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The linkages between oil market uncertainty and Islamic stock markets: Evidence from quantile-on-quantile approach

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ABSTRACT

In recent years, Islamic finance has become increasingly influential, especially Islamic stocks, which have created huge investment attractiveness. At the same time, the financialization of oil has made the international oil market increasingly uncertain and more likely to affect other markets. To effectively understand the correlation between the two markets, we empirically analyze the cases of four typical countries from the perspective of oil market uncertainty. This paper utilizes OVX as an accurate measure of oil market uncertainty and applies quantile-on-quantile approach to detect the asymmetric and heterogeneous relations between the variables. Our results show overall negative linkages between OVX changes and Islamic stock returns, and there is indeed asymmetry. Namely, the effects of oil market uncertainty will be more pronounced when it is at higher quantiles. Further comparing the results of the selected four countries, we find some heterogeneities. Oil-importing countries are more sensitive than oil-exporting countries, and Islamic countries are more sensitive than non-Islamic countries. The findings of this article about the linkages between oil market uncertainty and Islamic stock markets is meaningful to the research and financial practice in related fields.

1. Introduction

Islamic finance is deeply influenced by Islamic doctrine and has a series of guidelines that distinguish it from other financial markets. More specifically, there are several unique basic principles for it, such as prohibiting the sharing of interests and risks, prohibiting exploitation and prohibiting the financing of criminal activities. Recently, as the emerging of the Islamic commercial society and the development of the world economy, the Islamic finance has been experiencing enormous growth with its inherent advantages and attracting many international investors. Islamic stock is a typical part of Islamic finance, which has the same characteristics as other Islamic financial assets. Thus, its risk and revenue sharing bring more capability of risk aversion, more and more stock investors are focusing on the Islamic stock markets.

With the growing attention to it, several studies compared the Islamic and conventional stock markets then recognize some differences between them (see e.g., Al-Khazali et al., 2014; Al-Khazali et al., 2016; Ftiti and Hadhri, 2019; Majdoub et al., 2016; Shahzad et al., 2019). And a few studies conduct deep exploration on the relationships between Islamic stock markets and other assets or commodities, for instance, interest rates (Hammoudeh et al., 2016), exchange rates (Hussin et al., 2012), precious metals (Hussin et al., 2013; Mensi et al., 2015; Raza et al., 2016), crude oil (Abdullah et al., 2016; Mezghani and Boujelbene, 2018; Badeeb and Lean, 2018; Narayan et al., 2019) and etc. These studies have found that the Islamic stock market differs from the conventional stock market in terms of market efficiency, information transmission, risk aversion, and linkages with other financial or commodity markets. These processes prove the need for targeted analyses of Islamic stock markets. Though various researches have focused on the characteristics and cross-market relationships of Islamic stock market, existing research barely explored the effects of the uncertainty of related financial market on Islamic stock markets. Among them, an appropriate work is based on the oil market uncertainty, since oil price volatility would always have a profound impact on financial markets.

Specifically, the deepening of oil financialization has gradually made oil an important consideration in portfolio strategies (Fattouh et al., 2013; Lin and Su, 2020), some studies have already analyzed a lot on this area (see Arouri and Nguyen, 2010; Mensi et al., 2017). Given that crude oil has obvious financial characteristics, oil price usually fluctuates drastically. Thus, uncertainty regarding its prices should also be fully considered when constructing an effective portfolio strategy (Henriques and Sadorsky, 2011). In fact, oil price uncertainty refers to the degree and state of volatility in oil prices (Elder and Serletis, 2010). A high degree of uncertainty in oil prices indicates that oil prices are in a more violent state, while the opposite indicates that oil prices are in a stable situation (Gong and Lin, 2017). Oil price uncertainty can delay or change important decisions about production, consumption, investments, and other issues. Thus, uncertainty is inevitably

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transmitted to the economic and financial system and affects the return of the asset. Further theoretically, whether the net present value is greater than the option value of waiting determines the final investment behavior. As oil price uncertainty rises and the options value of waiting subsequently increases, stock investors may delay their investment decisions, so stock returns will be affected accordingly to fall (Liu et al., 2013; Wang et al., 2017; Maghyereh and Abdoh, 2020). As a special type of the stock markets, the Islamic stock market only filter the industries that conflict with Islamic doctrine, such as gambling, alcohol and pork, so it will also be affected by the uncertainty of oil prices through similar transmission mechanisms. Meanwhile, Islamic stock market follows the principles of revenue and risk sharing, resulting in less speculative activities (Mensi et al., 2016). This may lead to a smoother transmission procedure of the impact from oil market uncertainty to Islamic stock market. In other words, by a similar path, oil market uncertainty could affect both conventional and Islamic stock market, but the impact on the two will be unequal.

Some investigators have demonstrated the financial impact of the oil market uncertainty through empirical researches. They found that oil market uncertainty shows an overall negative impact on the stock returns (Park and Ratti, 2008), and this impact will be asymmetric and long term (Huang et al., 2017; Liu et al., 2013; Xiao et al., 2019; Xiao et al., 2018). Despite the substantial literature considering it, less progress has been made in the area of the linkages between oil market uncertainty and Islamic stock markets. Considering the important status of Islamic stock markets and the inadequacies of the existing researches, we are motivated to unearth some findings in this domain.

In parallel, the previous studies observing the oil market uncertainty are always based on GARCH models (Dutta et al., 2017; Xiao et al., 2018). However, a distinct shortcoming could be found in this method. That is, it can only reflect the historical situation of the oil market but neglects the investors' expectations for future movement. Thus, this paper utilizes the crude oil volatility index (OVX) to indicate the oil market uncertainty, which is proposed by the Chicago Board Options Exchange (CBOE) and contains both historical and future expected information. From prior research works (Campos et al., 2017), OVX appears to be a superior indicator to measure oil market uncertainty, and the proliferation of futures and options on OVX furtherly made it more practical. In addition, a recent literature (Karim and Masih, 2019) furtherly made an initial attempt to investigate the responsiveness of the Islamic stock market returns to the realized volatility of oil price and OVX, which further reveals that Islamic stock market returns are more sensitive to OVX. This directly proves that OVX is a more efficient projection than others, therefore we choose this index as the main proxy of oil uncertainty.

