Volatility Spillover between the Oil Market and Stock Market: Evidence from Oil Revenue-Dependent Countries

Abstract

This paper investigates volatility transmission between oil revenue-dependent countries' stock markets and oil price. We employed the Toda-Yamamoto causality procedure, dynamic conditional correlation (DCC) and the diagonal BEKK models to examine volatility transmissions between oil price and stock indices of these countries, disentangling the process into pre-crisis, crisis, and post-crisis periods. The outcome established the existence of volatility transmissions between oil price and the tested assets, revealing more volatility transmission during periods of pre-financial crisis. We also determine the implication of forward sales for oil revenue-dependent countries' oil reserves. Results present a diverse range of policy suggestions for the selected countries.

JEL classification: G11; G12
Keywords: Oil price, Stock markets, Hedging, Volatility transmission

1. INTRODUCTION

Like other primary commodities, crude oil is a source of revenue for its exporting countries. However, oil price volatility continues to constitute a problem in the commodity market, which exposes oil revenue-dependent countries[1] to adverse economic consequences. The direct consequence of oil price volatility for a dependent country could be revenue uncertainty, particularly where there may be a high expenditure dependence on the commodity. Such a development leads to concerns in terms of planning for the sustainable level of domestic investment and government spending. Wang et al. (2013) and Khalifa et al. (2017) have evinced the adverse effect of crude oil shock on the economies of oil revenue-dependent countries. While some of the countries can lever on the existence of investment opportunities to hedge against the revenue fluctuation from oil price volatility, others are increasingly exposed to the adverse consequences.[2] This paper investigates volatility transmissions between major oil revenue-dependent countries' stock markets and oil price. We also examine the ability of oil reserves forward selling to provide potential hedge for the oil price volatility problem of oil revenue export-dependent countries. The countries under study are Canada,

[1] We define a crude oil revenue-dependent country based on multiple criteria: (i) a net exporter of crude oil, (ii) among top 15 exporters of crude oil, (iii) among top 20 producers of crude oil, and (iv) exporting up to 1m barrels of crude oil a day. The qualifying countries are selected based on the classification provided in the Energy Information Administration's top oil exporters, the World Bank's countries' outlook as well as the CIA's World Factbook (Central Intelligence Agency, 2014; Energy Information Administration, 2019; World Bank, 2015). See also Kilian and Park (2009) and Wang et al. (2013) for similar criteria definition.

[2] Norway is one oil export revenue-dependent country considered successful at managing its oil proceeds (see Caner and Grennes, 2010; Cleary, 2016; Murtinu and Scalera, 2016; van der Ploeg and Venables, 2011). The country achieved this status using a platform called the Government Pension Fund Global (GPFG) to invest its oil revenue around the world financial markets (Norges Bank Investment Management, 2020). The Norwegian authorities therefore make use of the global equity markets as a hedging mechanism for the country's oil revenue. The approaches which other oil export revenue-dependent economies employ to manage their oil proceeds differ in terms of assets allocation (Sovereign Wealth Fund Institute, 2015). However, the act of focusing oil revenue investments activities outside the domestic stock market may be costing these countries a staggering opportunity to benefit their economies. Perhaps the latest move by the Saudi Arabian Oil Company (Aramco) to list its initial public offering (IPO) into the Saudi Stock Exchange (Tadawul) on 11th December 2019 is an eye opener to other oil revenue-dependent countries alike. As of April 2021, Aramco had the third highest market capitalization (USD 1.89T) in the world.

Mexico, Nigeria, Norway, Qatar, Russia, Saudi Arabia, United Arab Emirates (UAE) and Venezuela. We also investigate the potential effect of the financial crises on the transmission between the oil market and the stock markets.

