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Asymmetric effect of oil prices on stock market prices: New evidence from oil-exporting and oil-importing countries

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ABSTRACT

This paper examines the short-run and long-run effect of oil prices across bullish, bearish, and normal states of the stock markets in oil-exporting and oil-importing countries where oil-exporting countries include Russia, Mexico, Venezuela, and Norway and oil-importing countries include India, China, Japan and Norway. For this purpose, we use quantile ARDL model and compare its findings with the standard nonlinear ARDL model. Moreover, this study uses quantile nonlinear ARDL model where oil price series is decomposed into positive and negative oil price shocks. The nonlinear ARDL estimates do not support co-integration in the long-run whereas, in the short-run, it supports asymmetric effect in all countries except Norway. Besides, the quantile ARDL estimates indicate that oil prices asymmetrically affect stock prices both in the short-run and long-run and for all sample countries. Finally, the empirical estimates of the quantile nonlinear ARDL model are consistent with the estimates from the quantile ARDL model. The findings of this study provide important policy implications for investors, policymakers and other stakeholders.

1. Introduction

In the last few decades, numerous studies have been conducted to examine the relationship between oil prices and stock prices. (see for example Jones and Kaul, 1996; Driesprong et al., 2008; Sukcharoen et al., 2014; Creti et al., 2014; Chou and Tseng 2016; Bouri 2015; Joo and Park 2017). These studies indicate that the main reason behind this relationship is the effect of international oil prices on corporate cash flows and earnings (Arouri et al., 2012). Moreover, the relationship between oil prices and stock prices can also be explained by the theory of equity valuation. This theory states that stock prices are the sum of discounted values of future cash flows which firms receive during different periods. These cash flows are affected by macroeconomic factors (e.g. economic growth, income, production costs, interest rates, inflation, and consumer confidence), and macroeconomic factors, in turn, are affected by oil price shocks (Jouini 2013; Arouri and Nguyen 2010). Due to this fact, the available literature suggests that substantial changes in oil prices cause changes in stock prices (Huang et al., 1996). Moreover, this literature supports positive relationship between oil prices and stock prices in oil-exporting countries (Kilian and Park, 2009), whereas it provides inconsistent findings in oil-importing countries (Badeeb and Lean, 2018).

Recent literature further suggests that the relationship between oil and stock prices is asymmetric (See for example; Chang, 2020; Chang et al., 2020a; Demirer et al., 2019; Badeeb and Lean, 2018; Basher et al., 2018; Ready 2018). Therefore, this literature uses different techniques to examine the asymmetric/nonlinear relationship between oil prices and stock prices. For example, Wang et al. (2011) checked the nonlinearity using threshold co-integration framework proposed by Endres and Siklos (2001). Beckmann and Czudaj (2013) also checked the nonlinearity using Markov-switching vector error correction model proposed by Hamilton (1989) and concluded the nonlinear relationship between oil and stock prices. Recently, Badeeb and Lean (2018) extended the existing literature by using nonlinear ARDL (NARDL) model proposed by Shin et al. (2014). Their empirical results indicate that positive and negative shocks in oil prices asymmetrically affect stock prices. However, their study fails to examine the asymmetric relationship across various states of the stock markets; whereas, recent literature concludes that stock markets' response to oil price shocks varies across bullish, bearish, and normal states of the stock markets (Chang et al., 2020a). Moreover, other studies also conclude that the relationship between oil prices and stock prices is quantile dependent (You et al., 2017; Zhu et al.,

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2016; Xiao et al., 2019). Therefore, keeping in view the limitations of existing literature, this study examines the short-run and long-run asymmetric effect across bullish, bearish and normal states of the stock markets in oil-exporting and oil-importing countries. For this purpose, we use a recent model called quantile ARDL (QARDL) model proposed by Cho et al. (2016). We particularly use this model, since it helps to examine more minutely whether the effect of oil prices on stock prices varies from extremely small to extremely large changes in stock prices that are, across bullish, bearish and normal states of the stock markets. We further extend the existing literature by examining whether the quantile dependent effect varies across oil-exporting and oil-importing countries. The oil-exporting countries included in this are Russia, Mexico, Venezuela, and Norway and oil-importing countries included in this study are India, China, Japan and Norway. This study particularly compares findings in oil-exporting countries with oil-importing countries since the literature suggests that stock prices respond differently to oil price shocks in oil-exporting and oil-importing countries (Kilian and Park, 2009; Badeeb and Lean, 2018). These studies further suggest that oil is considered as a source of export revenues in oil-exporting countries, therefore, increase in oil prices positively affect stock prices in oil-exporting countries (Buetzer et al., 2012; Ding and Vo, 2012; Fedoseeva, 2018). On the other hand, this relationship is less clear in oil-importing countries (Balcilar et al., 2019).

Overall, this study extends the existing literature in three ways. First, we extend Badeeb and Lean (2018) by examining this relationship across bullish, bearish and normal states of the stock markets. For this purpose, we use an enhanced methodology called quantile ARDL (QARDL) model proposed by Cho et al. (2016). The advantage of this model is that it is used to examine the short-run and long-run effect across quantiles of the dependent variable which the previous models fail to examine. Moreover, this model can be used when the variables are integrated of either order zero I(0) or one I(1).[1] Second, we use quantile ARDL model for both positive and negative shocks of oil prices and name this model as quantile nonlinear ARDL (QNARDL) model. The QNARDL helps to examine the effect of positive and negative shocks in oil prices across different quantiles of stock prices. Third, we extend the existing literature by focusing on this relationship both in oil-exporting and oil-importing countries.[2]

Our findings from the NARDL model indicate that, in the long-run, oil price shocks symmetrically affect stock prices for most of the countries whereas, in the short-run, they asymmetrically affect stock prices. Besides, the QARDL estimates indicate that, in the short-run and long-run, oil prices asymmetrically affect across different states of the stock markets in both oil-exporting and oil-importing countries. Finally, the findings based on QNARDL model are consistent with the findings of QARDL model.

The rest of the paper is organized as follows: Section-2 discusses the literature review. Section-3 discusses the data sources and methodology. Section-4 discusses the empirical findings and conclusion and policy implications are drawn in Section-5.

