volatility indices to enhance effective portfolio decisions. In this regard, we investigate the asymmetric effect of implied volatility indices on sustainable Islamic stocks across different market conditions. Hence, the quantile regression and quantile-on-quantile regression techniques are employed. The study discovered an asymmetric influence of volatility on sustainable Islamic stock returns at various quantiles. Furthermore, most volatilities' asymmetric effects were generally inversely associated to sustainable Islamic stock returns, implying diversification benefits across market outcomes. Also, with the exception of the extreme quantiles, there is a causal effect of volatilities on Islamic stock returns for most quantiles. It seems to reason that ordinary market outcomes, rather than market stress or boom, have a greater impact on causal estimates for our quantile regression model.

1. Introduction

The popularity of Islamic stocks has heightened over the years to induce the attention of investors, policymakers, researchers, asset managers, etc. This is as a result of their increased market performance relative to the conventional way of investing, even in times of crises. Investing in Islamic stocks further grants the opportunity to channel ones religious belief [1, 2]. Aside from this, the high levels of integration among most conventional assets (see [3–5]) requires that effective portfolios are formed with Islamic stocks due to the latter's high extent of satisfying investors' risk tolerance in times of crises [2, 6].

However, prior studies utilising Islamic stocks alone divulge that Islamic stocks exhibit similar patterns of high interactions [7, 8] depicting low degrees of diversification in the future. This is not surprising because, although Islamic stocks are mostly insulated from existing crises, their similar response to shocks weaken diversification potentials at various investment horizons.

This has brought about many empirical studies to investigate diversification benefits among conventional and Islamic assets simultaneously [2, 6, 9–12]. Findings from these studies generally divulge some considerable levels of interactions or contagion (increased in correlations after the onset of crises) among conventional and Islamic equities.

Comparatively, conventional equities are found to exhibit more volatility spillovers of excessive interactions than their Islamic counterparts [2] during market stress. Insights from these studies are that it is better to diversify among conventional as well as Islamic equities rather than concentrating on a particular asset class.

This opens up a gap to further assess the asymmetric effect of implied market volatilities which are forward-looking. Application of implied volatilities has gained massive attention with conventional stocks [13, 14] and cryptocurrencies [15–17], as well as commodities [5, 18, 19]. It is normally found from these studies that negative shocks are mostly transmitted from the implied market volatilities to these assets demonstrating diversification, hedge, or safe haven benefits depending on the market conditions as a result of portfolio formation.

It becomes pertinent to examine the asymmetric effect of implied volatilities on Islamic stocks which have gained investors' attention over time [20–22]. This is particularly important because Islamic stocks are most likely than not susceptible to external shocks [22, 23]. This empirical discourse would highlight the relevance of forming reliable portfolios among market volatility indices as external shocks transmitters and Islamic stocks. It would also give a chance to the existing investors of Islamic stocks to reconstruct or rebalance their portfolios to incorporate implied market volatilities. Also, observing the asymmetric effect of implied market volatilities provides existing investors of Islamic stocks the opportunity to hedge against shock transmission regarding contagion effect to either redeploy or scale up their investments.

Hence, a nascent and fledgling body of literature investigates the nexus between implied volatilities and Islamic stock returns. For instance, Karim and Masih [20] through the wavelet approach investigated the asymmetric impact of realised and implied crude oil volatility on Islamic stock returns. However, the study of Karim and Masih [20] was limited to the oil market, thereby creating a myopic view of the nexus. The closest study to ours is that of Chang et al. [1], but did not consider the influence of implied volatilities in the nexus.

Some of the implied volatilities that have spillover effects on most financial markets around the world include the US VIX as a significant measure of investor fear and expectations [14], implied volatility in the energy markets, emerging markets volatility, and developed markets volatility. These implied volatilities have been touted to have ravaging impact on financial markets [5, 13, 16, 18, 24] from which Islamic stocks could be more sensitive as a result of contagion effect from markets interactions.

This is because, recently, Islamic stocks are becoming linked to shocks from implied volatilities [22, 24]. This can be traced from the behaviour of conventional investors and fund managers who seek to invest in Islamic stocks to minimise losses during crises. In times of crises, firms with a relatively huge indebtedness tend to receive most of the shocks, wherein, Sharia-compliant firms operate around a certain interest-bearing debt threshold of about 33% in accordance with the screening method of Dow Jones Sharia,

to mention a few. This filtering criterion mitigates financial integration between Islamic stocks and implied volatilities to become less positively related to harness diversification benefits.

However, as found by Karim et al. [25], Islamic stocks are less exposed to implied volatility or fear index than their conventional counterparts due to the former's distinct screening features to be more decoupled from the risks facing conventional markets. Conversely, Tissaoui and Azibi [24] and Shahzad et al. [26] documented that both Islamic and conventional stocks are exposed to global risk factors similarly and achieving strong linkages with their conventional counterparts. This leads to the rejection of the decoupling hypothesis of both Islamic and conventional stocks. These inconsistencies render a further assessment of the susceptibility of most Islamic stocks (Sharia-compliant) to several relevant implied volatilities worthwhile of examination to enhance investors' understanding and confidence.

It is known that implied volatilities drive interconnectedness among financial markets including Islamic stocks during stressful times [22]. What is not known is the susceptibility of Islamic stock returns to implied volatilities at market conditions of stress, normal, and boom using the quantile regression approaches? That is, prior studies conducted on the susceptibility of Islamic equities to implied volatilities are mostly silent on the use of the quantile regression approaches (see [20–24, 26]). However, the quantile regression approaches, quantile regression (QR), and quantile-on-quantile regression (QQR) offer the opportunity to capture the nonlinear, asymmetry, and nonstationary influence of changes in implied volatilities [13] and Islamic stock returns (see [27, 28]), as well as the effect during bearish, normal, and bullish market situations. The traditional QR and regular least squares approaches alone do not display these properties as good as QQR does. Furthermore, the market condition of Shariah stocks may not be the same as volatility indices. Thus, Shariah stocks and volatility indices may witness different market conditions and, hence, analysing the asymmetric relationships between the two assets across their varied market conditions is important.

We contribute to literature in three folds. First, we utilise aggregated Islamic stock indices from various blocs as a result of the heightened interactions among country level Islamic stocks. They include Dow Jones Islamic Market Asia-Pacific Developed TopCap Index (DJIMAPDI), Dow Jones Islamic Market Developed Markets Index (DJIMDI), Dow Jones Islamic Market World Emerging Markets Index (DJIMWEI), Dow Jones Islamic Market Europe Index (DJIMEI), Dow Jones Islamic Market World Index (DJIMWI), S&P Africa Frontier Shariah Index (S.PAFSI), and S&P Global 1200 Shariah (S.PGS). These Islamic stocks meeting the faith-based criterion are also considered as sustainable. The sustainability criterion of these indexes is in line with several initiatives of the establishment of the UN Principles for Responsible Investment in 2006, Global Initiative for Sustainability Ratings in 2011, Sustainable Stock Exchanges Initiative in 2012, UN Sustainable Development Goals in 2015, etc. There is, therefore greater expectations for

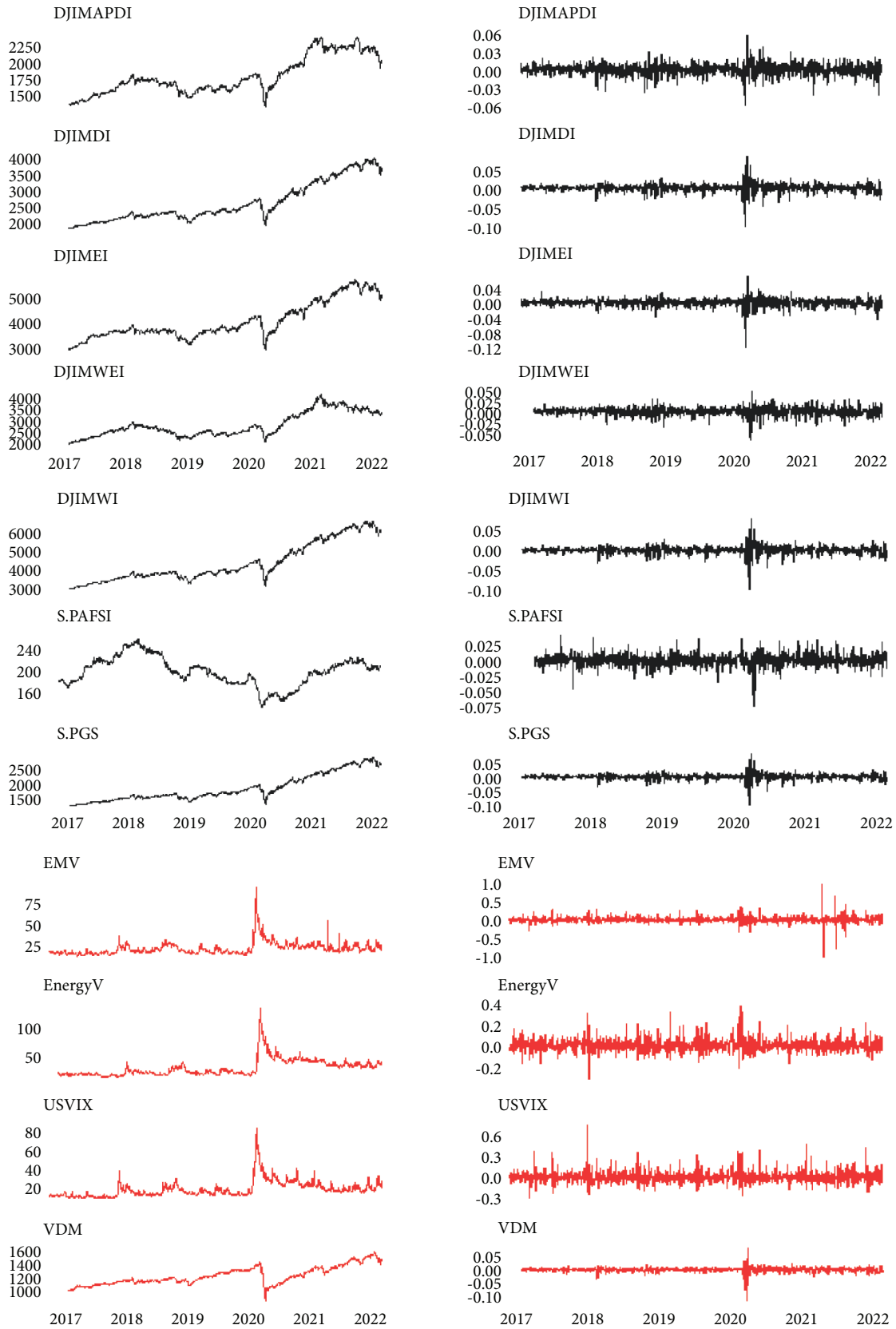


FIGURE 1: Price and returns series plots for Islamic stocks and volatility indices.

TABLE 1: Descriptive statistics.