Empirical studies are increasingly seeking to understand the relationships between oil price and other assets, with stock and gold spots being the most prominent ones (see Agyei-Ampomah et al., 2014; Degiannakis et al., 2014; Ewing and Malik, 2016; Hood and Malik, 2013; Kang et al., 2015; Malik and Ewing, 2009). Outcomes from some of these studies have found evidence of volatility transmission between stock prices and oil price (see Ewing and Malik, 2016; Malik and Ewing, 2009).[3] What is not immediately clear is whether oil revenue-dependent countries' stock markets are able to hedge oil price volatility: this is particularly the case given some of the countries' refusal to invest their own oil proceeds in their stock markets.[4] For example, Norway has a policy of not investing its oil fund in the Norwegian stock market (Norges Bank Investment Management, 2020).

This paper makes two specific contributions to the extant literature. First, we focus on investigating volatility transmissions between oil revenue-dependent countries' stock markets and oil price. We approach this by studying volatility transmission between oil price and the stock indices of selected oil revenue-dependent countries during crisis and crisis-free periods. This is in addition to contrasting the same position between oil price and world stock index. Since Malik and Ewing (2009), many studies have examined the potential for volatility transmission between various stock markets and oil spots with the resulting potential for cross-

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[3] In addition to these extant works, Ewing and Malik (2013), Hood and Malik (2013), Agyei-Ampomah et al. (2014) and, to an extent, Choudhry et al. (2015) all suggested that gold could also be used to hedge against volatility in stock prices and oil, among other commodities.

[4] This is despite the finding in Wang and Liu (2016) which indicates the stocks of oil-exporting countries is a better hedge against crude oil price risk as compared with the stocks of oil-importing countries.

market hedging. The case of volatility transmission between the stock indices of oil revenue-dependent countries are rare, noting that Basher et al. (2018) studied the impact of oil-market shocks on stock returns of major oil-exporting countries. Their approach, which focused on identifying shock drivers of oil prices and its impact on stock returns, offers little suggestion on the major oil revenue dependent countries' revenue situation. Thus, we see a compelling need to broaden the scope of countries and study their stock indices returns for response to oil price changes under different outcomes. The potential for cross/market hedging between oil price and stock market returns in this approach is based on the example in Ewing and Malik (2016), and Maghyereh et al. (2016), among others. Thus, the instance of the Norway decision not to invest its oil fund in the Norwegian stock market could be empirically ascertained for policy effectiveness. This is coupled with the decision by Saudi Arabian Oil Company (Aramco) to list its shares in the Saudi Stock Exchange (Tadawul).

The second contribution examines whether forward selling of oil reserves could lead to optimal revenue yield and attain a hedge potential for the oil price volatility problem of oil revenue export-dependent countries. Mohammadi and Su (2010), Kang and Yoon (2013) and Cheng et al. (2019) provided the empirical impetus to achieving oil price forecast. Czudaj (2019) empirically demonstrated how crude oil futures trading was possible in the face of uncertainty. Daniel (2002) argues that governments can take positions in the oil risk markets due to the unpredictable nature of oil prices. It should be noted that purchasing (consumption) or selling (production) oil prices can be locked in by the governments of the oil-exporting and oil-importing countries by hedging instruments (i.e., forwards) which would then stabilise the cost and revenue streams. Thus, by selling forward oil, revenue-dependent countries can make a good forecast of their future-related revenues. Both van der Ploeg (2010) and Borensztein et al. (2013) illustrated how this may be possible, but without a concrete forecast. We extend this logic by examining the forward sales potentials through forecasting the future value of revenue dependent countries' oil stock applying the autoregressive integrated moving average (ARIMA) model. This helps to determine the optimal sales potentials of the stock[5], as Daniel (2002) specifically advocated two ways (including forward selling) for an oil producer to hedge against significant price drop.