From a methodological perspective, the existing studies have addressed several kinds of methods to detect the relationship between oil and stock markets, such as SVAR, quantile regression, NARDL and etc. (Wen et al., 2019). However, there are always various complexities and heterogeneities in the linkages between two financial variables that made the estimate potentially difficult with these standard econometric techniques (Sim and Zhou, 2015). Theoretically, different countries will have different conditions in oil trade and Islamic prosperity. Net oil importers are more dependent on crude oil than net oil exporters, as a result, when oil uncertainty changes, the net oil importers get more influenced than the latter. This has been empirically demonstrated by Boldanov et al. (2016) and Zhou et al. (2019). Meanwhile, when a country has Muslims as its main religious group, there are naturally more Islamic trading stocks in its financial markets than non-Islamic countries, so the relationship between oil uncertainty and its Islamic stock market may also be different from the national level (Gazdar et al., 2019). In addition, many previous studies (e.g., Antoniou et al., 1998; Chinzara, 2011; Hu et al., 2018) confirmed that the impact of external uncertainties on the stock market is often asymmetric. And Fatima et al. (2019) reveal a similar conclusion which also holds in the Islamic stock market, negative shocks or bad news have stronger effects on Islamic stock as compared to positive shocks or good news. To investigate these possible heterogeneities or asymmetry, we employ a new nonparametric quantile method developed by Sim and Zhou (2015), namely quantile-on-quantile (QQ) approach, and conduct comparative research from the national level. This approach regresses a quantile of explanatory variables on another quantile of explained variables, thus, containing more information and is more flexible than standard quantile regression. Different quantiles of explanatory variables reflect the shocks with different sign and size, for example, 2nd percentile OVX is a large negative shock from oil market uncertainty. That is to say, the quantiles indicate the states of the independent variables, and the QQ approach involves all different states. Thence, it can resolve the heterogenous problem that is ignored by standard econometric techniques.

In summary, analyzing the linkages between oil market uncertainty and Islamic stock markets have important practical significance for promoting portfolios and reduce systemic risks for Islamic investors. The potential connection and inadequate related researches prompt us to work in this area. This study finally made three main contributions. Firstly, we fill the vacuum in the area about oil uncertainty-Islamic stock nexus and shed some new light on the investigation of Islamic finance. Secondly, few studies have studied Islamic stock markets at the national level and compared their different responses to financial uncertainties. In this regard, we premeditate the possible heterogeneities and analyze the cases of four typical countries. Thirdly, most oil uncertainty proxies only contain historical volatility information and traditional methodology is insufficient to detect whether the theoretically asymmetric responses also exist in Islamic stock markets. To overcome these deficits, this research uses the OVX as the main projection for oil uncertainty and employs a more flexible quantile approach, then uncovers comprehensive linkages between OVX changes and Islamic stock returns.

The remainder of this paper is organized as follows. Section 2 introduces the literature review. Section 3 describes methodology used in this study. Section 4 describes the research data. Section 5 presents and analyzes the main empirical results of this work. Section 6 discusses the main conclusion and the implication of this study.

2. Literature review

Due to the vacant of the literature on the relationship between oil market uncertainty and Islamic stock markets, this section reviews the existing researches from two related areas, namely oil-stock nexus and oil market uncertainty-stock nexus. Additionally, we also discuss the literature on Islamic stock markets to identify the potential knowledge gap.

In the area of oil-stock nexus, a large body of literature is available. Specifically, early researchers assessed the linkages by treating the oil price as the key factor and constructed the linear framework. Most of them provide evidence for the negative linkages (for example, Sadorsky, 1999; Miller and Ratti, 2009; Arouri and Nguyen, 2010; Basher et al., 2012; Zhang and Cao, 2013; Zhuang et al., 2015; Tursoy and Faisal, 2018), but there are still some researches find the opposite results (see, El-Sharif et al., 2005; Arouri and Rault, 2012 and etc.) or insignificant linkages between oil and stock market (see, Cong et al., 2008; Henriques and Sadorsky, 2008; Janabi et al., 2010). For this reason, more and more studies examine the linkages under an asymmetric framework to unearth the complex relationship between variables.

Based on Degiannakis et al. (2018), the previous studies mainly focused on an asymmetric specification that divides the oil return into positive and negative components for analysis. For example, Park and Ratti (2008) detect the impact of oil price on the US stock market by applying such asymmetric format and employed the VAR framework; they eventually found out that the negative oil price change allows for a superior prediction of stock price returns. Narayan and Gupta (2015) also found similar results, given that negative oil price changes will be

more accurate than positive oil price changes when using them to predict the stock returns of the USA. It should be noted that the asymmetric impact of oil prices can be found for firm-level data. Phan et al. (2015) used the firm-level data of North America to confirm the asymmetric effects. This study found that positive oil price change will drive the oil producers' stock price up while oil consumers' stock price falls. Tsai's (2015) and Broadstock et al. (2016) further support this asymmetric relation by using firm-level data.

Financialized oil prices are easily affected by financial turmoil, market risks, and other uncertain factors, showing the sharp fluctuation of oil prices in the short term. Therefore, when the uncertainty of the oil market increases, the oil price fluctuates more violently (Okorie and Lin, 2020). Facing this risk signal, investors will inevitably change their decision-making and production, consumption, purchases and other behaviors in the real economy will also be affected. Based on such background, many pieces of literature have been extended to the oil uncertainty. Elder and Serletis (2010) reinvestigated the relationship between the price of oil and investment, focusing on the role of uncertainty about oil prices. They found out that oil uncertainty has a negative effect on investment, durables consumption, and aggregate output. This article provides new ideas for research in related fields, thus successors concentrated on the linkages between oil uncertainty and financial markets (see Alsalman, 2016; Bams et al., 2017; Ma et al., 2019; Wei et al., 2019; He and Lin, 2019). Their empirical analysis shows that oil uncertainty negatively affects the stock returns with asymmetries and heterogeneity. To better measure the impact of this uncertainty, some literature compares the efficiency of related measurement methods. For example, Luo and Qin (2017) explore the relationship between oil uncertainty and Chinese stock market and suggest that it is of greater importance to consider the OVX as a proxy for oil uncertainty than realized volatility; Dupoyet and Shank (2018) also supported this result and even indicated that oil uncertainty has surpassed oil prices themselves in terms of influence on financial markets. Furthermore, considering that OVX contains both historical and future information about the oil market, it has a better capability to measure the oil market uncertainty (Dutta et al., 2017; Xiao et al., 2019). With this index, Luo and Qin (2017) and Xiao et al. (2018) further revealed the similarly significant asymmetric linkages between OVX and stock markets.