	Mean	Median	Std. dev.	Skewness	Kurtosis	Jarque-bera	KPSS	TRS
DJIMAPDI	0.0003	0.0007	0.0097	-0.3156	6.7857	775.7587***	0.0856	12.8470***
DJIMDI	0.0006	0.0011	0.0106	-1.1688	21.4895	18292.5600***	0.0442	44.4930***
DJIMEI	0.0004	0.0010	0.0103	-1.4309	20.0821	15799.4600***	0.0509	10.8780***
DJIMWEI	0.0004	0.0008	0.0104	-0.7121	7.7362	1288.2020***	0.1061	18.3440***
DJIMWI	0.0005	0.0010	0.0102	-1.2406	21.5027	18354.7600***	0.0473	41.5920***
S_PGS	0.0006	0.0009	0.0105	-1.1214	21.1882	17687.6400***	0.0394	41.1870***
S_PAFSI	0.0001	-0.0002	0.0096	-0.3806	7.8655	1277.3060***	0.1636	1.2022
EMV	0.0002	-0.0058	0.0885	-0.0772	36.7427	59966.0800***	0.0116	159.8300***
ENERGYV	0.0005	-0.0042	0.0601	0.8925	7.1629	1080.4880***	0.0257	1.8618
USVIX	0.0007	-0.0072	0.0856	1.5055	11.4187	4210.1710***	0.0143	7.9395**
VDM	0.0003	0.0008	0.0095	-2.7244	44.8531	93818.7200***	0.0323	38.8090***

Note. *, **, and *** denote significance at 10%, 5%, and 1%, respectively.

firms around the globe to have a pivotal mandate to disclose their performance on sustainability issues while putting up a sustainable behaviour. However, since investors desire to form reliable portfolios, diversification benefits with other assets become their utmost flight to quality.

Second, the asymmetric effect of implied market volatilities which have gained significant interest from a nascent and fledgling body of academic literature is utilised in tandem with the sustainability Islamic stocks. We select four relevant implied market volatilities to integrate shocks from developed market, emerging market, the US market, and energy market. Most of these volatilities have been touted to be significant risk transmitters in several conventional assets [5, 13, 14, 18], but a few studies on Islamic stocks utilise specific or few implied volatility indices [20–22] to ensure a myopic view on the nexus. We do this to draw insights into effective portfolio reconstructions, redeployment, and rebalancing towards risk minimisation strategies.

Third, to examine the asymmetric effect of the implied market volatilities on Islamic stocks across market conditions (stress, benign, and boom) [29], the quantile regression as well as quantile-on-quantile regression techniques are employed. Moreover, the robustness of these estimates would hinge on the application of the causality in mean at various quantiles. These are presented to clearly divulge the heterogeneous [30] behaviour of markets and their participants across market conditions of stressed, normal, or boom [11, 31–34].

We found asymmetric influence of volatility on sustainable Islamic stock returns at various quantiles. Furthermore, most volatilities' asymmetric effects were negatively related to sustainable Islamic stock returns, implying diversification benefits across markets conditions. Moreover, with the exception of the extreme quantiles, there was a causal effect of implied market volatilities on Islamic stock returns at most quantiles.

The next of this section is arranged as follows. In Section 2, we present the study's methodology whereas Section 3 contains results and discussion. Section 4 concludes the study with some implications, recommendations, and suggestions for further studies.

2. Materials and Methodology

2.1. Data Sources and Description. We utilised daily data on Islamic stock indices for sustainability equities. The sustainability equities include; Dow Jones Islamic Market Asia-Pacific Developed TopCap Index (DJIMAPDI), Dow Jones Islamic Market Developed Markets Index (DJIMDI), Dow Jones Islamic Market World Emerging Markets Index (DJIMWEI), Dow Jones Islamic Market Europe Index (DJIMEI), Dow Jones Islamic Market World Index (DJIMWI), S&P Africa Frontier Shariah Index (S.PAFSI), and S&P Global 1200 Shariah (S.PGS). We utilised the seven Islamic stock indices because they are the top seven regarding market capitalisation aside meeting the interest-bearing debt threshold of 33% in accordance with the screening method of Dow Jones Sharia. This makes the indices relevant to withstand shocks and support diversification with other financial assets. All the seven indices are needed for this current study because they would provide better information on most Islamic sustainability or Sharia-compliant equities across different regional blocs to examine their susceptibility to shocks, while encouraging regional policy decisions.

Also, we used four implied volatilities to gauge investors' fear into the Islamic market. The implied volatilities are the CBOE Emerging Markets Etf Volatility (EMV), Chicago Board Exchange Volatility Index (USVIX), Dorsey Wright Developed Market Momentum and Low Volatility (VDM), and CBOE Energy Sector Etf Volatility (EnergyV). The four implied volatilities would comprehensively give us the opportunity to investigate their heterogeneous as well as asymmetric impact on the seven selected Islamic stocks for effective portfolio reconstructions, redeployment, and rebalancing towards risk minimisation strategies.

The daily data span 11th January, 2017 to 11th February, 2022, yielding up to 1264 observations. The suggested period was chosen based on the availability of consistent data at the start and the end locations. Regardless, this time period includes significant economic events such as the Brexit, crude oil price crash in history, and the COVID-19 pandemic. The data on sustainability Islamic equities were

TABLE 2: Unconditional correlation.

	DJIMAPDI	DJIMDI	DJIMEI	DJIMWEI	DJIMWI	EMV	ENERGYV	S_PAFSI	S_PGS	USVIX	VDM
DJIMAPDI	1.0000										
DJIMDI	0.4093***	1.0000									
DJIMEI	0.4726***	0.7133***	1.0000								
DJIMWEI	0.5780***	0.5859***	0.5884***	1.0000							
DJIMWI	0.4416***	0.9966***	0.7277***	0.6504***	1.0000						
EMV	-0.1278***	-0.5228***	-0.3953***	-0.3837***	-0.5287***	1.0000					
ENERGYV	-0.1841***	-0.6476***	-0.4816***	-0.4101***	-0.6487***	0.5818**	1.0000				
S_PAFSI	0.1460***	0.1570***	0.1730***	0.1264***	0.1595***	-0.0799***	-0.0697**	1.0000			
S_PGS	0.3982***	0.9950***	0.7056***	0.6002***	0.9935***	-0.5272***	-0.6512***	0.1505***	1.0000		
USVIX	-0.1070***	-0.6844***	-0.4293***	-0.3583***	-0.6778***	0.6085***	0.7346***	-0.0787**	-0.6857***	1.0000	
VDM	0.4711***	0.7963***	0.7250***	0.5166***	0.7989***	-0.3946***	-0.4650***	0.1760***	0.7940***	-0.4617***	1.0000

Note. *, **, and *** denote significance at 10%, 5%, and 1%, respectively.

TABLE 3: Effect of volatilities on DJIMAPDI.

Quantiles	EMV	EnergyV	USVIX	VDM
0.05	-0.01575**	-0.02528***	-0.01011*	0.45535***
0.1	-0.01575**	-0.02528***	-0.01011**	0.47681***
0.15	-0.01575**	-0.02528***	-0.01011*	0.49609***
0.2	-0.01575**	-0.02528***	-0.01011**	0.49959***
0.25	-0.01575***	-0.02511***	-0.01011**	0.49959***
0.3	-0.01575***	-0.02511***	-0.01011***	0.49959***
0.35	-0.01575***	-0.02488***	-0.01011**	0.49959***
0.4	-0.01575***	-0.02488***	-0.01010**	0.49959***
0.45	-0.01575***	-0.02360***	-0.00920**	0.49959***
0.5	-0.01547***	-0.02360***	-0.00919**	0.49959***
0.55	-0.01547***	-0.02360***	-0.00919**	0.50519***
0.6	-0.01547***	-0.02302***	-0.00882**	0.51174***
0.65	-0.01547***	-0.02302***	-0.00882**	0.51951***
0.7	-0.01531***	-0.02302***	-0.00867*	0.52677***
0.75	-0.01531**	-0.02289***	-0.00867*	0.52831***
0.8	-0.01531**	-0.02289***	-0.00867*	0.52831***
0.85	-0.01531**	-0.02230***	-0.00832*	0.52831***
0.9	-0.01512**	-0.02230***	-0.00832*	0.52831***
0.95	-0.01512**	-0.02228***	-0.00832*	0.52831***

Note. *, **, and *** denote significance at 10%, 5%, and 1%, respectively.

TABLE 4: Effect of volatilities on DJIMDI.

Quantiles	EMV	EnergyV	USVIX	VDM
0.05	-0.06962***	-0.09963***	-0.07320***	0.88387***
0.1	-0.06962***	-0.09963***	-0.07320***	0.89498***
0.15	-0.06962***	-0.09963***	-0.07320***	0.89498***
0.2	-0.06926***	-0.09953***	-0.0730***	0.90393***
0.25	-0.06926***	-0.09937***	-0.07300***	0.90456***
0.3	-0.06926***	-0.09937***	-0.07289***	0.90823***
0.35	-0.06926***	-0.09924***	-0.07237***	0.91512***
0.4	-0.06926***	-0.09918***	-0.07237***	0.92651***
0.45	-0.06926***	-0.09918***	-0.07232***	0.93149***
0.5	-0.06926***	-0.09918***	-0.07210***	0.93149***
0.55	-0.06916***	-0.09918***	-0.07210***	0.93704***
0.6	-0.06916***	-0.09918***	-0.07210***	0.94197***
0.65	-0.06913***	-0.09918***	-0.07208***	0.94499***
0.7	-0.06913***	-0.09918***	-0.07208***	0.94505***
0.75	-0.06807***	-0.09843***	-0.07208***	0.94750***
0.8	-0.06786***	-0.09843***	-0.07208***	0.94925***
0.85	-0.06786***	-0.09830***	-0.07179***	0.95253***
0.9	-0.06786***	-0.09795***	-0.07179***	0.95336***
0.95	-0.06786***	-0.09795***	-0.07179***	0.95336***

Note. *, **, and *** denote significance at 10%, 5%, and 1%, respectively.

obtained from RobecoSAM database. The volatility indices were obtained from investing.com. We utilised the natural logarithmic returns for each market indices.

2.2. Quantile-on-Quantile Regression (QQR). The conditional quantile link between two or more variables is empirically justified using the QQR technique, which is a non-parametric variant of the traditional quantile regression (QR). The QQR is suited for studying bearish and/or bullish interrelations between the returns on Islamic stocks and

volatility indices since quantiles can express asymmetry among high and low logarithmic price patterns. We show susceptibility of the Islamic stocks to volatility indices which are non-parametrically expressed as

$$SR_t = \beta^\theta (VI_t) + u_t^\theta, \quad (1)$$

where SR_t and VI_t respectively, represent the returns of Islamic stock and volatility indices at period t , $\beta^\theta(\bullet)$ is the slope of the connection between the two assets at any

TABLE 5: Effect of volatilities on DJIMEI.