Therefore, the primary focus of this paper is to understand volatility transmission between crude oil revenue-dependent countries' stock markets, crude oil price, and global stock market returns. Also, we consider the forward selling potential of oil reserves in determining the optimal sales position. Our overall aim is to produce useful policy guidance for investment decision-makers and attain a revenue enhancement target for crude oil revenue-dependent countries in the face of price volatility. Thus, we employ a combination of Toda-Yamamoto causality procedure, dynamic conditional correlation (DCC) and the diagonal BEKK (Baba, Engle, Kraft, and Kroner) GARCH models to examine volatility transmissions between oil price and stock indices of these countries, disentangling the process into pre-crisis, crisis, and post-crisis periods.[6] Our results establish the existence of volatility transmissions between oil price and stock indices of crude oil export revenue-dependent countries; between oil price and world stock index. Further results suggest that a financial crisis period is more amenable to

[5] This paper further investigates volatility spillover between the gold market and the oil market. In this way, gold's ability to hedge risk in the old market can be studied. Our results from these tests are not presented but available on request.

[6] Basher and Sadorsky (2016) adopted three different types of multivariate GARCH approach: dynamic conditional correlation (DCC) (see also Nguyen et al., 2020), asymmetric dynamic conditional correlation (ADCC) and generalised orthogonal GARCH (GO-GARCH), with a greater focus on the latter which they noted was less applied in the extant literature. The study investigated emerging market stock prices, oil prices, VIX, gold prices and bond prices and found similar outcomes, with the ADCC model having more efficient hedge ratios. Lin et al. (2014) similarly applied VAR–GARCH, VAR–AGARCH and DCC–GARCH in volatility transmission between oil market and Ghanaian stock market returns while drawing a comparison with the Nigerian stock market. This is an interesting scenario investigating a wider dimension of oil revenue-dependent countries' stock market indices.

volatility transmission between oil price and examined countries' stock indices. Our forecast outcome of oil reserves indicates a favourable outlook for forward sales: crude oil revenue-dependent countries may be in a better position to forward sell their oil reserves to mitigate the effect of oil price volatility and hence earn better managed stable revenues.

This paper proceeds as follows. Section 2 provides the literature review and section 3 explains the methodology and model. Data and sample construction in section 4 explains the variables of choice. Data analysis, results and discussions are provided in section 5. Section 6 discusses some of the policy implications. Section 7 concludes.

2. LITERATURE REVIEW

The body of literature examining viability of stock markets in hedging oil price volatility has increased in recent years (see e.g., Park and Ratti, 2008; Malik and Ewing, 2009; Arouri et al., 2011; Degiannakis et al., 2014; Kang et al., 2015). A number of papers have directly analyzed the volatility transmissions regarding the oil prices and equity markets: Filis et al. (2011) examine the demand- and supply-originated oil price shocks and their impact on stock market movements for the six oil-importing and oil-exporting countries during 1987-2009. They use the dynamic conditional correlation asymmetric GARCH method and find that non-economic crises lead to a stronger negative association between oil prices and stock markets via precautionary demand shocks, but economic crises or booms cause a positive link between oil prices and stock markets. They further find that -unlike the demand side-supply side shocks do not affect this association.

Arouri et al. (2012) examine the association between oil prices and the European stock markets with specific reference to sectoral level indices to examine the presence of volatility transmissions. Based on the VAR-GARCH specification that takes the dynamics of conditional volatility into account, the authors find that the intensity of volatility interactions is sector-dependent. For instance, the automobile &parts sector does not bear any significant volatility effect, whereas there is significant transmission of volatility for the financial sector, which highlights the importance of the degree of oil dependence. The paper shows further the varying levels of optimal hedge ratios across sectors. Guesmi and Fattoum (2014) study the co-movements and dynamic volatility spillovers between stock markets and oil prices for nine oil-exporting and oil-importing countries. Using the multivariate GJR-DCC-GARCH specification, they report that there is no difference between these countries regarding dynamic correlations whereas precautionary demand shocks or worldwide crises heighten the positive correlations for the cross-market co-movements. They note that oil assets do not seem to be effective hedging tools while they obtain a direct link between oil prices and stock market trends.