2. Literature review

There is a vast literature available that examines the relationship between oil prices and stock prices but provides ambiguous empirical findings. This literature provides evidence related to asymmetric relationship between oil prices and stock prices (For example, Chang et al., 2020a; Demirer et al., 2019; Basher et al., 2018; Balcilar et al., 2019; Badeeb and Lean 2016; Salisu and Oloko 2015; Perdiguero-García 2013; Basher and Sadorsky 2006; Sadorsky 1999). The main reason behind this nonlinear relationship is that different stakeholders have different investment horizons (Reboredo and Rivera-Castro, 2014). In the financial markets, various investors with different time horizons[3] are gathered, therefore, all investors have different influences on the overall stock market. For example, Sadorsky (1999) provided evidence related to the asymmetric effect of oil prices on stock prices by using a vector autoregessive model. Basher and Sadorsky (2006) further concluded that an asymmetric relationship exists between oil and stock prices. Salisu and Oloko (2015) also provided evidence regarding asymmetric relationships during the slowdown period of the world economy. On the other hand, Cong et al. (2008) provided insignificant evidence for an asymmetric relationship between oil prices and the Chinese stock market. However, Park and Ratti (2008), and Nandha and Faff (2008) provided no evidence for an asymmetric effect of oil prices on the stock market.

Recent literature also provides inconsistent findings. For example, Badeeb and Lean (2018) examined the asymmetric effect of oil prices on sectoral stock indices by using a nonlinear ARDL model. Their study concludes a weak linkage between oil prices and Islamic stock indices. On the contrary, Chang et al. (2020a) examined the asymmetric effect of oil prices on Islamic composite and sectoral stock indices. Their findings show the presence of the asymmetric effects of oil prices on the DJ Islamic index. Moreover, their findings related to the industrial sector, utility sector, oil & gas sector, consumer services, consumer goods, healthcare sector, and financial sector are consistent with the findings of the DJ Islamic index. Finally, they note the symmetric effect of oil prices on basic material and technology and telecommunications sectors. Due to such an ambiguous relationship between oil and stock prices, as well as the impact of various other factors such as environmental concerns, new technology improvement, and policy changes, the relationship between oil prices and stock prices is quite complex, and therefore, it is difficult to find conclusive evidence. Hence, a more comprehensive analysis is required regarding asymmetric relationship between oil prices and stock prices. Following the limitations in the existing literature, this study makes another attempt to examine this relationship between oil prices and stock prices in both oil-exporting and oil-importing countries by using a recently developed quantile ARDL (QARDL) model proposed by Cho et al. (2016). This technique has various advantages over other techniques as discussed in the introduction section.

Keeping in view the oil-stock nexus, we believe that using QARDL model will provide a more comprehensive relationship between oil and stock prices especially in oil-exporting and oil-importing countries. The empirical findings would help portfolio managers to diversify their portfolios across oil-exporting and oil-importing countries to minimize risks and maximize returns. This empirical analysis would further help regulators, investors, and policymakers to understand the behavior of stock markets across different states of the oil markets and stock markets and hence formulate appropriate frameworks and better policies and/or investment decisions.

3. Data and methodology

3.1. Data

In this study, we examine the asymmetric effect of oil prices across various quantiles of the stock prices in oil-exporting and oil-importing countries. For this purpose, we use daily data from 25th September 1997 to 20th March 2020. The oil-exporting countries include Russia, Mexico, Venezuela, and Norway whereas oil-importing countries include India, China, Japan and South Korea. The Brent crude oil price

[1] The existing literature provides further details about ARDL and NARDL model (See for example Chang et al., 2019a; Chang et al., 2020b; Hashmi et al., 2020; Anjum et al., 2017).

[2] We are highly thankful to the reviewers for suggesting to compare this study in oil-exporting countries with oil-importing countries.

[3] Time horizon denotes the length of time over which an investment is made. It can range from seconds to decades. Day trader can make investments for seconds, minutes or for few hours whereas buy-and-hold investors can make investments up to the decades.

Table 1
Descriptive statistics.

Variables	Mean	Standard Deviation	Skewness	Kurtosis	Jarque-Bera
Oil prices					
Oil	57.24	28.25	0.36	2.26	256.73***
Stock prices of oil-exporting countries					
Norway	45427.74	45714.60	0.41	3.21	237.87***
Russia	1179.45	774.73	0.10	2.05	230.63***
Venezuela	4251.78	3524.94	0.63	1.93	542.43***
Mexico	28494.51	18124.14	0.28	1.63	536.46***
Stock prices of oil-importing countries					
India	3905.68	2833.29	0.58	2.21	481.93***
Japan	3124.57	1954.56	0.42	2.35	127.42***
South Korea	2341.32	4251.49	0.32	1.45	452.62***
China	2454.08	951.33	0.89	4.03	1026.53***

In this Table, we provide the descriptive statistics of oil prices and stock prices oil-exporting and oil-importing countries. The null hypothesis for Jarque-Bera statistics is that the data is normally distributed. *** denotes the rejection of the null hypothesis at a 1% significance level.

(BRT) is used as a proxy to measure oil prices and is collected from the Energy Information Administration (EIA). Besides, the stock price data for each country is collected from Bloomberg. Finally, this study uses 3 months T-bills data to represent an interest rate, which is used as a control variable in this study. This control variable is included in this study since existing literature considers it as an important variable in explaining the stock prices (Chen et al., 1986; Sadorsky, 2001). Table-1 provides descriptive statistics for oil prices and stock prices of oil-exporting and oil-importing countries. Besides, Figure-1 presents the time series plots of the variables used in this study.