All the existing studies that analyzed the impact of oil uncertainty are mainly from the perspective of conventional stocks. The essence of the Islamic stock market is a special sub-section of the conventional stock market that has unique revenue sharing characteristics and prohibits certain industries. Thus, Islamic stocks could also comove with other financial or commodity markets, and uncertainty risks will also affect its return. Further considering the potential distinct, the rapidly developing Islamic stock markets deserve the attention of investigators.

However, the existing literature related to Islamic stock neglects this point but concerned with the comparison with conventional markets. For instance, Al-Khazali et al. (2014) examined whether Islamic stocks outperform conventional stocks by means of stochastic dominance (SD) analysis and conclude that Islamic stock has more capacity to hedge the economic risk during meltdown economy. Ali et al. (2018) applied MF-DFA to conduct a comparative analysis too, which implies that Islamic stock markets are more efficient than conventional stock markets. Apart from them, few studies have focused on the linkages between Islamic stock markets and commodity markets (such as Hussin et al., 2013; Mensi et al., 2015; Abdullah et al., 2016; Mezghani and Boujelbene, 2018; Badeeb and Lean, 2018). As far as we know, no study is dedicated to the oil market uncertainty, and few studies discuss the issues from the national level.

To sum up, inadequate research in existing studies motivates us to conduct an in-depth exploration. We aim to investigate the asymmetric linkages between Islamic stock markets and oil market uncertainty. Based on Degiannakis et al. (2018), stock markets in different countries will be affected by the oil market in different ways, so we consider and discuss differences at the national level in the following study. This paper uses the QQ approach to examine the heterogeneity dependence and complex associations, which provide some detailed information for international investors to make efficient decisions.

3. Methodology

The quantile-on-quantile regression (QQ) approach is a new nonparametric quantile method proposed by Sim and Zhou (2015), which can be treated as a generalization of the standard quantile regression (QR) approach. This approach is constructed by combining the quantile analysis and nonparametric estimation, and there are some key advantages comparing with the QR approach. Firstly, it is able to analyze how the quantiles of explanatory variables affect the conditional quantiles of dependent variables, while traditional quantile regression neglects the possibility of the states of explanatory variables. Besides, as a kind of nonparametric quantile regression, the QQ approach could avoid restrictive parametric assumptions by uncovering the elaborate features of the impact from independent variables. Thus, we employ this econometric technique to investigate the complex and heterogenous linkages between oil market uncertainty and Islamic stock markets.

At first, let r_t be the Islamic stock returns for each country at time t. We assume superscript θ denoting its quantile so that a basic nonparametric quantile regression for θ-quantile of the Islamic stock returns can be developed as:

$$r_t = \beta^{\theta}(OVX_t) + \alpha_t^{\theta} r_{t-1} + \partial_1^{\theta} ER_t + \partial_2^{\theta} IR_t + u_t^{\theta} \tag{1}$$

where OVX_t is the differential logarithm for OVX series, and u_t^{θ} denotes an error term that has a zero θ-quantile. The monetary policy and foreign currency market are often considered in the interactions between the oil market and the stock market (Luo and Qin, 2017). Thus, the exchange rate and interest rates are included in this equation as the control variables. ER_t and IR_t refers to the exchange rate changes and the interest rate changes, respectively. Then assuming that $\beta^{\theta}(*)$ is unknown, for the reason that the prior information for the integration between Islamic stock markets and oil market uncertainty cannot be obtained, we further linearize this unknown function by taking a first-order Taylor expansion around OVX^{τ} (OVX^{τ} represent the τ-quantile of the OVX). The function $\beta^{\theta}()$ yields the following:

$$\beta^{\theta}(OVX_t) = \beta^{\theta}(OVX^{\tau}) + \beta^{\theta'}(OVX^{\tau})(OVX_t - OVX^{\tau}) \tag{2}$$

According to Sim and Zhou (2015), Eq. (2) shows that the parameters $\beta^{\theta}(OVX^{\tau})$ and $\beta^{\theta'}(OVX^{\tau})$ are both the functions of θ and τ, which implies that they can be rewritten as the $\beta_0(\theta,\tau)$ and $\beta_1(\theta,\tau)$, respectively. Then we redefine Eq. (2) as:

$$\beta^{\theta}(OVX_t) \approx \beta_0(\theta,\tau) + \beta_1(\theta,\tau)(OVX_t - OVX^{\tau}) \tag{3}$$

Next, Eq. (3) is substituted into the basic nonparametric quantile regression, as shown in Eq. (1), the following formula can be eventually obtained:

$$r_t = \underbrace{\beta_0(\theta,\tau) + \beta_1(\theta,\tau)(OVX_t - OVX^{\tau}) + \alpha(\theta) r_{t-1} + \partial_1(\theta) ER_t + \partial_2(\theta) IR_t}_{(*)} + u_{\theta}^t \tag{4}$$

where we define the $\alpha(\theta) \equiv \alpha^{\theta}$. Part of $(*)$in the equation is the θth conditional quantile of the Islamic stock returns. The QQ approach captures the relationship between the r_t and OVX_t in each respective quantile since the coefficients depend on the θ and τ. Also, $\beta_0(\theta,\tau)$ and $\beta_1(\theta,\tau)$

would provide more detailed information on the complex linkages, thus the key problem turns to solve these two coefficients.

In order to conduct the estimation, we replace the independent variables with their estimated counterpart, $\widehat{OVX}_t$ and $\widehat{OVX}^{\tau}$. Thus, the parameters b_0 and b_1 are then obtained as the minimization problem in the following formula:

$$\min_{\beta_0\beta_1}\sum_{i=1}^{n}\rho_\theta\Big[r_t-b_0-b_1\left(\widehat{OVX}_t-\widehat{OVX}^{\tau}\right)-\alpha(\theta)r_{t-1} -\partial_1(\theta)ER_t-\partial_2(\theta)IR_t\Big]K\left(\frac{F_n\left(\widehat{OVX}_t\right)-\tau}{h}\right) \tag{5}$$

where $\rho_\theta(*)$ is the absolute value function of the slope, which can be solved by the θ-conditional quantile of r_t. $K(*)$ denote a Gaussian kernel and h is the bandwidth parameter of it. With this parameter, we can weigh the observations in the neighborhood of $\widehat{OVX}^{\tau}$ (The bandwidth value for this process is selected by using the recent methodical technique of Sim and Zhou (2015)). Note that the weights are inversely correlated with the distribution between $\widehat{OVX}_t$ and $\widehat{OVX}^{\tau}$, the empirical function is as follow:

$$F_n(OVX_{t-1}) = \frac{1}{n}\sum_{k=1}^{n} I(OVX_k<OVX_{t-1}) \tag{6}$$

For an empirical purpose, the same exercise is constructed to investigate the cases of different countries and the constructed model allows us to in-depth explore the established research questions at the national level.