Quantiles	EMV	EnergyV	USVIX	VDM
0.05	-0.04915***	-0.07023***	-0.04680***	0.83735***
0.1	-0.04915***	-0.07023***	-0.04680***	0.83735***
0.15	-0.04915***	-0.07016***	-0.04637***	0.84321***
0.2	-0.04915***	-0.07016***	-0.04637***	0.84402***
0.25	-0.04915***	-0.07016***	-0.04634***	0.86153***
0.3	-0.04915***	-0.06983***	-0.04582***	0.86656***
0.35	-0.04915***	-0.06957***	-0.04582***	0.86656***
0.4	-0.04915***	-0.06957***	-0.04562***	0.86656***
0.45	-0.04915***	-0.06957***	-0.04552***	0.86656***
0.5	-0.04915***	-0.06957***	-0.04552***	0.86656***
0.55	-0.04915***	-0.06957***	-0.04464***	0.86824***
0.6	-0.04915***	-0.06957***	-0.04442***	0.88414***
0.65	-0.04915***	-0.06927***	-0.04397***	0.88484***
0.7	-0.04915***	-0.06926***	-0.04397***	0.89459***
0.75	-0.04915***	-0.06926***	-0.04397***	0.90442***
0.8	-0.04886***	-0.06895***	-0.04347***	0.90672***
0.85	-0.04847***	-0.06895***	-0.04347***	0.91555***
0.9	-0.04847***	-0.06895***	-0.04347***	0.92350***
0.95	-0.04847***	-0.06895***	-0.04334***	0.92755***

Note. *, **, and *** denote significance at 10%, 5%, and 1%, respectively.

TABLE 6: Effect of volatilities on DJIMWEI.

Quantiles	EMV	EnergyV	USVIX	VDM
0.05	-0.05836***	-0.05987***	-0.03758***	0.55451***
0.1	-0.05836***	-0.05963***	-0.03747***	0.55451***
0.15	-0.05834***	-0.05963***	-0.03667***	0.55556***
0.2	-0.05834***	-0.05917***	-0.03667***	0.55675***
0.25	-0.05834***	-0.05790***	-0.03664***	0.55675***
0.3	-0.05830***	-0.0579***	-0.03651***	0.57460***
0.35	-0.05830***	-0.05726***	-0.03651***	0.58527***
0.4	-0.05830***	-0.05726***	-0.03651***	0.59868***
0.45	-0.05811***	-0.05726***	-0.03616***	0.59868***
0.5	-0.05811***	-0.05582***	-0.03616***	0.59868***
0.55	-0.05811***	-0.05582***	-0.03592***	0.59868***
0.6	-0.05811***	-0.05511***	-0.03552***	0.60408***
0.65	-0.05811***	-0.05479***	-0.03503***	0.60544***
0.7	-0.05811***	-0.05404***	-0.03452***	0.60544***
0.75	-0.05811***	-0.05384***	-0.03415***	0.60544***
0.8	-0.05811***	-0.05384***	-0.03413***	0.60609***
0.85	-0.05811***	-0.05384***	-0.03365***	0.60609***
0.9	-0.05811***	-0.05384***	-0.03365***	0.60609***
0.95	-0.05811***	-0.05384***	-0.03363***	0.60609***

Note. *, **, and *** denote significance at 10%, 5%, and 1%, respectively.

conditional level, the θ th quantile of SR_t in equation (1) that is conditionally distributed is denoted by θ , and u_t^θ is the quantile in error which is made to have a θ th conditional quantile.

By a first-order Taylor approximation of a quantile of SR^τ equations (1) is expanded to yield equation (2) as follows:

$$\beta^\theta(SR_t) \approx \beta^\theta(VI^\tau) + \beta^{\theta'}(VI^\tau)(VI_T - VI^\tau), \quad (2)$$

where the partial derivative of $\beta^\theta(SR^\tau)$ is explained by $\beta^{\theta'}$, representative of a marginal effect as the slope. It is depicted that θ is the functional illustration of $\beta^\theta(SR^\tau)$ and $\beta^{\theta'}(VI^\tau)$, from equation (1), while τ is the functional illustration of VI and VI^τ also in respect of equation (2). Therefore, θ and τ are the functional representations of $\beta^\theta(VI^\tau)$ and $\beta^{\theta'}(VI^\tau)$, is for equation (2). By substituting each of $\beta^\theta(VI^\tau)$ and $\beta^{\theta'}(VI^\tau)$ from equation (2) for $\beta_0(\theta, \tau)$ and $\beta_1(\theta, \tau)$ we deduce equation (3) as

TABLE 7: Effect of volatilities on DJIMWI.

Quantiles	EMV	EnergyV	USVIX	VDM
0.05	-0.06769***	-0.09822***	-0.07147***	0.85924***
0.1	-0.06769***	-0.09802***	-0.07146***	0.86302***
0.15	-0.06769***	-0.09802***	-0.07146***	0.86791***
0.2	-0.06769***	-0.09802***	-0.07146***	0.87351***
0.25	-0.06769***	-0.09802***	-0.07130***	0.87520***
0.3	-0.06733***	-0.09802***	-0.07094***	0.88179***
0.35	-0.06733***	-0.09637***	-0.07094***	0.88179***
0.4	-0.06712***	-0.09637***	-0.07071***	0.88208***
0.45	-0.06712***	-0.09637***	-0.07071***	0.88565***
0.5	-0.06712***	-0.09628***	-0.07061***	0.88935***
0.55	-0.06708***	-0.09628***	-0.07009***	0.90236***
0.6	-0.06708***	-0.09586***	-0.07009***	0.90901***
0.65	-0.06708***	-0.09586***	-0.06969***	0.91342***
0.7	-0.06708***	-0.09568***	-0.06962***	0.91669***
0.75	-0.06708***	-0.09568***	-0.06962***	0.91669***
0.8	-0.06708***	-0.09568***	-0.06927***	0.91729***
0.85	-0.06708***	-0.09568***	-0.06896***	0.91848***
0.9	-0.06703***	-0.09553***	-0.06896***	0.92212***
0.95	-0.06703***	-0.09553***	-0.06894***	0.92212***

Note. *, **, and *** denote significance at 10%, 5%, and 1%, respectively.

TABLE 8: Effect of volatilities on S.PAFSI.

Quantiles	EMV	EnergyV	USVIX	VDM
0.05	-0.00658	-0.01063*	-0.00710*	0.07300
0.1	-0.00658	-0.01063*	-0.00710**	0.07300
0.15	-0.00632	-0.01063*	-0.00710*	0.07660
0.2	-0.00605	-0.01049*	-0.00683**	0.09160*
0.25	-0.00605	-0.01049**	-0.00674**	0.09160**
0.3	-0.00605	-0.01049**	-0.00674*	0.09958**
0.35	-0.00601*	-0.01049**	-0.00674**	0.10170**
0.4	-0.00601*	-0.01049**	-0.00674**	0.10275**
0.45	-0.00601*	-0.00989**	-0.00657*	0.10794***
0.5	-0.00601*	-0.00938**	-0.00657**	0.12050***
0.55	-0.00601*	-0.00926**	-0.00627*	0.12050***
0.6	-0.00601*	-0.00895**	-0.00627*	0.12050***
0.65	-0.00601*	-0.00895**	-0.00627**	0.12050***
0.7	-0.00601	-0.00888*	-0.00627*	0.12050***
0.75	-0.00601	-0.00885*	-0.00627*	0.12050***
0.8	-0.00601	-0.00885*	-0.00627*	0.12261***
0.85	-0.00601	-0.00885*	-0.00574	0.12856***
0.9	-0.00601	-0.00856	-0.00544	0.14270***
0.95	-0.00601	-0.00856	-0.00544	0.14475***

Note. *, **, and *** denote significance at 10%, 5%, and 1%, respectively.

$$\beta^\theta(SR_t) \approx \beta_0(\theta, \tau) + \beta_1(\theta, \tau)(VI_T - VI^\tau). \quad (3)$$

Equation (2) can now be substituted into equation (1) to arrive at equation (4) as

$$SR_t = \beta_0(\theta, \tau) + \beta_1 \left(\frac{\theta}{(*)}, \tau \right) (VI_T - VI^\tau) + u_t^\theta, \quad (4)$$

where $(*)$ yields the conditional quantile of θth of returns on VI in equation (4). It additionally portrays the true

susceptibility of the $SR(\tau th)$ to shocks from the quantile of the $VI(\theta th)$ in respect of equation (4), of the parameters β_0 and β_1 with indices represented by θ and τ .

Similar to the case of OLS, we apply an analogous minimisation to produce the following equation

$$\min_{b_0, b_1} \sum_{i=1}^n \rho_\theta [SR_t - b_0 - b_1(\widehat{VI}_t - \widehat{VI}^\tau)] K \left(\frac{F_n(\widehat{VI}_t) - \tau}{h} \right), \quad (5)$$

where the quantile loss function, $\rho_\theta(u)$, is represented as $\rho_\theta(u) = u(\theta - I(u < 0))$, i is the function of indicator, the

TABLE 9: Effect of volatilities on S.PGS.

Quantiles	EMV	EnergyV	USVIX	VDM
0.05	-0.06820***	-0.10178***	-0.07244***	-0.07244***
0.1	-0.06820***	-0.10178***	-0.07244***	-0.07244***
0.15	-0.06769***	-0.10178***	-0.07244***	-0.07244***
0.2	-0.06769***	-0.10148***	-0.07243***	-0.07243***
0.25	-0.06769***	-0.10148***	-0.07241***	-0.07241***
0.3	-0.06769***	-0.10148***	-0.07234***	-0.07234***
0.35	-0.06769***	-0.10148***	-0.07176***	-0.07176***
0.4	-0.06769***	-0.10148***	-0.07176***	-0.07176***
0.45	-0.06769***	-0.10148***	-0.07176***	-0.07176***
0.5	-0.06769***	-0.10119***	-0.07176***	-0.07176***
0.55	-0.06769***	-0.10075***	-0.07175***	-0.07175***
0.6	-0.06705***	-0.10075***	-0.07172***	-0.07172***
0.65	-0.06705***	-0.10053***	-0.07172***	-0.07172***
0.7	-0.06705***	-0.10028***	-0.07165***	-0.07165***
0.75	-0.06705***	0.09946***	-0.07165***	-0.07165***
0.8	-0.06705***	0.09946***	-0.07164***	-0.07164***
0.85	-0.06705***	0.09946***	-0.07164***	-0.07164***
0.9	-0.06702***	0.09946***	-0.07164***	-0.07164***
0.95	-0.06702***	0.09946***	-0.07164***	-0.07164***

Note. *, **, and *** denote significance at 10%, 5%, and 1%, respectively.

kernel density function (KDF) is denoted as $K(\bullet)$, and h is the bandwidth parameter of the KDF. The observations of VI^t is weighted by the KDF where the minimal weights are inversely connected to the distribution of \widehat{VI}_t in the form of $F_n(\widehat{VI}_t) = (1/n) \sum_{k=1}^n I(\widehat{VI}_k < \widehat{VI}_t)$.

Following the specifications of Sim and Zhou [35], the bandwidth for the quantiles we employ in this study for the QQ breakdown is defined as $h = [0.05 \text{ to } 0.95]$. The smoothness of the estimated results is contingent on the bandwidth, which represents the divisions of the quantiles. Smaller bandwidths are recommended over larger bandwidths because larger bandwidths may lead to biased estimates of the coefficients.