3.2. Methodology

The ARDL model assumes that the dependent variable responds similarly to positive and negative changes in the explanatory variable. Therefore, this traditional ARDL model (Pesaran et al., 2001) ignores the asymmetric nature of the relationship between independent and dependent variables. The following equation represents this traditional ARDL model.

$$\Delta lnSP_t = \alpha_0 + \sum_{j=1}^{n_1} \alpha_{1,j}\Delta LnSP_{t-j} + \sum_{j=0}^{n_2} \alpha_{2,j}\Delta LnOIL_{t-j} + \sum_{j=0}^{n_3} \alpha_{3,j}\Delta LnINT_{t-j} + \phi_0 LnSP_{t-1} + \phi_1 LnOIL_{t-1} + \phi_2 LnINT_{t-1} + \vartheta_t \tag{1}$$

Where $\alpha_1 - \alpha_3$ indicate short-run coefficients, $\phi_0 - \phi_2$ indicate long-run coefficients. SP_t represents stock prices at time t, OIL_t represents oil prices and INT_t represents interest rate. Moreover, Ln added with each variable denotes the logarithmic form of each variable. Next, for examining the long-run co-integration, bounds test is used where the null hypothesis under this test statistics is that there is no co-integration and can be represented as $\phi_0 = \phi_1 = \phi_2 = 0$.

For examining the asymmetric relationship between dependent and independent variables, Shin et al. (2014) proposed an extended version of the ARDL model called asymmetric ARDL or nonlinear ARDL (NARDL) model. This model decomposes the independent variable into a partial sum of positive and negative changes. This study, therefore, uses NARDL model where oil prices are decomposed into a partial sum of positive and negative changes and this model is represented as given below:

$$LnOIL_t^- = \sum_{k=1}^{t} \Delta LnOIL_k^- = \sum_{k=1}^{t} min(\Delta OIL_k, 0) \tag{2}$$

Using equation-2, we obtain the following asymmetric ARDL model:

$$\Delta lnSP_t = \alpha_0 + \sum_{j=1}^{n_1} \alpha_{1,j}\Delta LnSP_{t-j} + \sum_{j=0}^{n_2} \alpha_{2,j}\Delta LnOIL_{t-j}^+ + \sum_{j=0}^{n_3} \alpha_{3,j}\Delta LnOIL_{t-j}^- + \sum_{j=0}^{4} \alpha_{4,j}\Delta LnINT_{t-j} + \phi_0 LnSP_{t-1} + \phi_1 \Delta LnOIL_{t-1}^+ + \phi_2 \Delta LnOIL_{t-1}^- + \phi_3 LnINT_{t-1} + \vartheta_t \tag{3}$$

Equation-3 presents the asymmetric ARDL model where all variables are same as explained in equation-1 except OIL_t^+ and OIL_t^- where these variables represent partial sum of positive and partial sum of negative changes in oil prices respectively. The long-run asymmetry is tested using the Wald test where the null hypothesis is that $\phi_1 = \phi_2$. Similarly, the short-run asymmetry is tested using the Wald test where the null hypothesis is that $\alpha_2 = \alpha_3$. In both cases, the rejection of the null hypothesis indicates an asymmetric relationship. Besides, $\beta^+ = \phi_1/\phi_0$ *and* $\beta^- = \phi_2/\phi_0$ determine the long-run positive and negative coefficients respectively. Finally, the bounds test in NARDL model can be tested using the null hypothesis $\phi_0 = \phi_1 = \phi_2 = \phi_3 = 0$.

Next, we use quantile ARDL (QARDL) model to examine the asymmetric effect of oil prices on the conditional distribution of the quantiles of stock prices in oil-exporting and oil-importing countries. Using this model, we divide the stock market into three conditions which are bullish, bearish and normal as per quantiles (Naifar, 2016; Mensi et al., 2014). The main advantage of this model is that it is more robust in terms of non-normal errors. It also incorporates the presence of outliers, heterogeneity, and skewness in the dependent variable. Moreover, it provides better results when the sample size is small. Finally, like ARDL and NARDL model, it is useful when the variables are integrated of either order zero I(0)) or one (I(1) (Anjum et al., 2017; Bhutto and Chang, 2019; Chang and Rajput, 2018; Chang et al., 2018, 2019b). However, this model fails to provide robust results when either of the variables is integrated of order two. Therefore, for examining the order of integration of the variables we use ADF and KPSS test statistics. After confirming the order of integration of the variables we proceed further and use the QARDL model proposed by Cho et al. (2016). Extension of ARDL model in the quantile framework leads to the following QARDL model which is based on the standard ARDL model present equation-1.

$$Q_{sp_t} = a(\tau)_0 + \sum_{i=1}^{n1} b_i(\tau)\Delta LnSP_{t-i} + \sum_{i=0}^{n2} c_i(\tau)\Delta LnOIL_{t-i} + \sum_{i=0}^{n3} d_i(\tau)\Delta LnINT_{t-i} + \alpha_1(\tau)LnSP_{t-1} + \alpha_2(\tau)LnOIL_{t-1} + \alpha_3(\tau)LnINT_{t-1} + e_t \tag{4}$$

To empirically analyze the relationship we use the following quantiles in this study.

$\tau \in \{0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 0.95\}$. Moreover, we test the short-run and long-run asymmetry using the Wald test. The short-run symmetry for equation (4) is tested by using the following null hypotheses:

$$H_0^s: \ c_i(0.05) = c_i(0.1) = \ldots = c_i(0.95)$$

Similarly, the long-run symmetry is tested by using the following hypotheses:

$$H_0^l: \ \alpha_2(0.05) = \alpha_2(0.1) = \ldots = \alpha_2(0.95)$$

Next, QARDL model is further extended by dividing the oil price series into partial sum of positive and negative changes and we call this extended model as quantile nonlinear ARDL (QNARDL) model. This extended model can be represented in equation-5 below.