4. Data description

To dissect the linkages between oil market uncertainty and Islamic stock markets, the daily series of OVX (crude oil volatility index) and Dow Jones Islamic Market Indices are employed in this study. We obtain them all from the Datastream database. Based on Smales (2016) and Li and Zeng (2018), oil-importing countries may be more sensitive to the shocks from oil market; and the Islamic stock markets are more efficient than conventional stock markets, thus the prior can respond to the risk information more accurately and timely. In order to fully reflect these possible heterogeneities between countries, our data set includes four countries Canada, Japan, Turkey and Kuwait. More specifically, Canada is a typical non-Islamic oil-exporting country, Japan is a typical non-Islamic oil-importing country, Turkey is a typical Islamic oil-importing country and Kuwait is a typical Islamic oil-exporting country.[1] By comparing their estimated results of the relationship between oil uncertainty and Islamic stock markets, we can effectively obtain heterogeneous information in two dimensions. The sample period is selected from 25 April 2013 to 15 April 2019, since the Islamic stock indices of Turkey and Kuwait have not been released till April 25, 2013. All the time series are calculated as the logarithmic difference to represent the continuously returns, that is $r_t = log\,(P_t/P_{t-1})$, where P_t is the index value at time t and P_{t-1} is the price at time t − 1.

Table 1 presents the descriptive statistics of the variables, from which we can gain some basic hindsight before going to deeper empirical estimation. For standard deviations, there is a similar magnitude across variables, but in contrast, Turkish Islamic stock returns are more volatile than others. The coefficients of skewness and kurtosis reveal that all the returns are skewed and exhibit significant leptokurtosis. Meanwhile, all the series in this empirical research reject the null of normality, as shown by the Jarque-Bera test, which furtherly validates the strong motivation to use quantiles-based methods.

Table 1
Descriptive statistics of the variables.

	OVX	Canada	Japan	Turkey	Kuwait
Mean	0.0000	−0.0001	0.0003	−0.0005	−0.0001
Std. Dev	0.048	0.0106	0.011	0.018	0.008
Minimum	−0.440	−0.0493	−0.059	−0.167	−0.052
Maximum	0.425	0.0473	0.058	0.080	0.079
Skewness	0.765	−0.1116	−0.252	−0.783	0.134
Kurtosis	13.034	4.7452	6.271	10.444	13.479
Jarque-Bera	1400.50***	181.21***	641.1***	3387.70***	6432.50***

Note: **, *** indicate statistical significance at the 5% and 1% level, respectively.

In addition, we applied a BDS test (Broock et al., 1996) to investigate the distributional pattern of the Islamic stock return series, which is a widely accepted test to check the non-linear structure of a time-series. The results have been presented in Table 2 and rejected the null hypothesis under different ε and m, suggesting that the presence of a likely nonlinear structure in Islamic stock returns.

5. Empirical results

5.1. Preliminary analysis

As the first step in empirical exercise, we compare the effect of OVX on the Dow Jones Islamic Market Index and Dow Jones index by linear regression so that the basic knowledge about the channel on how the OVX affects Islamic stock could be obtained. The model is defined as:

$$r_t = c + \gamma_0 OVX_t + \gamma_1 r_{t-1} + \partial_1 ER_t + \partial_2 IR_t + \varepsilon_t \tag{7}$$

where r_t represent return series of the Islamic stock markets (conventional stock markets), OVX_t indicate the OVX changes, obtained from the differential logarithms for OVX.

Table 3 Panel A shows the results of OLS regression for Islamic stock markets and it suggests that the effects of OVX changes are significant at the level of 1%, except the case of Canada. Considering the direction of the impact, we find that OVX exerts a negative effect on each Islamic stock markets, though the link is too tenuous. Furthermore, comparing the estimated coefficients for different markets, we can suggest that oil importers are generally more affected than oil exporters and Muslim countries are more vulnerable than non-Islamic countries. This implication preliminarily reveals that the linkages between OVX changes and

Table 2
BDS test for national Islamic stock return series.

	m	ε (1)	ε (2)	ε (3)	ε (4)
	2	6.4115	6.7848	6.5951	6.3672
	2	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	3	8.0432	8.3587	7.9612	7.4833
Canada	3	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	2	1.6146	1.8639	1.8450	1.8516
	2	(0.1064)	(0.0623)	(0.0650)	(0.0641)
	3	2.1497	2.7477	3.2554	4.2042
Japan	3	(0.0316)	(0.0060)	(0.0011)	(0.0000)
	2	4.6703	5.9278	7.2041	8.3932
	2	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	3	6.7210	8.1325	9.6249	10.2052
Kuwait	3	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	2	2.6304	3.0562	3.9942	4.5661
	2	(0.0085)	(0.0022)	(0.0001)	(0.0000)
	3	3.5139	4.1256	5.1949	5.7694
Turkey	3	(0.0004)	(0.0000)	(0.0000)	(0.0000)

[1] As of now, there are nine national markets of the Dow Jones Islamic Stock Index with more than two years of historical data: The United Kingdom, the United States, Japan, India, Canada, Sri Lanka, Kuwait, Turkey and Malaysia. In order to ensure that the sample is sufficiently representative, we avoid choosing countries where the status of oil trade has changed or unclear during the sample period, like US, Sri Lanka and Malaysia. Considering that Japan is a heavy oil importing dependent country and its Islamic culture is extremely marginalized, it is more suitable to represent the oil imports to non-Islamic countries than India. Both the UK and Canada can represent non-Islamic oil exporters, since Canada has a larger size of net oil export volume, this article chooses it as a sample country.

Table 3
The basic estimation results for the OLS (linear model).