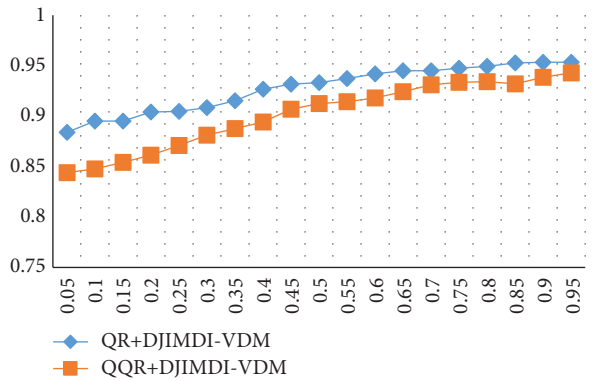
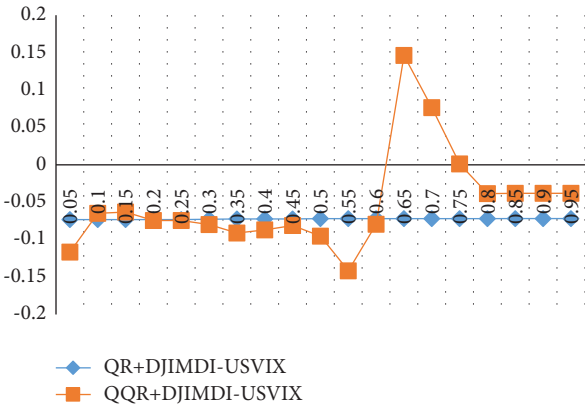
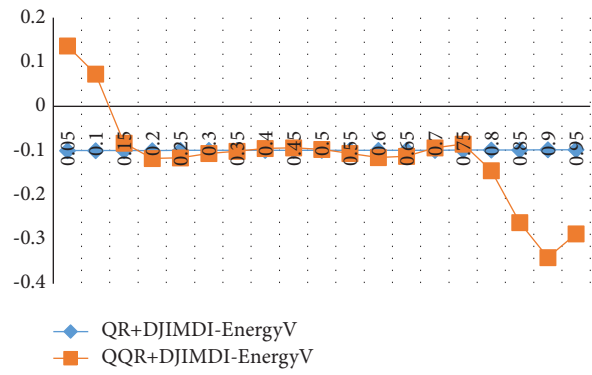
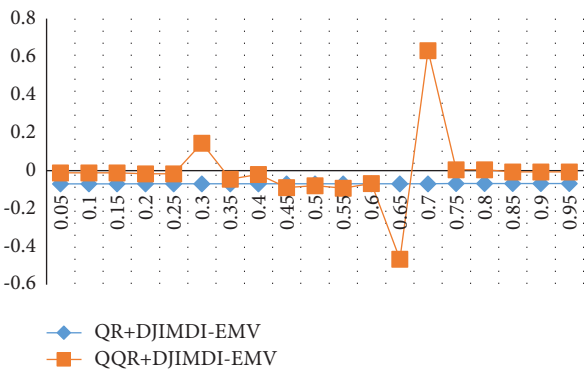
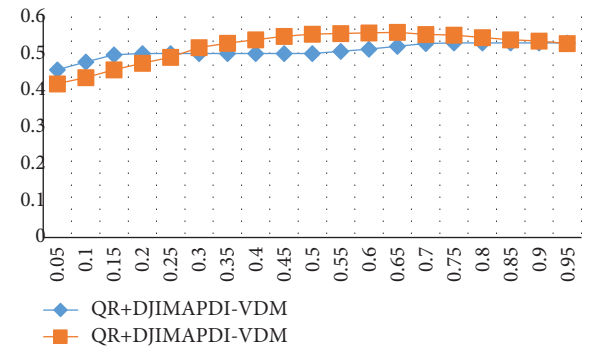
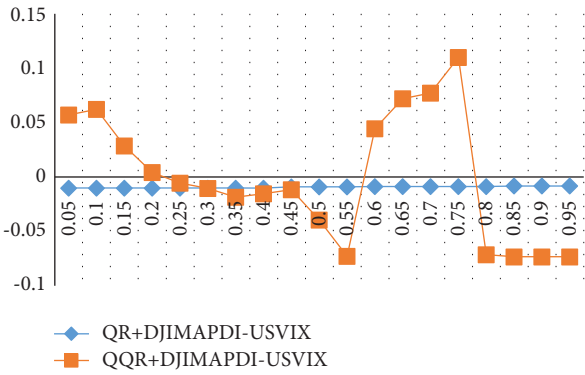
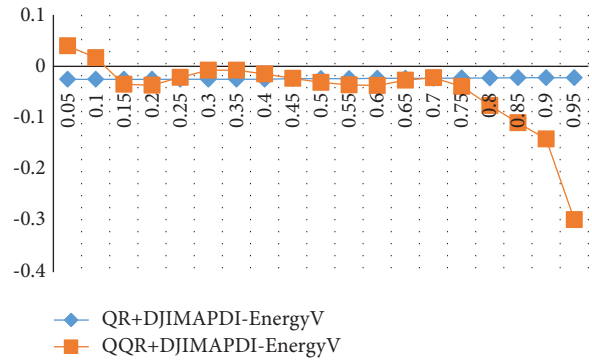
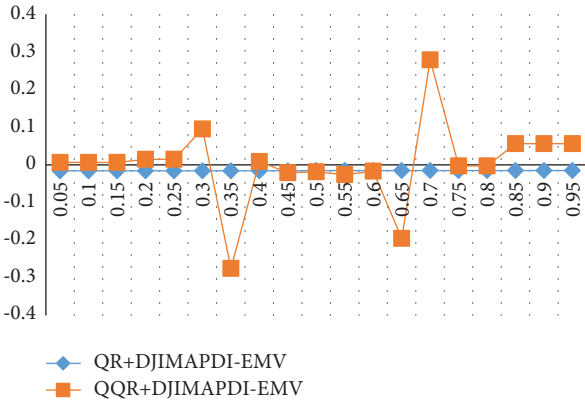
3. Results and Discussion

3.1. Preliminary Analysis. The time series plots of both price and returns for sustainable Islamic stocks (in black) and volatility indices (in red) are presented in Figure 1. Most of the Islamic stocks trend upwards prior to mid-2020, plunge in the mid-2020, and skyrocketed afterwards. It can be observed that markets rebound after the COVID-19 pandemic, demonstrating high market performance, supersede that of prior to the pandemic. Accordingly, we find prospects of extreme markets rebound after the onset of a shock within the sustainable Islamic stock markets. Conversely, except for the developed market volatility index, the remaining volatility indices are inversely related to the Islamic stock market, indicating a potential hotspot for portfolio diversification, hedge, or safe haven. Also, the plunge in prices at the COVID-19 pandemic is shown as shocks in the returns plots of the sustainability Islamic stocks. Generally, all the returns series exhibit volatility clustering.

We present Table 1 to examine the behaviour of individual financial time series over the sampled period. It can be seen that all the variables have positive mean suggesting potential for increased market performance. Also, there are fewer variations in the data and tendency for more negative values than higher values in addition to a leptokurtic distribution. We confirm that the data distribution of all financial time series demonstrates non-normality from the Jarque-Bera statistics.

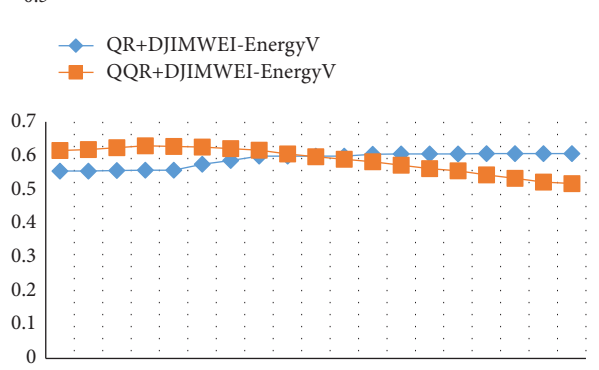
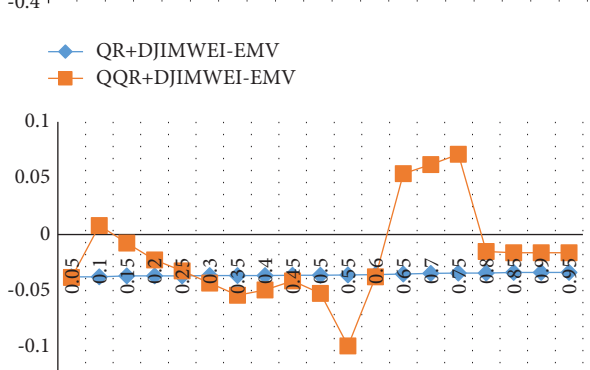
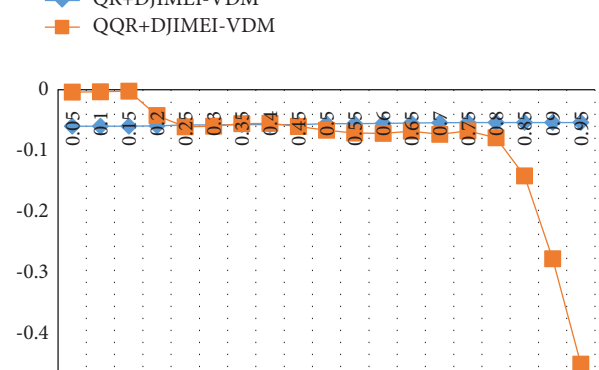
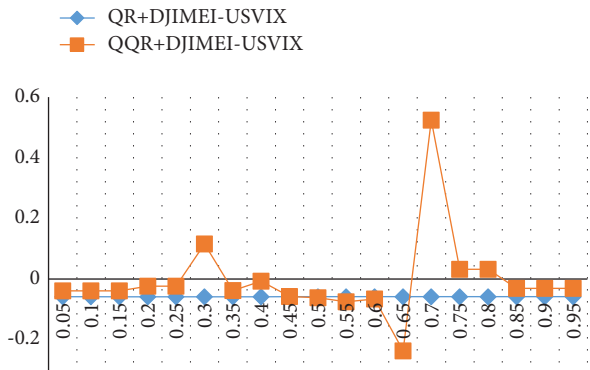
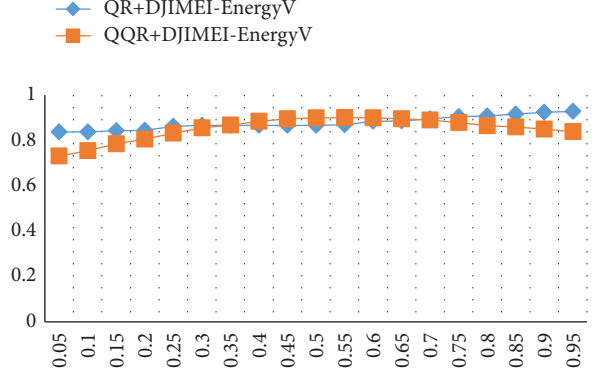
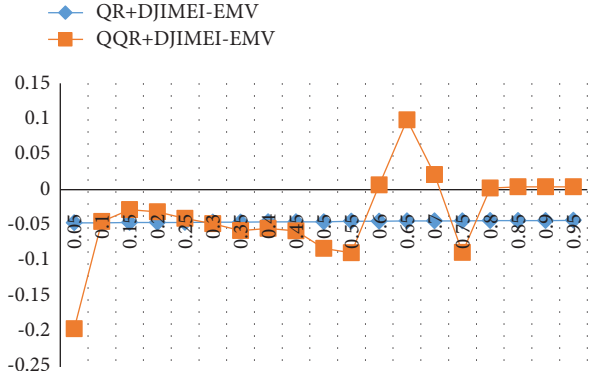
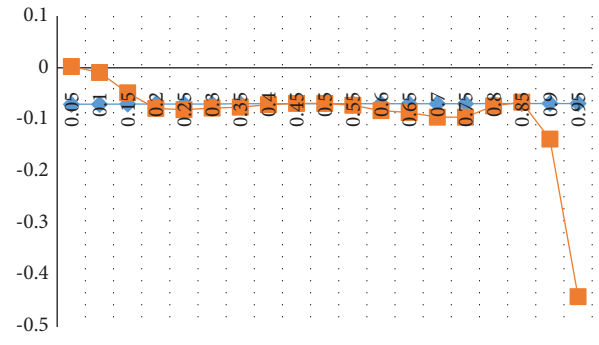
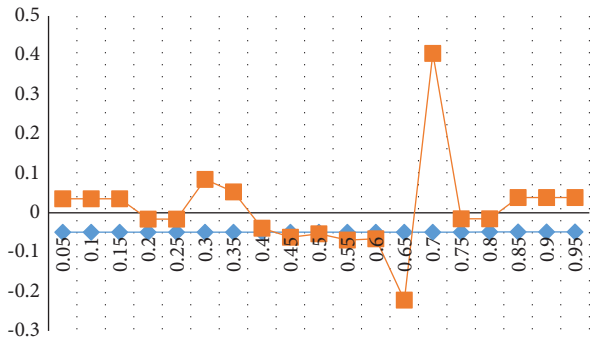
Additionally, we observe from the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test that all the returns series are stationary with a failure to reject the null hypothesis of stationarity (p -value > 0.05). However, since all the returns series are not normally distributed, it accentuates the relevance of employing an asymmetric statistical tool capable of revealing relationships across market situations. In assessing the linearity of the financial time series, the Teraesvirta's Neural Network (TRS) test with a null hypothesis of linearity is employed. The TRS test suggests that the original returns series are nonlinear (p -value < 0.05). This further addresses the need for employing the QQR technique which is able to effectively deal with issues of asymmetry and nonlinearity relative to the traditional QR and OLS (see, e.g., [36] and references therein).