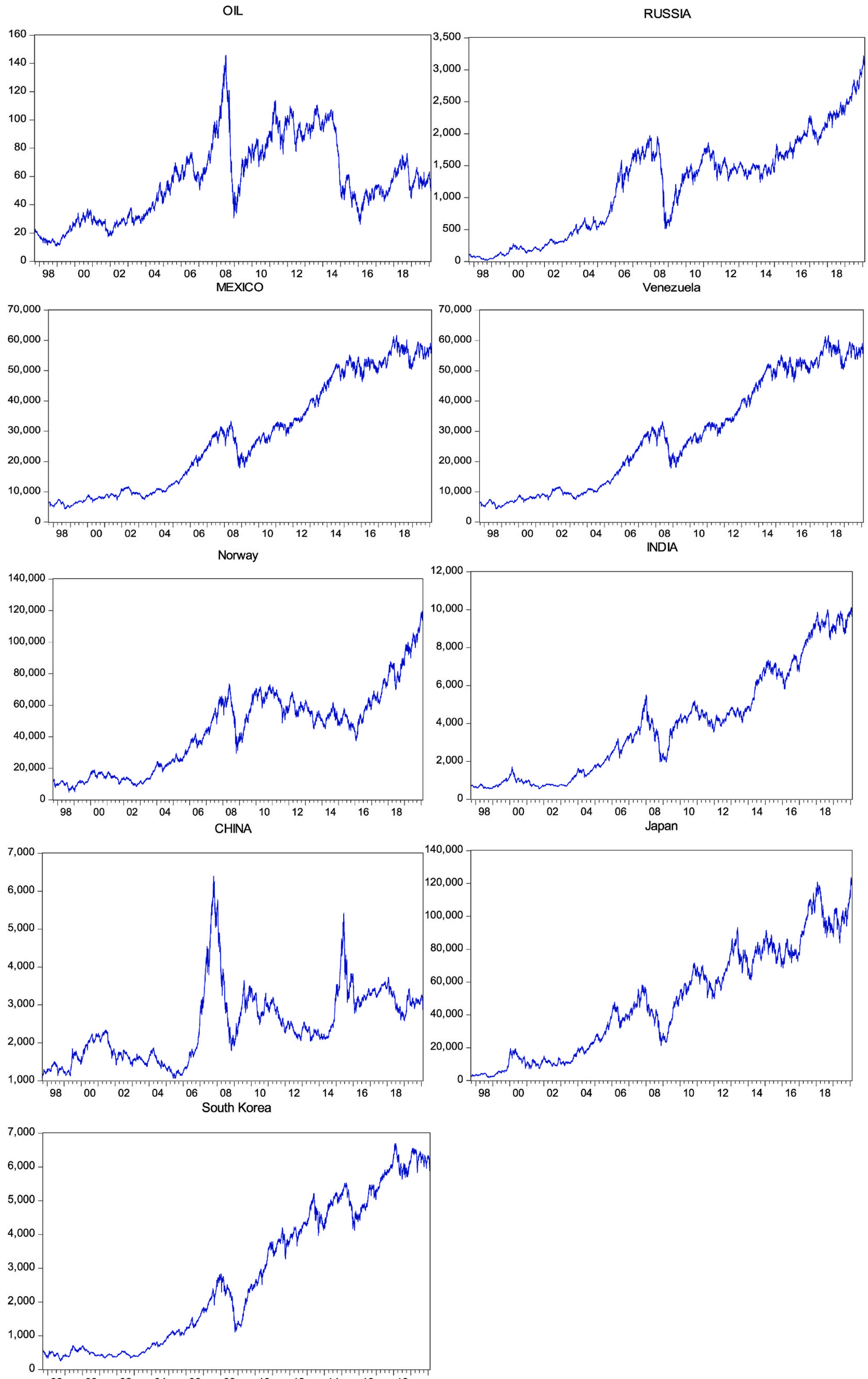

Fig. 1. Time series plots of the oil price and stock prices of oil-exporting and oil-importing countries.

Table 2
Unit root tests at the level and first difference.

Variables	ADF at level	ADF at first difference	KPSS at level	KPSS at first difference
Oil prices				
Oil prices	-2.01	-78.61***	0.14	0.43
Stock prices of oil-exporting countries				
Mexico	-1.03	-72.53***	9.63***	0.07
Russia	-1.41	-70.66***	7.88***	0.10
Norway	-2.12	-42.52***	5.32***	0.14
Venezuela	-1.98	-25.25***	6.35	0.21
Stock prices of oil-importing countries				
India	-0.76	-70.31***	9.35***	0.04
Japan	-1.21	-63.22***	6.24***	0.12
South Korea	-2.11	-54.42***	5.52***	0.18
China	-2.04	-75.72***	5.20***	0.09

This Table presents the ADF and KPSS test results used to examine the stationarity properties of the variables where these test statistics have been used both at the level and first difference. Stock prices for each country have been represented by the name of the respective country. The null hypothesis for the ADF test is that the data is nonstationary whereas the null hypothesis for KPSS test statistics is that data is stationary. *** indicates the rejection of the null hypothesis at a 1% significance level. The natural log is taken for both stock prices and oil prices before checking the stationarity of the variables.

$$Q_{sp_t} = a(\tau)_0 + \sum_{i=1}^{n1} b_i(\tau)\Delta LnSP_{t-i} + \sum_{i=0}^{n2} c_i^+(\tau)\Delta LnOIL_{t-i}^+ + \sum_{i=0}^{n3} c_i^-(\tau)\Delta LnOIL_{t-i}^- + \sum_{i=0}^{n4} d_i(\tau)\Delta LnINT_{t-i} + \alpha_1(\tau)LnSP_{t-1} + \alpha_2^+(\tau)LnOIL_{t-1}^+ + \alpha_3^-(\tau)LnOIL_{t-1}^- + \alpha_4(\tau)LnINT_{t-1} + e_t \tag{5}$$

Finally, for examining the goodness of fit of the model, we apply stability tests and diagnostic tests. Ramsey RESET test is used for model specification, serial correlation (LM) test is used for autocorrelation, CUSUM and CUSUMQ tests are used for checking the stability of the model and finally, adjusted r squared is used for checking the goodness of fit of the model.

4. Empirical results and their discussion

ARDL, NARDL and quantile ARDL model provide better results when the variables are integrated of either order zero I(0) or one I(1). Therefore, before proceeding further, this study uses ADF and KPSS test statistics to examine the integrating properties of the variables. Table 2 presents the results of both ADF and KPSS test statistics where both test statistics are used at the level and first difference. The null hypothesis for ADF test statistics is that data is nonstationary. The ADF estimates in Table 2 indicate that the null hypothesis is not rejected when the data is used at a level however it is rejected when the data is used at first difference. Therefore, these estimates indicate that all variables are integrated of order one which fulfills the requirement of the models used in this study. Besides, the estimates based on KPSS test statistics also support that the underlying variables are stationary either at the level or first difference. Since both ADF and KPSS test statistics support that all variables are either integrated of order zero I(0) or I(1), therefore, we proceed further in estimating the NARDL, QARDL and QNARDL models.