Using the causality-in-variance tests, Bouri and Demirer (2016) report a volatility spillover from oil prices to stock markets especially for the oil-exporting countries and this effect is present for the oil-importing countries following the 2008 global financial crisis. Wang and Liu (2016) investigate the volatility spillover between crude oil price and stock market movements by acknowledging the differences between the oil-importing and oil-exporting countries in terms of the susceptibility of their economic activities to the oil price shocks. The authors also provide evidence, during 2000-2011, based on out-of-sample predictability as they state that in-sample evidence would be incomplete due to lower forecasting performance. Using the multivariate BEKK-GARCH models, they report that the volatility spillover (positive correlations) from the oil market to the stock markets are stronger for oil-exporting countries compared to the oil-importing peers. Regarding the consideration of stock markets as investment tools for hedging, it is shown that investing in the stocks of oil-exporting countries is more effective than those in the oil-importing countries as the former are less sensitive to the significant oil price changes.

Basher et al. (2018) assess the impact of oil shocks on stock prices in major oil exporting countries. They consider oil shocks related to demand, supply and speculative-demand and market-related idiosyncratic changes. Using the multi-factor Markov-switching technique that allows volatility to vary across regimes, they find that the shocks have significant effects on the excess returns, except in the case of Mexico. The findings further reveal that switching between equities in the low volatility state and T-bills in the high volatility state yields better returns than the buy-and-hold strategy. Khalfaoui et al. (2019) use the symmetric and asymmetric dynamic conditional correlation GARCH models to study interdependence between stock markets and oil prices in four oil-exporting and oil-importing countries during 2010-2016. They reveal that oil market volatility influences the stock markets in these countries, negative shocks causing more significant consequences. Further, it is suggested that investors in oil-exporting countries should hold more oil assets to hedge the risk relative to the investors in oil-importing countries.

Daniel (2002) suggested a more practical hedging mechanism in advocating a two-way approach which recognises the effectiveness of forward selling and insurance purchase for the oil stock in stabilising the oil revenue dependent countries income streams from the product. Further to this, he suggests that governments can resort to the use of crude futures contracts as well as the options contracts strategy. Over the counter (non-exchange) instruments such as oil swaps or oil-indexed bonds could be the alternative hedging strategies. The list can include the forward sales as well. Chang et al. (2011) adopt the multivariate GARCH models to obtain optimal portfolio weights for the international crude oil markets. The authors suggest several trading strategies for hedging depending on the market: it is feasible to hold more oil futures than spot for Brent but for WTI holding more crude oil futures relative to spot is optimal. Overall, taking short positions in crude oil futures and long positions in crude oil spot can benefit the oil producing countries. In a recent study, Wang et al. (2020) highlight the importance of crude oil exporting countries' political risks whilst managing financial risks related to crude oil imports. Their recommendation to the oil-importing countries is the use of forward oil purchases to deal with especially physical risk (e.g., transportation and political risks). This then implies that forward oil sales are associated with oil-exporting countries.

Siddiqui et al. (2019) study 10 oil-exporting and oil-importing countries to investigate the time-varying link between oil and stock prices with the nonlinear autoregressive distributed lag models during 2014-2016. They report that negative oil price shocks have larger impact than positive shocks on stock prices in the oil-exporting countries and the effects are stronger in the oil-importing countries than their counterparts. Jiang and Yoon (2020) adopt the wavelet analyses to establish a simultaneous link between oil prices and stock markets for six oil-exporting and oil-importing economies. They find that the impact of oil price shocks on stock prices is stronger in oil-exporting countries than oil-importing economies and the co-movements are stronger during 2007-2012 that includes the financial crisis. The approach examined several country-specific instances and outlined their results. He et al. (2020) studied the impact of oil price uncertainty in the risk-return nexus of stock markets in oil-importing and oil-exporting countries by adopting the GARCH-M models. They find that there is a positive (negative) risk-return association during low (high) price uncertainty. It is found that the negative link is more apparent in oil-exporting countries and for the post-crisis years.