Nations	Canada	Japan	Turkey	Kuwait
Panel A: the impact on Islamic stock markets				
Et − 1	0.0696	−0.2361	0.1059	−0.0732
	(0.0650)	(0.0000)	(0.0300)	(0.0400)
OVX	−0.0074	−0.0244	−0.0699	−0.0128
	(0.3190)	(0.0060)	(0.0000)	(0.0030)
ER	−0.0134	−0.0819	0.0202	−0.2153
	(0.8610)	(0.2770)	(0.7440)	(0.5070)
IR	0.0144	0.0148	0.0566	−0.0033
	(0.2610)	(0.0000)	(0.0560)	(0.2780)
Constant	0.0002	0.0005	−0.0002	−0.0002
	(0.6170)	(0.1540)	(0.6660)	(0.4500)
Adj R-squared	0.0062	0.0732	0.0442	0.0088
Panel B: the impact on conventional stock markets				
Et − 1	0.0828	−0.0028	−0.0620	−0.0008
	(0.0340)	(0.9480)	(0.0770)	(0.9840)
OVX	−0.0052	0.0180	−0.0132	0.0037
	(0.3170)	(0.0360)	(0.1470)	(0.5060)
ER	0.0068	−0.0498	−0.0081	0.0654
	(0.8950)	(0.4940)	(0.8690)	(0.8470)
IR	−0.0261	−0.0045	−0.0653	−0.0660
	(0.1000)	(0.1720)	(0.0000)	(0.0680)
Constant	0.0003	0.0002	0.0000	0.0003
	(0.1980)	(0.6020)	(0.9780)	(0.3040)
Adj R-squared	0.0112	0.0058	0.0129	0.0017

Note: The value in brackets under the estimated coefficients represents the p-value of them. It can be seen from the results of the adjusted R-square if only OLS is used for regression analysis of variables, the fitting is obviously poor.

national Dow Jones Islamic returns may be heterogeneous across countries. The adjusted R squared value of each regression result is too small to capture the real linkages between variables, which are all below 0.1. Overall, based on the evidence from the linear method OLS, OVX does not appear to have a reliable and close relationship with Islamic stock returns, which further indicate that the complex linkages should be furtherly explored by some nonlinear methods.

Panel B shows the estimation based on conventional stock markets as a parallel. There are some differences compared with the results for Islamic stock markets. At first, the linkages between Islamic stocks and OVX are statistically insignificant at the average level, which is similar to the findings of Alsalman (2016) and Bouri et al. (2018). Note that Japan is unique as its conventional stock market can be influenced by the OVX changes, it may be due to Japan's heavy dependence on the international oil market. Secondly, the estimated coefficients proved that oil importers could gain more influence than exporters, but whether the country is Islamic seems to have little effect on the results.

In summary, Islamic stock markets seem to be more affected by oil uncertainty than conventional markets, and the former is more likely to have heterogeneities caused by differences in national Islamic levels. We further use the QQ method to perform the core analysis of this article to gain a deeper understanding of the complex relationships between variables and the possible asymmetry.

5.2. The results of the QQ approach

This section describes the main empirical results of the QQ estimates. Figs. 1–4 display the presence of the quantile on quantile relationship between OVX and Islamic stock for Canada, Japan, Turkey and Kuwait, respectively. It is evident from the figures that variations of $\beta_1(\theta,\tau)$ for all countries are not the same, suggesting that there are considerable heterogeneities across the sample countries. Additionally, the estimated $\beta_1(\theta,\tau)$ varies in the different quantiles of both dependent and independent variables. This suggests that the link between OVX and the Islamic stock market is indeed asymmetric. To completely capture the linkages and heterogeneities within them, we will introduce each country's situation one by one and make a summarized comparison. It should be noted that all statistical insignificant estimated coefficients (at 1% level) have been stetted to zero.

Fig. 1 roughly illustrates the several characteristics for variation in the slope coefficient $\beta_1(\theta,\tau)$. For Canada, it can be seen that the coefficients estimated by the QQ approach are only significant in some cases meanwhile those that passed the significance test are all negative and generally small. This shows that there is a weak negative linkage between oil uncertainty and the Canadian Islamic stock market. In detail, when the Islamic stock return is at different quantiles, the linkages are similar, but when OVX is at different quantiles, the relationship between variables shows a large difference. In other words, we can find that the linkages between OVX and Islamic stock market returns are not significant in the low to middle quantiles (0.05–0.6) of OVX changes.

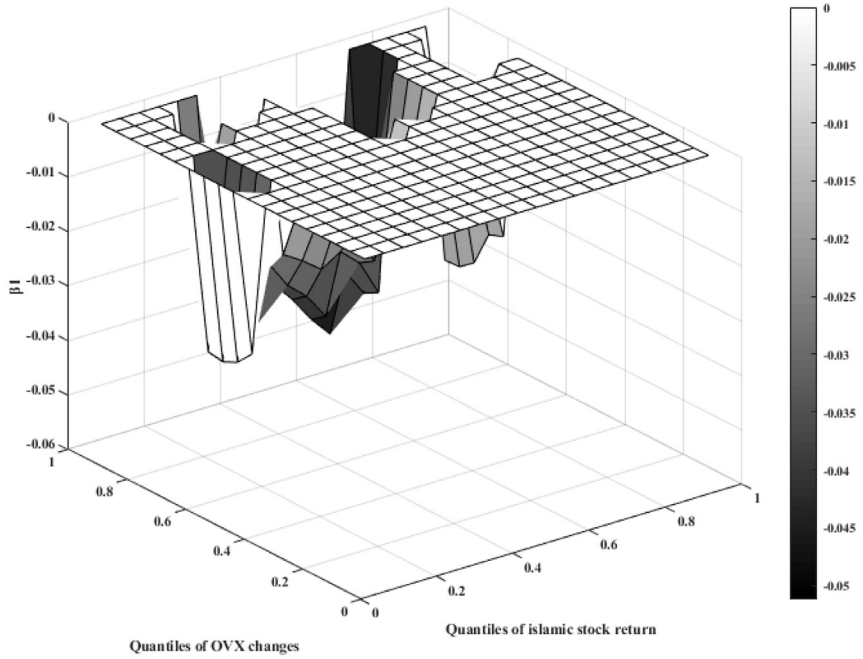

Fig. 1. The QQ estimation for OVX changes and Islamic stock return for Canada.