Table 3 presents the NARDL estimates for both oil-exporting and oil-

Table 3
Estimates from nonlinear ARDL model.

	Oil-exporting countries				Oil-importing countries			
	Russia	Mexico	Venezuela	Norway	India	China	Japan	South Korea
Panel A: Short-run coefficients								
ΔSP(-1)	0.68***	0.36***	0.12***	0.22	-0.81***	0.10	-0.27***	0.22
ΔSP(-2)	0.12	0.12	0.35	0.55***	0.14	-0.20	0.52	-0.45***
ΔSP(-3)	0.07	-0.34***	0.42	0.52	0.12	-0.34***	0.25	0.42
ΔOIL+	0.27***	0.72***	0.52***	0.62***	0.01	0.24*	-0.44***	-0.62***
ΔOIL+(-1)	-0.06	0.41***	0.32	0.23	0.11	0.22	0.43	0.25
ΔOIL+(-2)	0.62***	0.25	0.11	0.12	0.09	0.21	-0.42	-0.34
ΔOIL-	0.89***	0.11***	0.52***	0.42***	-0.16***	-0.56***	-0.64***	-0.86***
ΔOIL-(-1)	0.69***	0.28***	0.32**	0.52	0.07	-0.33**	-0.49**	-0.16
ΔINT	0.03**	0.03**	0.11**	0.12**	-0.03**	-0.03**	-0.33**	-0.43**
ΔINT(-1)	0.75***	0.75***	0.65***	0.78***	-0.75***	-0.75***	-0.55***	-0.95***
Panel B: Long-run coefficients								
OIL+	0.35	-0.49	0.14	-0.65	-0.53*	0.54	-0.54	-0.43
OIL-	0.52	-0.36	-0.65	-0.84	-0.67	-0.34	0.45	0.54
INT	0.43**	0.34*	0.47	0.64	0.72**	0.54*	0.54*	0.43*
Panel C: Diagnostics								
F-statistics	2.5	2.14	3.12*	1.54	2.21	3.12*	3.15*	3.42*
Reset	8.84	4.05	4.07***	0.84	2.19*	5.52***	1.31	2.21*
LM	0.35	1.01	0.03	7.59***	0.89	0.15	0.15	1.13
CUSUM	S	S	S	S	S	S	S	S
CUSUMQ	US	US	US	US	US	US	US	US
ECM	-0.12**	-0.71**	-0.42*	-0.23**	-0.31**	-0.32**	-0.23**	-0.32***
Adj. r^2	0.23	0.14	0.25	0.15	0.28	0.32	0.16	0.21
$Wald_{SR}$	2.01*	2.21**	2.31**	1.24	1.32*	2.03**	1.91*	2.35**
$Wald_{LR}$	0.98	0.85	0.78	0.46	1.91*	0.81	0.99	0.85

This Table presents results related to the NARDL model. Panel-A presents short-run results, Panel-B presents long-run results and Panel-C presents diagnostic test statics. F-statistics denotes the obtained f-statistics values for bounds test. $Wald_{SR}$ and $Wald_{LR}$ are the Wald tests used to check the short-run and long-run asymmetry respectively. ***, **, and * indicate that the null hypothesis is rejected at 1%, 5%, and 10% significance level. Stock prices, oil prices, and interest rates are transformed into a natural log before using the NARDL model.

Table 4
Quantile ARDL (QARDL) estimates.

	Oil-exporting countries				Oil-importing countries			
	Russia	Mexico	Venezuela	Norway	India	China	Japan	South Korea
Panel A: Short-run coefficients								
$Q_{0.05}$	0.21***	1.13***	0.54***	0.61***	-1.02***	-0.12**	-0.63***	-0.61***
$Q_{0.1}$	0.07***	0.26***	0.45***	0.33***	0.02	-0.71**	-0.34***	-0.33***
$Q_{0.2}$	0.01	0.13	-0.12	-0.11	0.02	-0.67*	-0.02	-0.11
$Q_{0.3}$	0.22***	0.82*	0.54	0.51	-0.12**	-0.06	0.53	0.51
$Q_{0.4}$	0.02	-0.26	1.34**	1.18**	-0.11**	0.52	-1.21**	-1.18**
$Q_{0.5}$	0.07	0.88**	-0.56	-0.71	-0.09*	0.52	-0.71	-0.71
$Q_{0.6}$	0.08	2.53	-0.64	-0.30	-0.35*	0.63	-0.36	-0.30
$Q_{0.7}$	0.01	0.58*	-1.12	-0.11	0.03	0.41	-1.12	-0.11
$Q_{0.8}$	0.16	1.56	1.86	0.19	-0.12	-0.47**	1.86	0.19
$Q_{0.9}$	-0.03	0.31	0.29	0.29	-0.08*	-0.52**	0.29	0.29
$Q_{0.95}$	-0.01	0.72*	0.02	0.21	0.01	-0.43-	0.02	0.21
Panel B: Long-run coefficients								
$Q_{0.05}$	0.24***	0.61**	0.52***	0.42***	-0.33***	-0.31**	-0.41***	-0.33***
$Q_{0.1}$	0.35	0.24	0.51	0.24	-0.13*	0.14	-0.45**	-0.14*
$Q_{0.2}$	0.61	-0.33	0.44*	-0.31	-0.31	-0.32	-0.52	-0.41
$Q_{0.3}$	0.60	0.17*	0.46**	0.47***	0.29	0.17	0.15	0.29
$Q_{0.4}$	-0.43	-0.42	-0.44***	0.71***	-0.42**	-0.23	-0.52	-0.61
$Q_{0.5}$	0.51	0.35	0.14	0.14	0.22**	0.24	-0.23	-0.15***
$Q_{0.6}$	0.53*	0.16*	0.23**	0.16	0.35	-0.18*	0.27**	0.17
$Q_{0.7}$	0.40	0.16*	0.47**	0.48***	0.47	0.17	0.27	0.24
$Q_{0.8}$	-0.43	-0.42	0.44***	0.81***	-0.61	-0.43	-0.42*	-0.81
$Q_{0.9}$	0.61	0.35	0.15	0.32	-0.32***	0.26	-0.73***	-0.42***
$Q_{0.95}$	0.73*	0.17*	0.22**	0.25	0.35	-0.19*	-0.27**	-0.35
Panel C: Diagnostics								
Reset	1.43*	0.31	1.32	1.41	1.02	1.75*	0.83	1.19*
LM	0.85	0.99	1.35	3.42**	1.25	1.42	1.03	1.72
CUSUM	S	S	S	S	S	S	S	S
CUSUMQ	S	US	S	S	S	S	S	S
ECM	-0.54***	-0.21***	-0.34***	-0.21***	-0.38***	-0.36***	-0.23***	-0.43***
Adj. r^2	0.43	0.34	0.45	0.42	0.41	0.32	0.51	0.42
$Wald_{SR}$	4.03***	3.91***	12.62***	3.24***	16.32***	6.31***	11.01***	12.21***
$Wald_{LR}$	2.81***	1.99*	4.91***	5.46***	1.91*	2.78***	1.98**	1.85*