Malik and Ewing (2009) investigated volatility transmission between oil prices and different equity sectors of the Dow Jones and found supporting evidence for cross-market hedging between equity sectors and oil prices. In this paper we focus on the potentials of oil revenue-dependent countries' stock indices to provide oil spot with volatility hedging mechanism, an area which the extant literature has failed to address. By focusing on the hedging need of oil revenue-dependent countries, we aim to narrow the identified gaps in the extant literature. Testing for volatility transmission between the stock indices of oil revenue-dependent countries and crude oil price will determine whether oil-producing countries' stock markets are able to hedge for oil price volatility, and will also help us to understand the economic dynamics associated with the policy decision of not investing oil revenues in the countries' stock markets. Further, some analyses are conducted using the world stock index and gold spot index.

In examining the stock market indices of oil revenue-dependent countries, we aim for an inherent risk factor mitigation strategy. This is given as per our knowledge that oil revenue-dependent countries do not currently invest their oil revenue in their stock markets; the earlier-cited Norwegian case is a good example. Caner and Grennes (2010) show that despite the country's oil fund investment return in the global equity market is higher than the stock market average, the portfolio risk is riskier than the stock market risk, which further confirms this point.

3. DATA AND METHODOLOGY

We apply daily Brent crude oil spot price (representing oil spot), Brent futures price, gold spot, World stock index and national stock indices of nine crude oil export revenue-dependent countries.[7] Also, annual crude oil reserves' data in respect of the sampled countries in this study

[7] Although it is not possible to directly substitute one type of oil for another, we still expect that oil with similar characteristics (e.g., sweetness) will cointegrate very strongly; Nigeria's Bonny Light and Brent are good examples. Bachmeier and Griffin (2006) examined time-series relationships among WTI, Brent, Alaska North Slope, Dubai Fateh, and the Indonesian Arun and concluded that they are all closely linked. Brent is chosen as representative of oil spot on the strength of it being the benchmark for crude oil production from the African, Middle Eastern and European continents where most of the examined countries in this paper are located. Also, since we are looking to find a numeraire price for the countries concerned, we picked the series that has the highest

were examined. The range of the daily data applied depends on the availability for each individual country.[8] Our selected countries are Canada (1 January 1990-30 September 2019), Mexico (1 January 1990-30 September 2019), Nigeria (19 January 2000-30 September 2019), Norway (1 January 1990-30 September 2019), Qatar (31 May 2005-30 September 2019), Russia (1 September 1995-30 September 2019), Saudi Arabia (19 October 1998-30 September 2019), the United Arab Emirates (UAE) (1 January 2004-30 September 2019) and Venezuela (1 April 1993-30 September 2019).[9] These countries qualified for inclusion in the sample based on the criteria listed in footnote 1 and between them accounted for nearly 70% of the global crude oil exports in 2015[10] (Energy Information Administration, 2019). Interestingly, we find that the six countries adopted in Wang et al. (2013) for their analysis of world major oil exporting countries also qualify under our criteria and are included in our sample; these are Saudi Arabia, Mexico, Norway, Russia, Venezuela and Canada. All data are obtained from the Thomson Reuters Datastream.

The world stock index is applied to give a broader perspective and alternative to provide oil-producing countries with volatility hedging mechanism. The world stock index is seen here as a potentially useful proxy given its low probability to highly correlate with the oil price;

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traded volume or production volume; in this instance, the 'Brent'. This is given that we are attempting to find effective hedging instrument(s) against the most relevant price risk that producers are facing. The gold spot is based on the Standard and Poor's index, a choice which is based on availability and wider application. The world stock index being applied here is the Morgan Stanley Capital International (MSCI). The choice is based on its wide applicability in similar studies (see e.g., Hammoudeh and Choi, 2006).

[8] In addition to availability, data coverage was also influenced by the need to cover financial crisis periods to test for crisis period influence on our markets' variables in relation to our research question.

[9] Data availability and significant period coverage determined our countries selection. For instance, Angola, Iran and Libya fulfilled our four qualifying criteria of oil export revenue-dependent countries; however, as we could not have significant data on their stock indices, we excluded them from our sample.