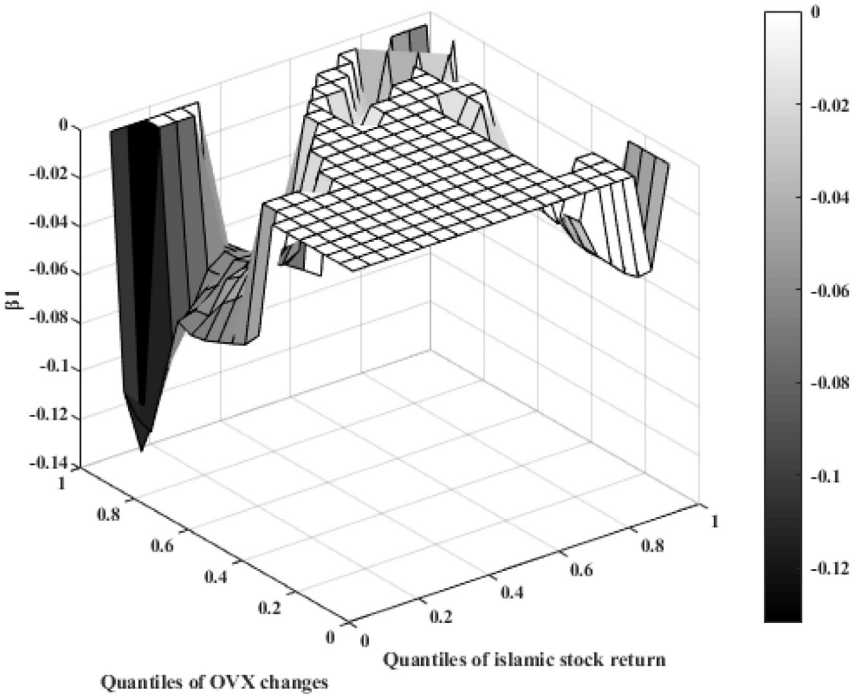

Fig. 2. The QQ estimation for OVX changes and Islamic stock return for Japan.

However, when OVX changes are in a bullish state, the linkages will gradually change from insignificance to significance. This phenomenon fully illustrates the asymmetric impact of oil market uncertainty on the Canadian Islamic stock market. According to Tsai (2014), investors may produce less rational responses to bad news than good news. Thus, when the uncertainty of the oil market is rapidly increasing (OVX is at a high quantile), the bad news from the global oil market is more likely to have a significant negative impact on stock markets.

In the case of Japan (Fig. 2), similar to Canada, the OVX changes at the low to moderate quantiles cannot influence the Islamic stock market, which also verifies the asymmetric linkages between variables. However, this impact shows more obvious differences in different states of the Japanese Islamic stock market. When the Islamic stock market is a bear market, the bad information about oil volatility will have a significant negative effect, but on the contrary, the impact is less obvious. In addition, the linkages are statistically significant in an extreme bull state of Islamic stock market. It supports some previous studies (such as Smales, 2016; and Li and Zeng, 2018), implying that the relationship between financial indices or returns is more sensitive under extreme conditions. The differences between the coefficient and the degree of significance confirm the results of our primary analysis. Japan and Canada are both non-Islamic countries, but as an oil-importing country,

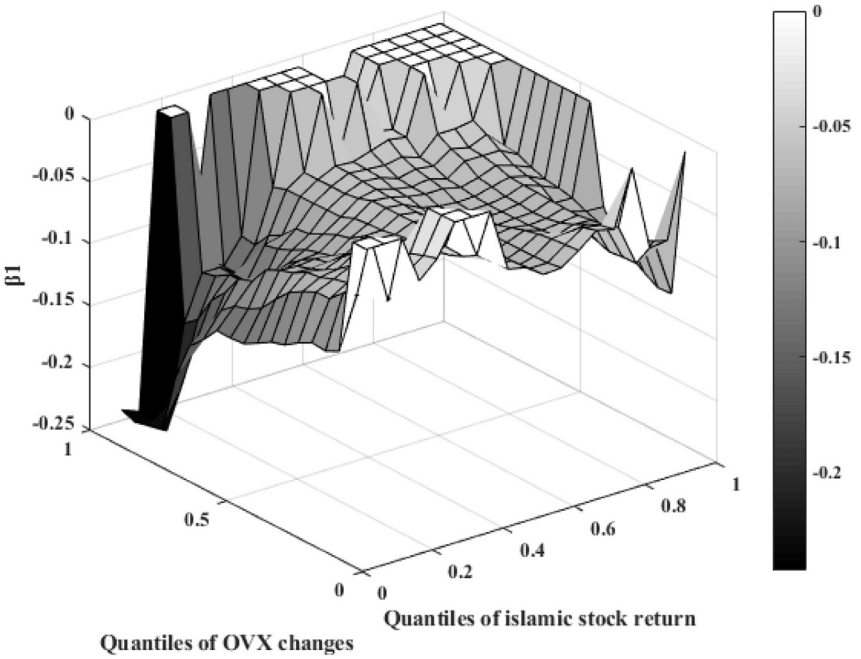

Fig. 3. The QQ estimation for OVX changes and Islamic stock return for Turkey.

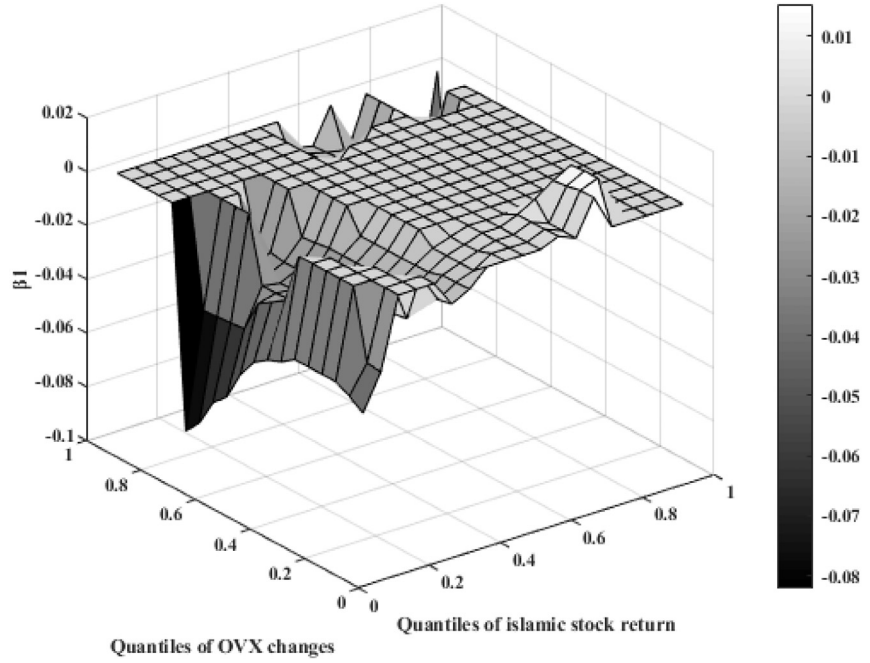

Fig. 4. The QQ estimation for OVX changes and Islamic stock return for Kuwait.