This Table presents the findings based on quantile ARDL (QARDL) model. Panel A presents the results in the short-run, Panel B in the long-run and Panel C provides the diagnostic test statistics. *,** and *** denote the rejection of null hypothesis at 10%, 5%, and 1% significance level. Data for all variables is transformed into a natural logarithm before using the quantile ARDL model.

importing countries where panel-A presents the short-run estimates, panel-B presents the long-run estimates and finally, panel-C presents the diagnostic test statistics. The F-statistics value for bounds test (see for example Table 3, Panel-C) suggests that no co-integration exists in the long-run since the null hypothesis of no co-integration is not rejected at 5% significance level. The main reason for no co-integration maybe that stock markets respond differently to oil price shocks across different states of the stock markets (Badeeb and Lean, 2018). In other words, investors, policymakers and other stakeholders' decisions depend on the performance of stock markets that is either the stock market returns are quite high, average, or quite low. Basher et al. (2018) also support that stock market's response to oil price shocks depends upon the different states of the stock markets that is either the stock market is in bullish, bearish and normal states. However, the standard nonlinear ARDL model ignores these different stock market conditions. Moreover, the findings of our study are inconsistent with the findings of Badeeb and Lean (2018) since their study concluded that co-integration exists in seven out of ten sectorial stock indices. Another reason for these inconsistent findings may be that they conducted study in the context of Islamic indices where the behavior of Islamic stock indices is different from the normal stock indices.

Besides, the NARDL coefficients indicate that, in the short-run, positive and negative changes in oil prices do not have same effect on stock prices of oil-exporting and oil-importing countries. For example a 1% increase in oil prices increases stock returns in Russia by 0.27% whereas 1% decrease in oil prices decreases stock returns by 0.89%. Moreover, the coefficients at lag zero are different from those of the coefficients at lag 1. For example, for Norway, the coefficient for positive changes in oil prices is significant at lag zero only.

Next, Wald tests have been used to formally test whether the effect is symmetric or asymmetric both in the long-run ($Wald_{LR}$) and short-run ($Wald_{SR}$). In the long-run, the Wald test supports symmetric effect for all sample countries except India at a 10% significance level. In the short-run, the asymmetric effect is found in the case of South Korea, China, Venezuela and Mexico at a 5% significance level whereas for rest of the countries asymmetric effect is found at a 10% significance level except Norway.

As mentioned earlier, the standard nonlinear ARDL model decomposes only explanatory variables into a partial sum of positive and negative changes and it does not consider the effect across different quantiles of the dependent variable. However, existing literature suggests that stock markets' response to oil price shocks depends upon whether the stock markets are in bullish, bearish and normal states. Therefore, keeping in view the limitations of existing literature we use quantile ARDL (QARDL) model to examine the short-run and long-run effect across different states of the stock markets. For using this model, we decompose stock prices into nine quantiles and examine the effect of oil prices across nine quantiles of the stock prices in both oil-exporting and oil-importing countries. Table 4 presents the estimates of quantile ARDL model where panel-A presents the results in the short-run, panel-B in the long-run and panel-C presents the diagnostic test statistics. The short-run estimates (see Table 4, panel-A) indicate that stock prices of both oil-exporting and oil-importing countries respond differently to oil price shocks across different quantiles of the stock

Table 5
Quantile nonlinear ARDL (QNARDL) estimates for oil-exporting countries.