Moreover, the unconditional correlation coefficients between two time series are shown in Table 2. It is clear that the correlation of all the financial time series are almost significant at the 1% level. We notice a mixture of positive and negative correlations ranging from small to large magnitudes. The negative relationships between the variables have high likelihood for diversification, and this can be found between the Islamic stock returns and most of the volatility indices. This implies that portfolio diversification



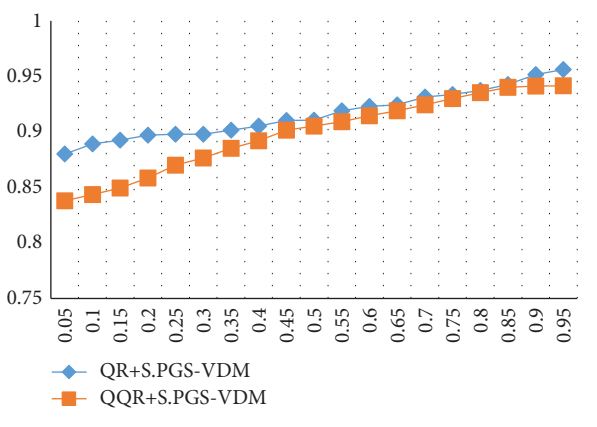
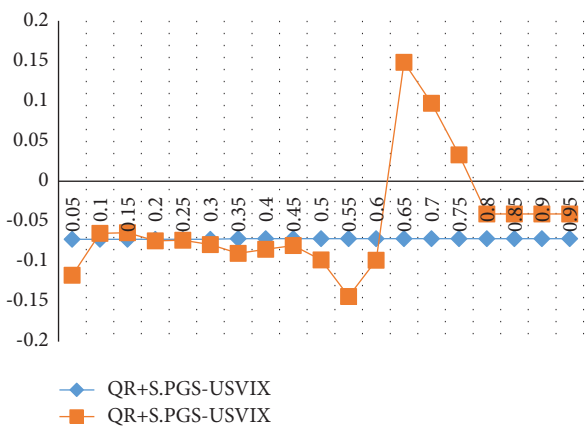
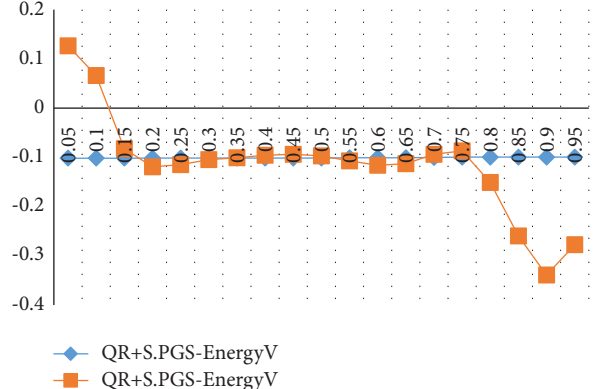
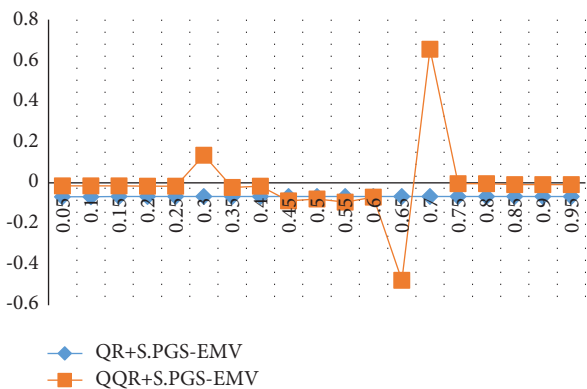
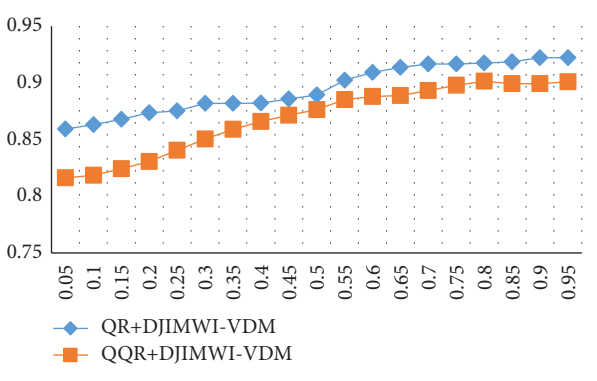
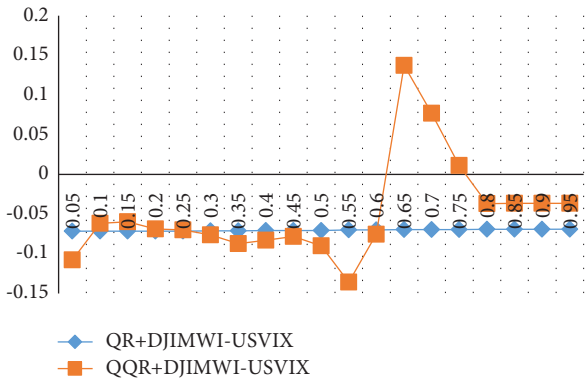
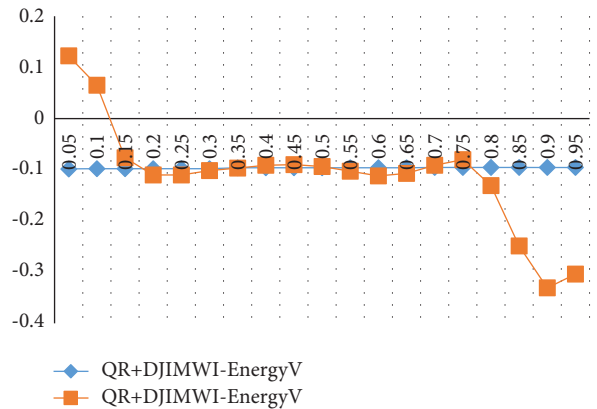
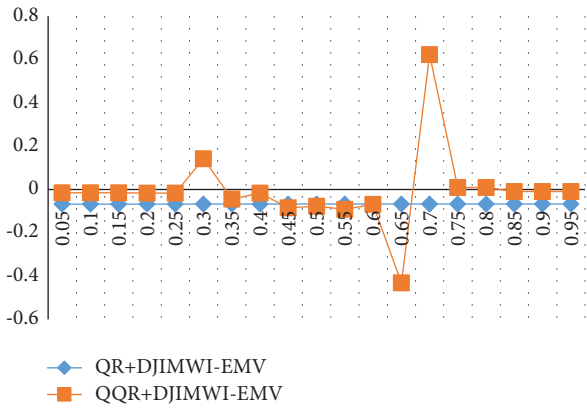
(a)

FIGURE 2: Continued.



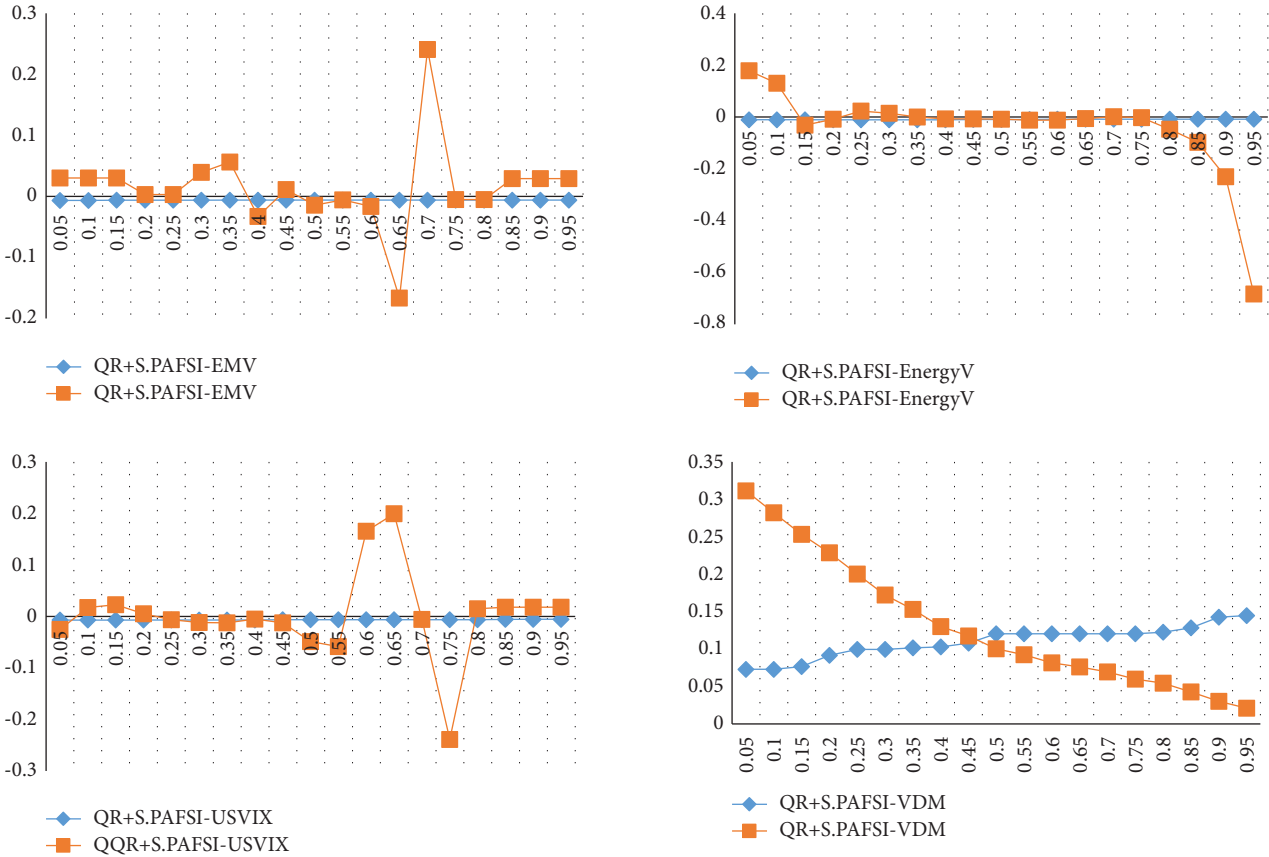
(b)

FIGURE 2: Continued.