Japan is more dependent on the international oil market, and its financial system is more vulnerable to variation of the oil market than Canada (Bjornland, 2009; Arouri and Rault, 2012). This result illustrates the heterogeneities caused by the differences in national oil trade status.

Fig. 3 shows the results of QQ analysis based on Turkey. As can be seen from the figure, the asymmetric impact of OVX changes is also obvious. When OVX changes gradually change from higher quantiles to lower quantiles, their impact on the Islamic stock market is also gradually weakening, which is similar to other countries. The estimated coefficients are consistently negative and generally show an inverted U-shaped change state as the stock market changes from bear to bull. From this figure, there are more estimated $\beta_1(\theta,\tau)$ pass the significance test and their absolute values are overall larger than the previous two countries. In other words, oil market uncertainty is more closely related to the Turkish Islamic stock market than Canadian or Japanese. The possible reason for this circumstance is the heterogeneities between Islamic and non-Islamic nations. Turkey is an Islamic country, thus its Islamic stock market is more prosperous and responds faster to changes in market risks.

For the case of Kuwait (Fig. 4), the strong and obvious negative association mainly occurs at the bear Islamic stock market (0.05–0.4), which is in line with the cases of other countries, reflecting that the responses of bear markets to risk information are more pronounced. Meanwhile, an asymmetric link between oil uncertainty and Islamic stock markets does exist; OVX changes at higher quantiles could bring greater impact than lower quantiles. Fig. 4 also shows a strange pattern that there may be some positive linkages when OVX changes are in the 0.05–0.25 quantiles and the Islamic stock market is in a bull market (0.6–0.8 quantiles). This result supports the actual situation in Kuwait, which is the only Gulf country in this study that has rich oil resources, bringing more investment for their assets than other countries when the oil market uncertainty is constant or decreased. Meanwhile, the economy of Kuwait is dominated by the oil industry; it makes the Islamic stock market to have more hedging power to the risk of the international oil market, especially in the bullish stages. As an oil exporter, Kuwait hedges the risk of uncertainty from oil market more effective than Turkey, which further shows that there are heterogeneities within Islamic countries due to different national oil trade conditions in the oil uncertainty-Islamic stock nexus. Additionally, comparing the results for Kuwait and Canada, which are both oil exporters, we can see that the former as an Islamic country will respond more significantly and violently to changes in OVX. This suggests that the heterogeneities caused by the Islamic level have always existed both for oil-importing and exporting countries.

In summary, the impact of OVX changes on Islamic stock returns is overall significantly negative in some quantiles and this is consistent with the previous OLS estimation. For each country, the linkages between OVX changes and Islamic stock markets are asymmetric. When OVX changes are at higher quantiles, they are more likely to affect the Islamic markets, no matter the cases of Islamic or non-Islamic and oil-importing or oil-exporting nations. Comparing the results from different countries, we can further obtain some heterogeneous information. Differences in empirical results across countries may be attributed to the fact that each country has its unique features, that is, in different situations of oil import and export and the degree of Islamization. As oil-importing countries, Japan and Turkey are more dependent on international crude oil markets than oil-exporting countries (Canada and Kuwait), so they are more influenced by the oil market uncertainty. Meanwhile, oil market uncertainty could produce heterogeneous effects on the basis of national-Islamic characteristics. Compared to non-Islamic countries (Canada and Japan), Islamic stock markets in Islamic countries (Turkey and Kuwait) are more sensitive to oil market uncertainty. The possible reason is that Islamic stock markets are more efficient than non-Islamic stocks, allowing for more agile adjustments to information (Ali et al., 2018). As Islamic stock markets are bound to be more prosperous in Islamic countries, their response to external uncertainty information will be more pronounced than it in other countries.

5.3. Robustness check

The QQ approach is a kind of improved quantile method, with which we can "decompose" the quantile regression estimation and obtain the specific estimates for explanatory variables in different quantiles. By contrast, the quantile regression approach neglects the nonlinear linkages between variables. Taking the variables in this study as an example, the quantile regression approach regresses the θ quantiles of Islamic stock returns for each country on OVX changes, thence, the coefficients will be indexed only by θ. While the QQ approach regresses θ quantiles