	Positive oil price shocks (OIL^+)				Negative oil price shocks (OIL^-)			
	Russia	Mexico	Venezuela	Norway	Russia	Mexico	Venezuela	Norway
Panel A: Short-run coefficients								
$Q_{0.05}$	0.32***	1.23***	0.52***	0.64***	0.34***	0.23***	10.12***	0.84***
$Q_{0.1}$	0.21***	0.36***	0.48***	0.35***	0.45***	0.56***	0.54***	0.65***
$Q_{0.2}$	0.12	-0.33	0.32	-0.31	0.42	0.53**	0.34	0.31***
$Q_{0.3}$	0.43***	0.85*	0.57	0.53	0.73***	0.45	0.45	0.55
$Q_{0.4}$	0.12	-0.36	1.37**	1.23**	0.42**	-0.56	1.65	1.25
$Q_{0.5}$	0.21	0.98**	0.66***	0.51	0.26	0.93	0.56	0.43
$Q_{0.6}$	-0.28	2.67	0.84**	0.50	-0.48	2.63	0.75	0.53
$Q_{0.7}$	-0.21	0.43**	1.32**	-0.41	-0.51	0.45	1.54**	-0.51
$Q_{0.8}$	0.23	1.23	1.89*	0.39*	0.25	1.28**	1.23**	0.45*
$Q_{0.9}$	0.12**	0.32**	0.26	0.59***	0.15*	2.33**	0.12***	0.67***
$Q_{0.95}$	0.21***	0.89**	0.04**	0.51**	0.24***	1.29**	0.32**	0.67***
Panel B: Long-run coefficients								
$Q_{0.05}$	0.34***	0.81***	0.42***	0.62***	0.36***	0.51***	0.72***	0.62***
$Q_{0.1}$	0.35***	0.44**	0.53	0.44	0.32***	0.54**	0.63**	0.34***
$Q_{0.2}$	0.63**	0.53*	0.54*	0.61	0.67**	0.83*	0.84*	0.81**
$Q_{0.3}$	0.63*	0.37*	0.48**	0.67***	0.83*	0.17*	0.68**	0.87***
$Q_{0.4}$	0.53	-0.62	0.54***	0.81***	0.83	-0.72	0.74	0.81
$Q_{0.5}$	0.53	0.65	0.44	0.17	0.58	0.75	0.84	0.57
$Q_{0.6}$	0.56*	0.36*	0.43**	0.46	0.56*	0.66*	0.83**	0.36
$Q_{0.7}$	0.44	0.36*	0.77**	0.68***	0.44	0.96*	0.97**	0.88*
$Q_{0.8}$	-0.73	-0.62	0.54	0.61***	-0.73	-0.72	0.84	0.91***
$Q_{0.9}$	0.66	0.37	0.55	0.36	0.66	0.35	0.65	0.96
$Q_{0.95}$	0.75*	0.37*	0.52**	0.27	0.75*	0.38*	0.55**	0.47
Panel C: Diagnostics								
Reset	1.23*	0.51	1.52	1.41	1.12	1.65*	0.87	1.29*
LM	0.65	0.69	1.55	3.22**	1.43	1.42	1.34	1.62*
CUSUM	S	S	S	S	S	S	S	S
CUSUMQ	S	US	S	S	S	S	S	S
ECM	-0.44***	-0.51***	-0.64***	-0.51***	-0.58***	-0.54***	-0.29***	-0.53***
Adj. r^2	0.45	0.38	0.65	0.82	0.51	0.23	0.65	0.62
$Wald_{SR}$	4.23***	3.94***	12.82***	3.64***	14.52***	7.51***	16.56***	12.41***
$Wald_{LR}$	2.51***	5.34*	4.61***	5.76***	8.84***	5.68***	6.76***	1.45*

This Table presents the findings based on quantile nonlinear ARDL (QNARDL) model for oil-exporting countries. Oil prices are decomposed into positive (OIL^+) and negative (OIL^-) oil price shock series and are used as explanatory variables. Panel A presents the results in the short-run, Panel B in the long-run and Panel C provides the diagnostic test statistics. *, ** and *** denote the rejection of null hypothesis at 10%, 5%, and 1% significance level. Data for all variables is transformed into a natural logarithm before using the quantile ARDL model.

prices. For example, oil prices significantly affect stock prices at lower quantiles ($Q_{0.05}$, $Q_{0.1}$) for both oil-exporting and oil-importing countries where this effect is positive for oil-exporting countries and negative for oil-importing countries. On the contrary, this effect is insignificant at upper quantiles for most of the countries except Mexico at $Q_{0.95}$, India at $Q_{0.9}$, and China at $Q_{0.9}$, and $Q_{0.85}$. Likewise, the long-run estimates (see Table 4, panel-B) also indicate that the effect varies across each quantile of the dependent variable. For example for Russia and Mexico, oil prices significantly affect stock prices at a 1% significance level at the lowest quantile ($Q_{0.05}$), whereas it is insignificant for most of the other quantiles. Likewise, for other countries, this significant effect varies across different quantiles. Moreover, like the findings in the short-run, the long-run findings are also positive for oil-exporting countries and negative for oil-importing countries.

These findings overall conclude that in the short- and long-run, stock prices asymmetrically respond to oil price shocks both in the oil-exporting and oil-importing countries, however, this effect is found positive in oil-exporting countries and negative in oil-importing countries. This positive and negative effect is consistent with the existing literature (Kilian and Park, 2009; Buetzer et al., 2012; Ding and Vo, 2012; Badeeb and Lean, 2018; Fedoseeva, 2018). Specifically, the asymmetric findings across different quantiles provide important policy implications. These findings suggest that investors, policymakers, and other stakeholders need to consider the stock market conditions before making investment, policy or other related decisions. Moreover, they also need to consider whether it's oil-exporting or oil-importing country since stock prices respond differently in both of these countries.

The diagnostic tests also indicate that QARDL model is more robust as compared to NARDL model. For example, CUSUM and CUSUMQ tests have been used to check the stability of the models where findings indicate that QARDL model (see CUSUM and CUSUMQ results in Table 4) is more stable as compared to NARDL model (see CUSUM and CUSUMQ results in Table 4). Likewise, adjusted r-squared present in panel-C of Tables 3 and 4 also indicate that QARDL model enjoys a better fit than the NARDL model.

For robustness purposes, we extend QARDL model by decomposing oil prices into positive and negative oil price shocks and examine the effect of both positive and negative shocks in oil prices across different quantiles of the stock prices. Tables 5 and 6 present the estimates when oil prices have been divided into two oil price shocks. Table 5 presents the results for oil-exporting countries and Table 6 presents the results for oil-importing countries. The findings in these Tables also present an asymmetric effects across different quantiles. Moreover, these findings are also mostly positive for oil-exporting countries and negative for oil-importing countries.

5. Conclusion

Oil prices play an important role in explaining stock prices. Therefore, various empirical studies have been conducted to examine the relationship between oil prices and stock prices. Moreover, recent literature further examines that stock prices asymmetrically respond to

Table 6
Quantile nonlinear ARDL (QNARDL) estimates for oil-importing countries.