(c)

FIGURE 2: Continued.



(d)

FIGURE 2: Comparison plots of QR and QQR.

among the sustainability Islamic stocks would do more harm than good to potential investors.

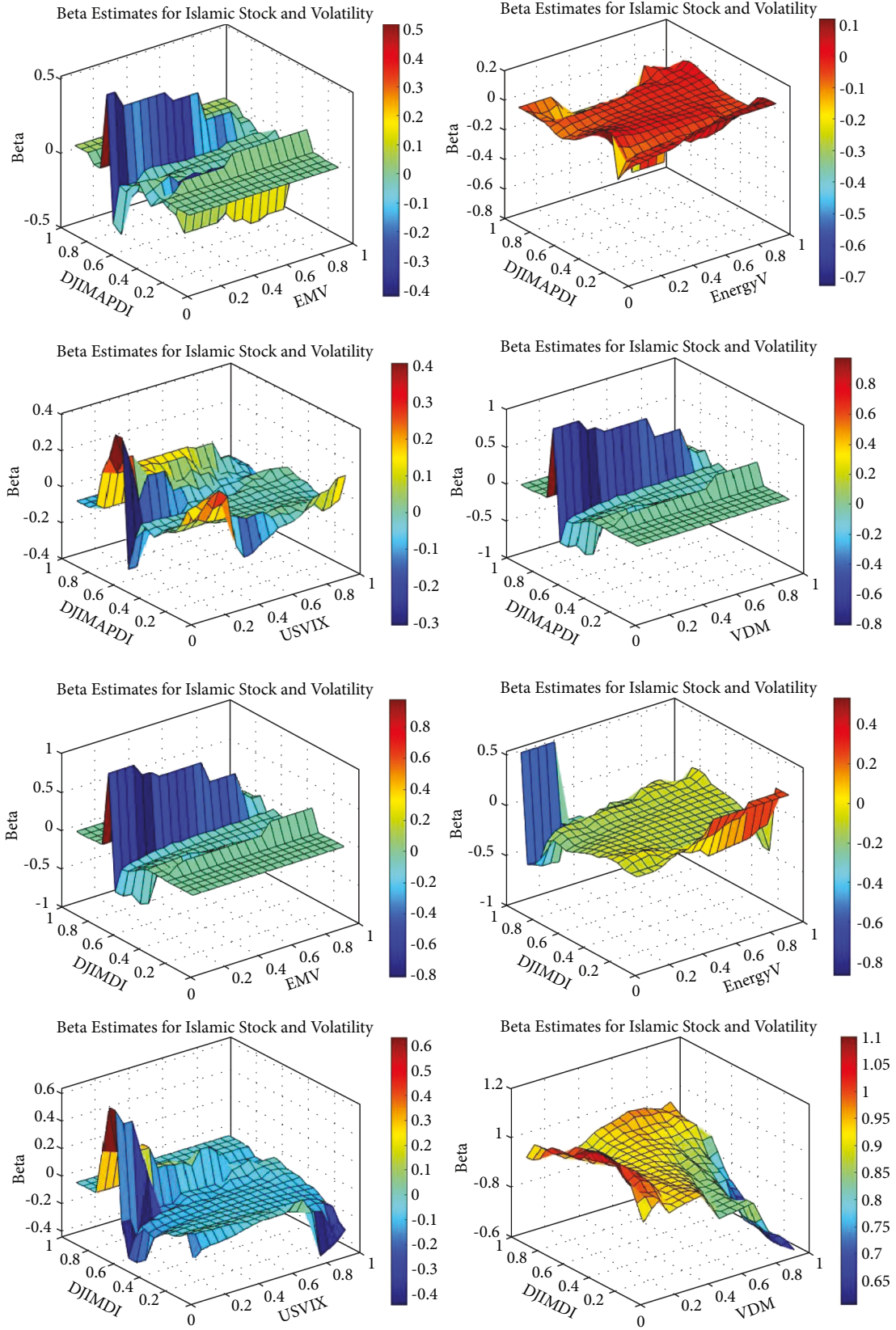
3.2. *Quantile Regression.* Tables 3–9 present the asymmetric effect of implied market volatilities on sustainable Islamic equities. We find a significant effect of implied market volatilities on Islamic stock returns across quantiles at varying levels of significance. The susceptibilities of Islamic stock returns to market volatilities across market conditions (stressed, benign, and boom) are mostly negative, except for volatilities from developed markets. Surprising, the effect of developed market volatilities on Islamic stocks have large magnitude, and considered to be positive except for S.PGS from Table 9. The similar asymmetric coefficients at most markets conditions demonstrate the persistence of Islamic stocks to external shocks. This explains that it takes a while for Islamic stocks to respond to changes in shocks from external shocks.

Comparatively, all volatility indices but developed market volatility demonstrate reduction in magnitudes from the lower quantile to the upper quantile. Suggesting that negative shocks are more prominent at stressed market outcome, whereas positive shocks are stronger at market boom for all Islamic equities. It can therefore be concluded that most sustainable Islamic stocks are vulnerable to implied market volatilities.

This is partly in line with the assertion made by Haddad et al. [23] that Islamic equities are susceptible to international shocks. The significant negative effect of implied volatility from the energy market concurs with the findings of Karim and Masih [20] and Lin and Su [21]. Conversely, Lin and Su [21] found that negative shocks between implied volatility from crude oil and Islamic stocks are more prominent at higher quantiles. Moreover, outcomes generated from the current study do not absolutely deviate from the ones generated by prior studies on conventional assets as well as commodities [5, 13, 14, 18].

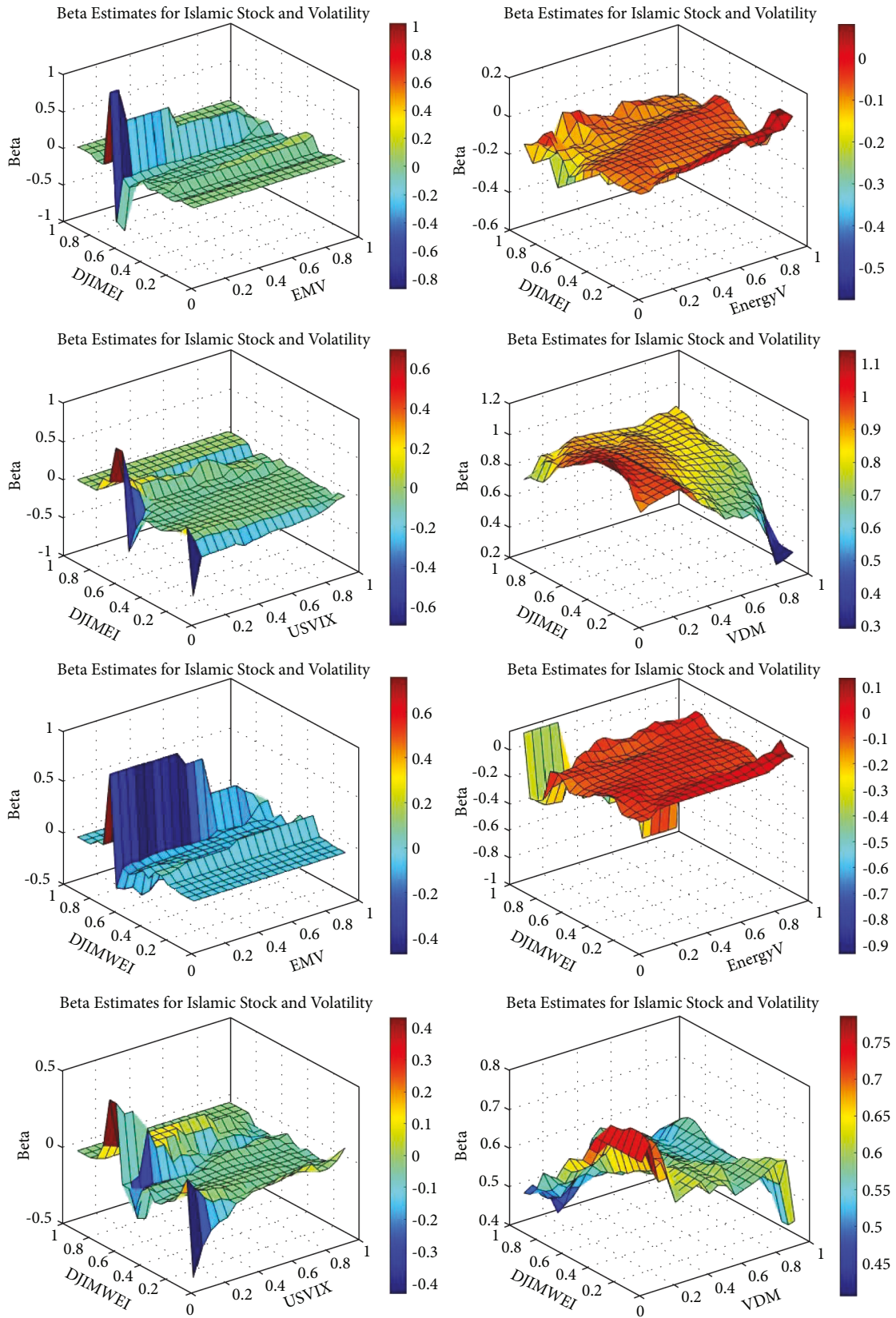
It is relevant that investors of Islamic stocks form a well diversifiable portfolio with market volatilities. Also, existing investors of sustainable Islamic stocks should hedge against fluctuations in Islamic stocks having in mind the behaviour of market volatilities or redistribute their existing Islamic stock portfolios.