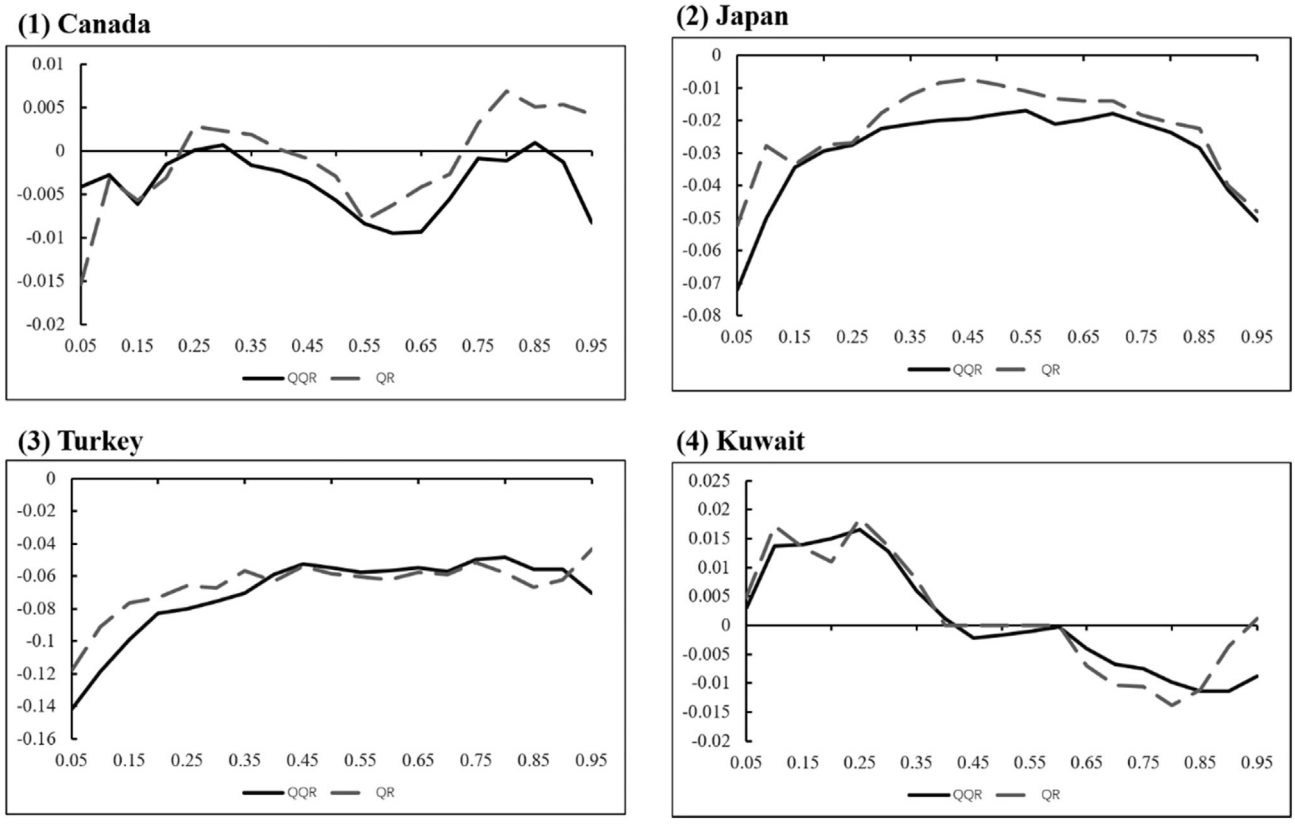

Fig. 5. Robustness test by comparing the results for the QR method and average QQ estimation.

on the τ quantiles of the OVX changes, thus, the coefficients will be indexed both by θ and τ. For the reason that there are potential heterogeneous across quantiles of the explanatory variable, the QQ approach contains more detailed information about the linkages between OVX changes and Islamic stock returns than the quantile regression.

Given this property of decomposition that is inherent to the QQ approach, it is consequent that QQ estimates recover the key characteristics of the quantile regression. Otherwise, this approach is methodologically flawed and the results are not credible. Therefore, the robustness test for the QQ approach can be developed by recovering the quantile regression estimates of the QQ estimates. Specifically, we average the estimating coefficients of the QQ approach along τ to generate the quantile regression coefficients, only indexed by θ. Denoting the slope coefficient of quantile regression estimation as $\gamma_1(\theta)$ it can be obtained as follow:

$$\gamma_1(\theta) \equiv \overline{\hat{\beta}_1}(\theta) = \frac{1}{s}\sum_{\tau}\hat{\beta}_1(\theta,\tau) \tag{8}$$

where S = 19 is the number of quantiles τ = [0.05, 0.1, 0.15…0.95] considered.

In order to check the validity of the QQ approach, we firstly summarize the QQ estimates by averages along with τ, then compare them with the estimated quantile regression coefficients. By plotting the quantile regression and the averaged QQ estimates, Fig. 5 shows how the slope coefficients of different countries variate across θ, with the two empirical approaches.

The graphs reveal that the QQ estimates for slope coefficients are similar to quantile regression estimates for all countries in this study, regardless the quantiles considered. As a result, we can conclude our QQ estimates have good robustness; the slope coefficients estimated by this approach are able to display the real variation for the linkages between OVX changes and Islamic stock returns. Notably, the trend of the QQ lines is nearly the same as the QR lines, but the values are somewhat different. This result further validates that across the quantiles of OVX changes, there is apparent heterogeneity within each country, thus the QQ approach has more explanatory ability than simple quantile regression estimation.

All in all, this graphical evidence provides a direct validation of the QQ approach. Though there are still some subtle differences for the values in the two lines, Fig. 5 largely confirms the results of the QQ estimation reported earlier. The diagrams also indicate that the results obtained by the QQ approach are robust and more faithful compared to the linear methods.

6. Conclusions

This study focused on investigating the linkages between oil market uncertainty and Islamic stock markets at the national level, especially its asymmetric relations and heterogeneities within it. Specifically, this paper uses the OVX as the proxy of oil market uncertainty and employs the quantile on quantile approach as the main regression model.

This study contains the cases of four countries, Canada, Japan, Turkey, and Kuwait, since they include typical oil exporters and importers as well as Islamic and non-Islamic countries. Our results show overall negative linkages between oil market uncertainty and Islamic stock returns for most sample countries, especially when the Islamic stock market is in a bearish stage. One exception in our results is Kuwait, whose Islamic stock market may be positively impacted by the strong negative OVX shock during a bull stage. The possible reason for this phenomenon is that Kuwait, as the unique Gulf country in this study, its Islamic stock market could gain more investment by take advantage of massive oil industry as oil market uncertainty declines, especially when the market is in a bull stage.

With the estimation of the QQ approach, the link between oil market uncertainty and the Islamic stock markets does have heterogeneity and asymmetry. On the one hand, comparing the results of four typical countries, we can find that this link will be more significant and stronger

in the cases of oil-importing and Islamic countries. There are some heterogeneities caused by differences in national economic conditions. On the other hand, OVX changes on higher quantiles are likely to have a greater impact, which exists in each country and reveals the asymmetric linkages between variables. At last, the paper also examines the robustness of the empirical results by comparing the quantile regression results, suggesting that the results obtained by the QQ approach are robust and more faithful compared to the linear methods.

Our findings could provide some valuable implications for investors and risk managers. For example, international investors should pay enough attention to the asymmetric effects of the uncertainty of the international oil market on Islamic stocks. And the bad news of uncertainty is riskier than the good news, especially when the Islamic markets are bearish. Therefore, risk managers need to adopt some means to avoid great investment risks and treat countries differently based on their oil trade status and Islamic level.

CRediT authorship contribution statement

Boqiang Lin: Conceptualization, Data curation, Writing - original draft, Investigation, Software. **Tong Su:** Data curation, Writing - original draft, Investigation, Software.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.eneco.2020.104759.

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