	Positive oil price shocks (OIL^+)				Negative oil price shocks (OIL^-)			
	India	China	Japan	South Korea	India	China	Japan	South Korea
Panel A: Short-run coefficients								
$Q_{0.05}$	-1.23***	-0.45**	-0.63***	-0.63***	-1.43***	-0.47**	-0.53***	-0.93***
$Q_{0.1}$	-0.21	-0.65**	-0.54***	-0.34***	-0.51	-0.67**	-0.56***	-0.54***
$Q_{0.2}$	0.05	-0.67*	-0.22**	-0.21**	0.45	-0.69*	-0.43**	-0.51**
$Q_{0.3}$	-0.16**	-0.26	0.57*	-0.54**	-0.36**	-0.24	0.45***	-0.44**
$Q_{0.4}$	-0.13**	0.34	1.21**	-0.18**	-0.33**	0.37	1.21**	-0.38**
$Q_{0.5}$	-0.14*	0.45	-0.74	-0.74	-0.24*	0.42	-0.44	-0.64
$Q_{0.6}$	-0.45*	0.43	-0.34	-0.33	-0.46*	0.45	-0.24	-0.43
$Q_{0.7}$	0.12	0.56	-1.32	-0.13	0.14	0.58	-1.62	-0.73
$Q_{0.8}$	-0.32	-0.77**	1.83	0.16	-0.52	-0.57**	1.87	0.76
$Q_{0.9}$	-0.48*	-0.56**	-0.26*	-0.27	-0.68***	-0.86**	-0.46*	-0.67
$Q_{0.95}$	0.34	-0.63**	-0.23**	-0.25*	-0.67**	-0.93**	-0.63**	-0.55*
Panel B: Long-run coefficients								
$Q_{0.05}$	-0.53***	-0.41**	0.51	-0.53***	-0.33***	-0.71***	0.31***	-0.43***
$Q_{0.1}$	-0.23*	-0.44**	-0.51	-0.34*	-0.43***	-0.64**	-0.41***	-0.54***
$Q_{0.2}$	-0.41	-0.42	-0.62	0.61	-0.21**	-0.52	-0.66**	0.51**
$Q_{0.3}$	0.49	0.47	0.55	0.59	0.47	0.77	0.56	0.49
$Q_{0.4}$	-0.82	-0.43	-0.72	0.41	-0.62	-0.63	-0.42	0.31
$Q_{0.5}$	-0.27***	0.44	-0.53	-0.35***	-0.67***	0.84	-0.83	-0.55
$Q_{0.6}$	0.37	0.38*	-0.57**	0.47	0.34	0.78*	-0.57**	0.45
$Q_{0.7}$	0.49	0.27	0.57	0.54	0.44	0.57	0.53	0.56
$Q_{0.8}$	-0.41	-0.53	-0.62	-0.91	-0.31	-0.93	-0.52	-0.61
$Q_{0.9}$	-0.52***	0.56	-0.83***	-0.72***	-0.92***	0.86	-0.63***	-0.52***
$Q_{0.95}$	0.65	-0.39**	-0.47**	0.55	0.69	-0.79**	-0.67**	-0.59***
Panel C: Diagnostics								
Reset	1.33*	0.41	1.45	1.21	1.42	1.75*	0.47	1.24*
LM	0.35	0.59	1.45	1.76*	1.13	1.42	1.14	1.65*
CUSUM	S	US	S	S	S	S	S	S
CUSUMQ	S	S	S	US	S	S	S	S
ECM	-0.34***	-0.41***	-0.94***	-0.31***	-0.48***	-0.34***	-0.39***	-0.63***
Adj. r^2	0.35	0.58	0.95	0.42	0.57	0.53	0.71	0.82
$Wald_{SR}$	4.43***	3.54***	12.42***	4.44***	12.92***	7.91***	15.26***	8.51***
$Wald_{LR}$	2.41***	5.64*	14.11***	8.54***	10.44***	9.48***	12.56***	12.45***

This Table presents the findings based on quantile nonlinear ARDL (QNARDL) model for oil-importing countries. Oil prices are decomposed into positive (OIL^+) and negative (OIL^-) oil price shock series and are used as explanatory variables. Panel A presents the results in the short-run, Panel B in the long-run, and Panel C provides the diagnostic test statistics. *, ** and *** denote the rejection of null hypothesis at 10%, 5%, and 1% significance level. Data for all variables is transformed into natural logarithm before using the quantile ARDL model.

oil price shocks. This study extends the existing literature in three ways. First, this study examines the short-run and long-run effects across different stock market conditions. For this purpose, we use a recent methodology called quantile ARDL (QARDL) model proposed by Cho et al. (2016) and compare the QARDL findings with the standard NARDL model. Second, using this enhanced methodology, this study compares the findings in both oil-exporting and oil-importing countries. Third, this study further divides the oil prices into positive and negative oil price series and examines the short-run and long-run effect of these negative and positive oil price series across bullish, bearish and normal states of the stock markets and name this extended model as quantile nonlinear ARDL (QNARDL) model.

The NARDL findings indicate that no co-integration exists in the long-run for both oil-exporting and oil-importing countries. In the short-run, stock prices in Mexico, Venezuela, China, and South Korea asymmetrically respond to oil prices at a 5% significance level whereas for rest of the countries they asymmetrically respond at a 10% significance level. The QARDL estimates indicate that, in the short- and long-run, stock prices asymmetrically respond to oil price shocks in both oil-exporting and oil-importing countries. Moreover, the findings of QNARDL model are consistent with the findings of QARDL model.

This study provides important implications for investors, policy-makers and other stakeholders. Since the QARDL estimates, in the long-run, are different from those of NARDL model, which indicates that making investments or other policy decisions without considering the various stock market conditions may result in unfavorable consequences. For example, in the long-run, stock prices of Russia and Mexico asymmetrically and positively respond to oil prices shocks at the lowest quantile (i.e $Q_{0.05}$) which indicates that an increase in oil prices may benefit the investors during the stock markets' recession period. On the contrary, during the recession period (i.e $Q_{0.05}$), stock prices negatively respond to oil price shocks in oil-importing countries, therefore, an increase in oil prices may hurt the investors who have invested in stock markets of oil-importing countries.

Author statement

Shabir Mohsin Hashmi: Obtained data, estimated the results and wrote methodology and results discussion section. **Bisharat Hussain Chang:** Wrote the introduction, and literature review section. **Niaz Ahmed Bhutto:** Wrote the conclusion, abstract and proof read the whole manuscript.

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