3.3. *QQR and QR Comparison.* In this section, we investigate the relevance for a non-parametric asymmetric distribution among the sustainable Islamic stock returns and volatilities returns. It also gives the opportunity to infer how significant the QQR estimates are, having the knowledge of the QR estimates. Figure 2 presents the combined plots for both QQR and QR. A look at Figure 1 indicates that although



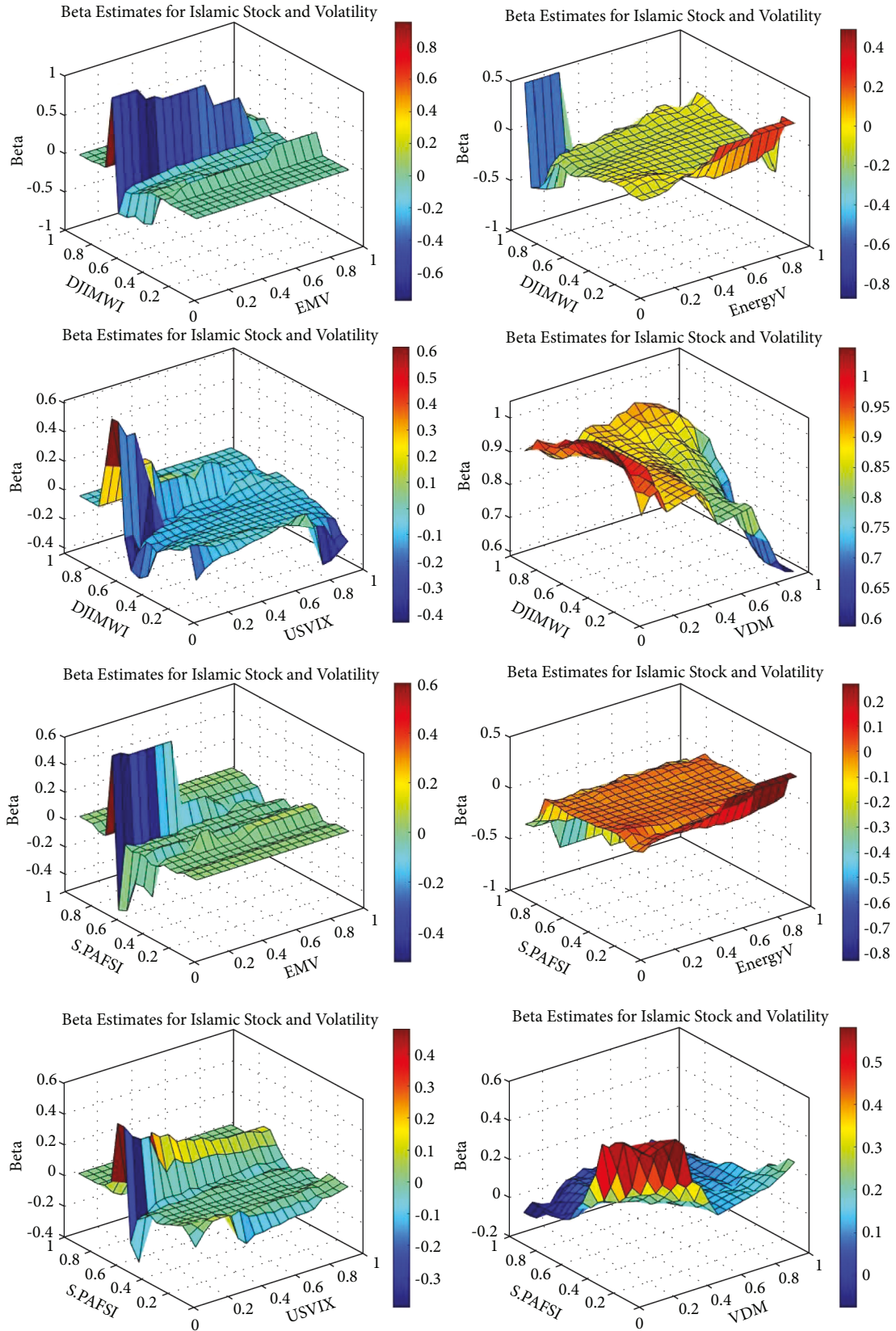
(a)

FIGURE 3: Continued.



(b)

FIGURE 3: Continued.



(c)

FIGURE 3: Continued.

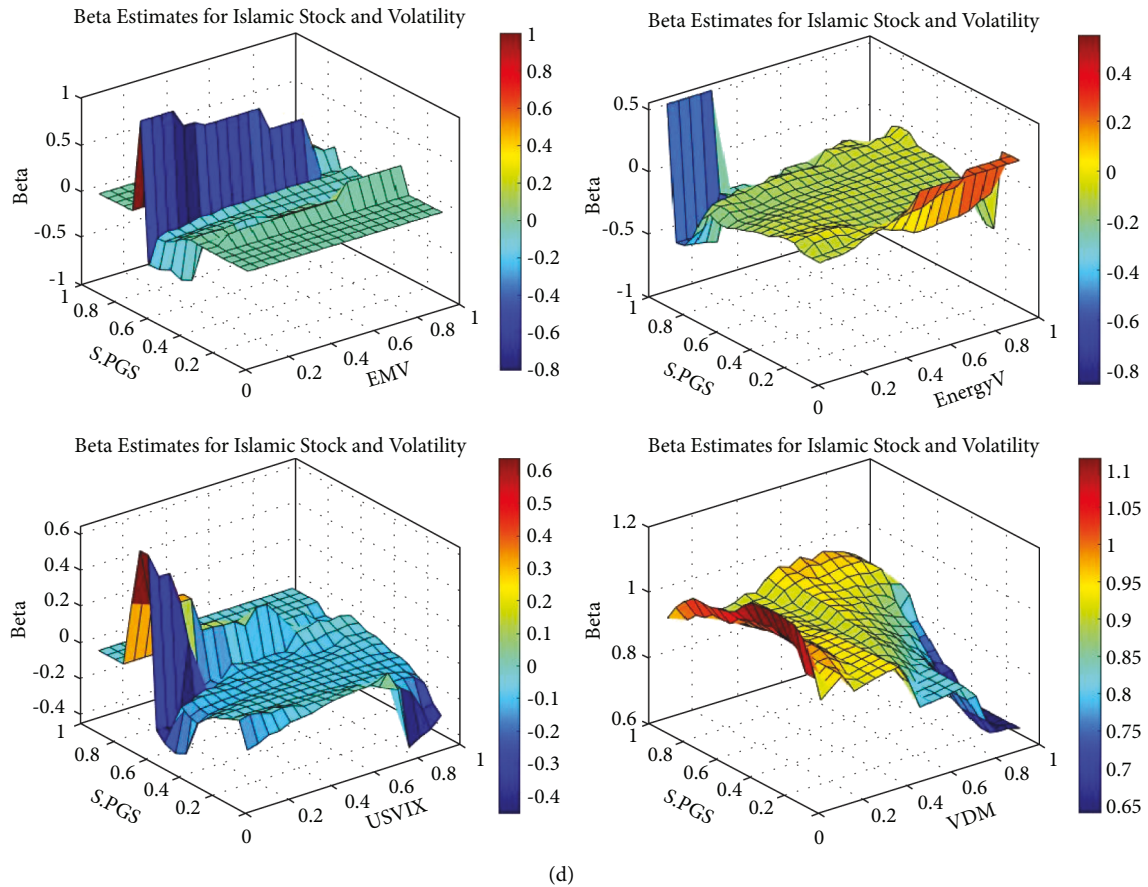


FIGURE 3: QQR plots for Islamic stocks and volatility indices.

most of the QQR estimates are not mirror images of the QR estimates, they are a little closer to each other. The reason why the line graphs are not mirror images of each other could be due to the presence of different information contained in the asymmetric distributions of both Islamic and implied volatilities simultaneously as addressed by the QQR alone (see [21, 27, 28]). Nonetheless, to some extent, the line graphs confirm the QQR except for the extreme quantiles of most relationships.

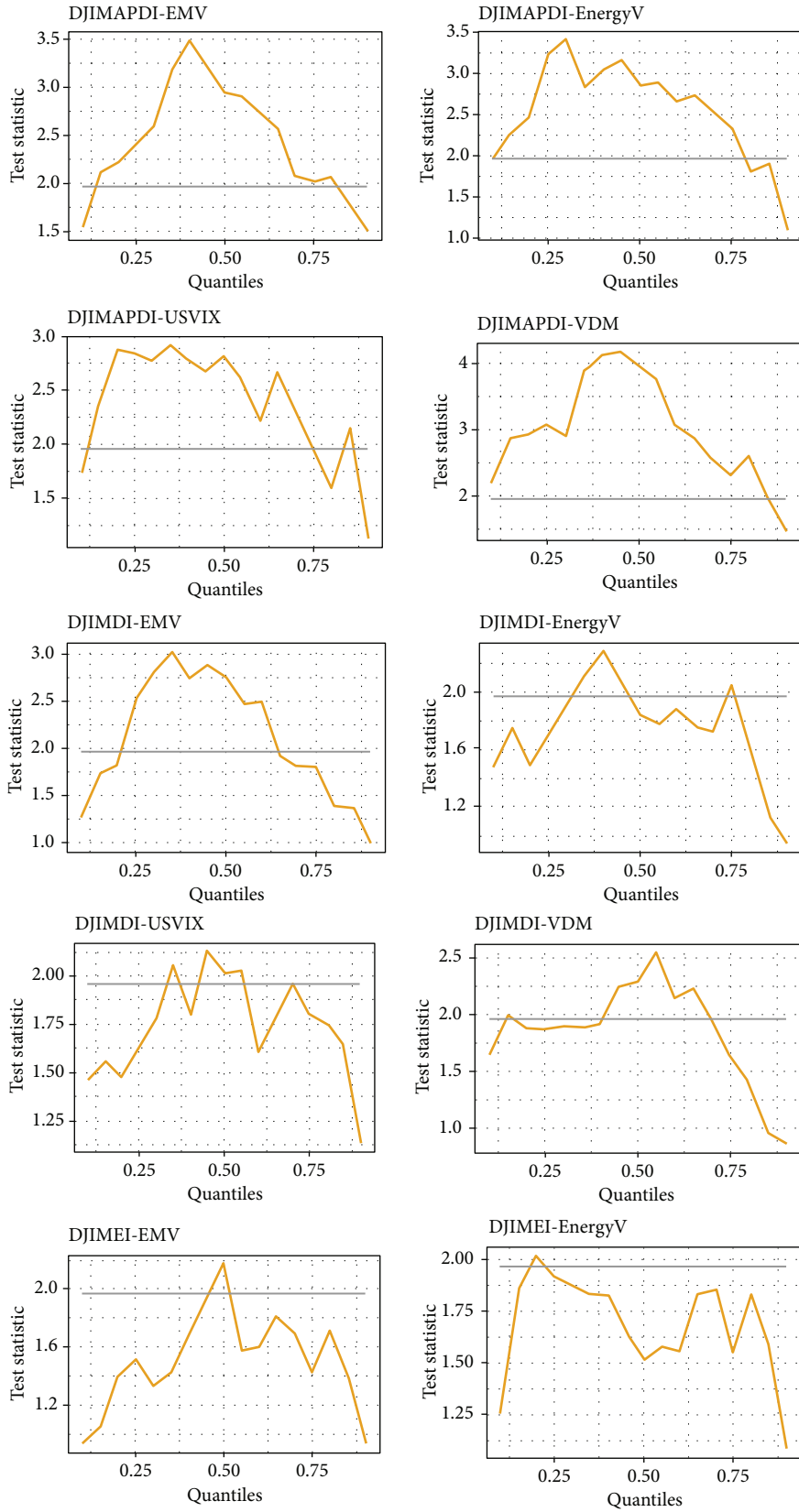
It is worth noting that relative to the QR, the QQR projects a better view of the asymmetric linkages among the dependent and independent variables at varied quantiles of both variables. Hence, given that majority of the QQR estimates are confirmed by their QR counterparts, we emphasise the relevance of the chosen methodological framework. We present the three-dimensional QQR estimates in the next subsection to further address the asymmetric and nonlinear dynamics of the employed financial time series.