[10] Even though some of the countries we included in our data sample have low turnover of stock market activities, we added them since they have functional stock markets in addition to attaining the criteria set out in footnote 1. For example, even though most of the included Middle Eastern countries have less active stock markets, they are functional and thus qualified.

hence, it may be a ‘safe haven’ asset. It is assumed that the world stock market index is able to capture global stock market reactions, thus creating an avenue for broader comparison. Again, the world stock market could capture the situation of crude oil dependence in terms of consumption.[11]

We also analysed the annual crude oil reserve data of nine selected countries ranging from 1980 to 2018[12] to understand the trend and volume of the available commodity for each of the selected countries of interest. This further allows us to form an understanding of per-country oil volumes and thus supports the notion or otherwise of the forward sales potentials in relation to optimal revenue generation for the countries. Brent futures price is included as a variable to measure oil prices as a forecast index, the outcome of which will give us an indication of whether the oil price is forward stable, falling, or rising. Such information will allow for the decision ‘whether to forward sale’ and even help with the informed decision on the amount to sale.

As stated earlier we employ the Toda-Yamamoto causality procedure to test the causality between variables and enhance the robustness of our GARCH results. We choose this approach given that the standard Granger causality method is not consistent, as it employs the Wald test only in a long-run equilibrium situation. Toda and Yamamoto (1995) suggested employing modified Wald (M-Wald) test statistics, which is not conditional upon the cointegration and

[11] Finally, the gold spot is brought in to capture alternative investment avenues for crude oil revenue, and for consideration of a commodity which may not be serially correlated with stock returns. We choose gold spot for its ability to remain more stable over time compared with stock market indices and crude oil spot prices. This is due to increasing empirical evidence that gold spot has the potential to serve as a safe haven for sovereign debt and other assets class (Agyei-Ampomah et al., 2014; Ewing and Malik, 2013; Hood and Malik, 2013). Also, as shown by Choudhry et al. (2015) gold spot can remain comparatively more stable than stock market return during volatile periods like the global financial crisis. Thus, gold spot displays far more predictable price changes than the world stock market index does, even during volatile times.

[12] The period coverage herein is based on crude oil reserves data availability for the sampled countries.

stationarity properties of series but has the standard asymptotic distribution. In addition, unlike the Granger test that is based on first differencing, this procedure employs variables in levels and hence mitigates the risk of wrongly identifying the order of variables' integration (*I*). This model, as adopted in Amiri and Ventelou (2012) and Tahir et al. (2017), is presented below:

$$Y_t = \alpha_0 + \sum_{i=1}^{k} \beta_{1i} Y_{t-i} + \sum_{j=k+1}^{dmax} \beta_{2i} Y_{t-j} + \sum_{i=1}^{k} \lambda_{1i} X_{t-i} + \sum_{j=k+1}^{dmax} \lambda_{2i} X_{t-j} + \varepsilon_t \qquad (1)^{13}$$

The model includes our exogenous binary dummy variable. We use a standard unrestricted VAR(*k*) setting and the optimal lag length is determined by the Akaike information and Schwarz criteria. The notation *dmax* is the maximal order of integration that this procedure requires to artificially extend the VAR system. The new augmented system will therefore have the order "*k* + *dmax*". The earliest lag is used for all variables to treat them as exogenous whereas the latest lags are assigned to the same variables to treat them as endogenous. To justify the presence of causality from *X* to *Y* in equation (1), λs should be statistically different from zero. Thus, the relevant null hypothesis is that 'there is no causality from variable *X* to variable *Y*'.

3.1 Bivariate GARCH (BEKK) model specification

We adopt the diagonal BEKK from Engle and Kroner (1995) as the model to examine volatility transmissions among oil price and stock market indices. The model which estimates conditional variance and conditional covariance is applied to analyse volatility transmissions among data series. We choose this model over other available multivariate GARCH methods for its relative ability to constrain the parameter space in volatility estimates while retaining sufficient flexibility to adequately characterize the data-generating process (see Zhang and Choudhry,

[13] We did not show for brevity other equations in which the dependent variable is one of the six factors.