3.4. Quantile-on-Quantile Regression. The three-dimensional asymmetric dependent nexus among Islamic stock returns and implied market volatilities is shown in Figure 3. It can be observed that lower values leading to negative

values relative to higher ones are persistent with emerging market volatility and the US VIX. This implies that considering the quantile dependence structure of both Islamic stocks and implied market volatilities, it is better to diversify with the emerging market volatility and the US VIX. Accordingly, having in mind of the quantile dependence structure of the possible combinations of this study, portfolio rebalancing or redeployment is pertinent with volatilities from the energy and developed markets.

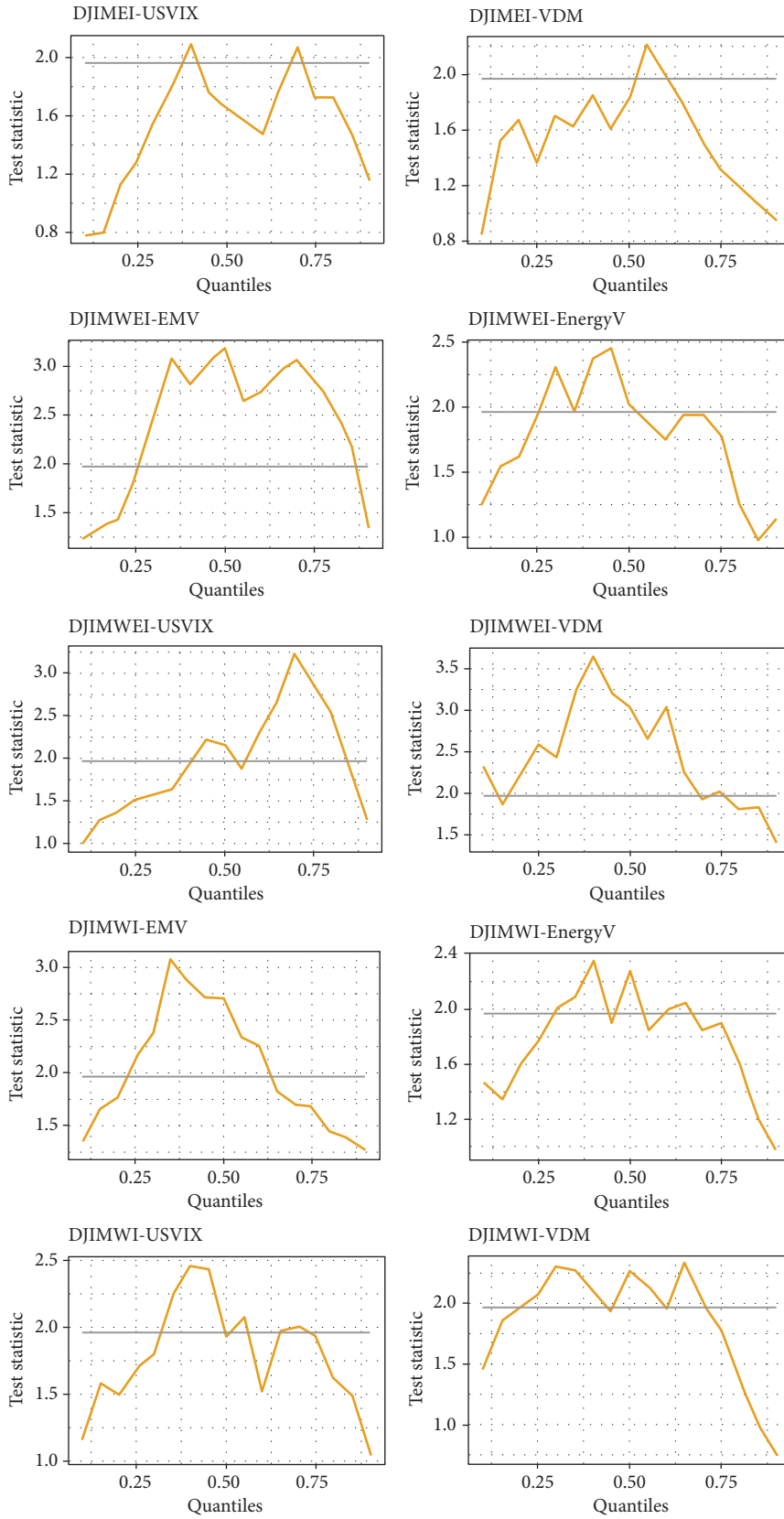
3.5. Robustness. The causality in mean, as proposed by Jeong et al. [37] and advanced by Balcilar et al. [38] is employed in this study to confirm if sustainability Islamic stock returns are significantly driven by volatilities at varying levels of market conditions. Prior empirical research investigating the resilience of quantile regression has used this approach (see [13, 39]).

Figure 4 shows that, with the exception of the S&P Africa Frontier Shariah Index, volatility indexes have a strong causal impact on sustainable Islamic stock returns. From the lower mid quantiles to the upper mid quantiles, the causation grows stronger. This means that typical market outcomes influence causal estimates for our quantile regression model more than market stress and boom.



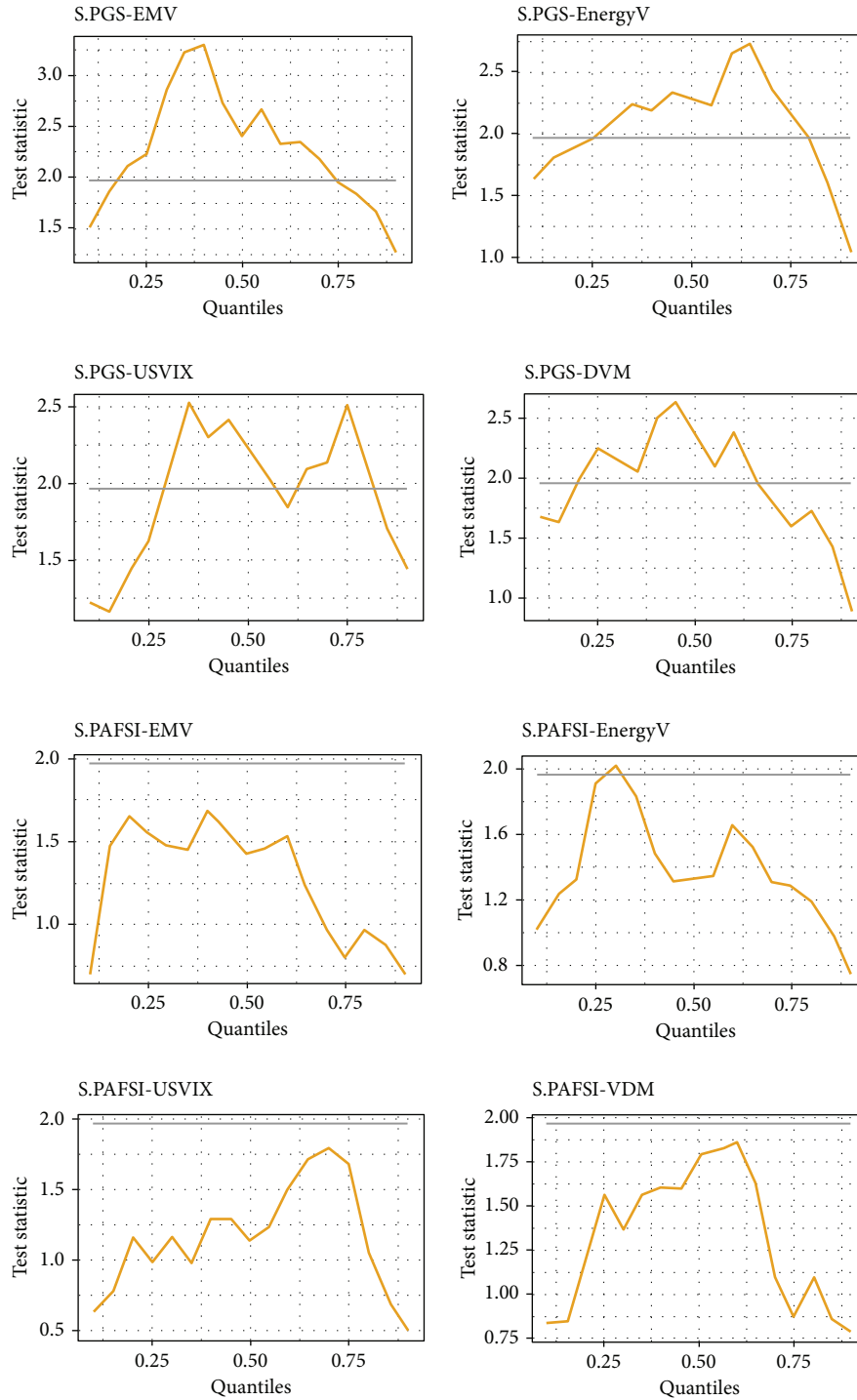
(a)

FIGURE 4: Continued.



(b)

FIGURE 4: Continued.



(c)

FIGURE 4: Causality in mean at various quantiles.

4. Conclusion

We contribute to the asymmetric relationship among sustainability Islamic stock returns and volatility returns across market conditions. Hence, the quantile regression and quantile-on-quantile regression techniques were employed.

The causality in mean technique at various quantiles was further utilised to examine the robustness of our quantile estimates.

Findings from the study revealed asymmetric effect of volatilities on sustainability Islamic stock returns at various quantiles. In addition, the asymmetric effects of most

volatilities were mostly inversely related with sustainability Islamic stock returns, suggesting diversification benefits at various markets outcome. Also, we document causality from volatility to Islamic stocks at various quantiles, except for the extreme quantiles. It goes to reason that typical market outcomes influence causal estimates for our quantile regression model more than market stress or boom.

Particularly for each volatility indexes, volatility index from developed markets transmits positive shocks to sustainability equity indices, except for the S&P Global 1200 Shariah (S.PGS). Hence, diversification benefit would manifest only with the S.PGS index from shocks from the developed market volatility index. On the other hand, the remaining volatility indices transmit negative shocks at various quantiles indicating the need to diversify, hedge, or seek safe haven from them. The significant asymmetric relationship among Islamic stock returns and implied market volatilities across quantiles demonstrates inefficient market dynamics exacerbated by the irrational behaviour of investors to accentuate the heterogeneous and adaptive market hypotheses.

It is recommended that existing and potential investors of sustainable Islamic stocks be mindful of the heterogeneous susceptibilities of these stocks to market volatilities. It is important that they study the market at various markets condition, having in mind the potency of market volatilities. It is necessary that optimal policy interventions from these sustainable Islamic regional blocs are deployed to revamp vulnerable Islamic markets to external shocks. Further studies can assess frequency-dependent asymmetric impact of market volatilities on sustainability stocks at various investment horizons and market outcomes [12, 40, 41].

Data Availability

The data used to support this study are available upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

The authors would like to acknowledge the financial support of Taif University Researchers Supporting Project number: TURSP-2020/162, Taif University, Taif, Saudi Arabia.

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