2015 for comparison of the BEKK with other related models). Engle and Kroner (1995) and Kroner and Ng (1998) detailed the theoretical reasoning behind the model application, while Basher and Sadorsky (2016) highlighted the model's tendency to have a poorly-behaved likelihood function, thus making estimation difficult. We deal with this resulting estimation difficulty by estimating two variables at the same time, just as BEKK models are typically estimated in the extant literature – see Malik and Ewing (2009), Ewing and Malik (2013) and Green et al. (2018). Also, consistent with Basher and Sadorsky (2016), we applied the dynamic condition correlation GARCH (DCC GARCH) model to estimate the variance and covariance correlations. This DCC specification is applied to back the BEKK results and takes care of the noted weaknesses of the BEKK model.[14]

The model application will begin with the multivariate conditional variance specification below:

$$z_t = \delta z_t + \varepsilon_t, \qquad \varepsilon_t \sim N(\mathbf{0},\ \boldsymbol{h_t}) \tag{2}$$

where $\boldsymbol{z_t} = [\boldsymbol{y_{1t}} \;\; \boldsymbol{y_{2t}}]$ is a (2x1) vector containing returns from asset *i* and asset *n*. $\boldsymbol{\varepsilon_t} = [\boldsymbol{\varepsilon_{1t}} \;\; \boldsymbol{\varepsilon_{2t}}]$ and $\boldsymbol{h_t} = \begin{bmatrix} h_{11t} & h_{12t} \\ h_{21t} & h_{22t} \end{bmatrix}$ is the covariance matrix. Application of GARCH will normally require a parameterisation process which works to restrict $\boldsymbol{h_t}$ to be positive and definite for all values of $\boldsymbol{\varepsilon_t}$. $\delta = [\delta_1 \; \delta_2]$ is a 2x1 matrix of parameters that measures the effect of returns from asset *i* on returns from asset *n* and vice-versa.

The following setting presents the BEKK bivariate GARCH (1,1), with K=1.

$$H_t = C'C + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'H_{t-1}B \tag{3}$$

$$H_t = C'C + \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix}' \begin{bmatrix} \varepsilon^2{}_{1,t-1} & \varepsilon_{1,t-1}\varepsilon_{2.t-1} \\ \varepsilon_{2,t-1}\varepsilon_{1,t-1} & \varepsilon^2{}_{2,t-1} \end{bmatrix} \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} + \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix}' H_{t-1} \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix}$$

[14] The DCC results are not reported for brevity but they are available upon request.

where C is a 2x2 lower triangular matrix in the conditional variance equation with intercept parameters, A and B are 2x2 square matrices of parameters. ε_t is the matrix composed of the residual terms for the mean equations. The parameters in *A* represent the conditional variances of the two variables are correlated with past squared errors. The off-diagonal elements are related to how the past squared error of one variable impacts the conditional variance of another variable. The volatility linkages are accounted for via the parameters A_{12} and A_{21}. The diagonal element A_{11} shows the ARCH process in the residuals from the asset *i* equation and the elements A_{22} shows the ARCH process in the residuals from the asset *n* equation.

The parameters in *B* illustrate as to whether the current levels of conditional variances are correlated with past conditional variances. More specifically, the diagonal elements (i.e., B_{11} and B_{22}) reflect the level of persistence in the conditional variances. The off-diagonal elements (i.e., B_{12} and B_{21}) reveal the extent to which the conditional variance of one variable is correlated with the lagged conditional variance of another variable. High values of off-diagonal elements imply a correlation between volatility of two variables.

The diagonal BEKK GARCH (1,1) following Engle and Kroner (1995) is specified below; it is devoid of other considerations and implemented given a diagonal representation which avoids complications related to large parameterization.

$$\boldsymbol{h_{11,t} = \alpha_{01} + \alpha_{11}\varepsilon^2_{1,t-1} + \beta_{11}h_{11,t-1}} \quad (\boldsymbol{4a})$$

$$\boldsymbol{h_{12,t} = \alpha_{02} + \alpha_{22}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + \beta_{22}h_{12,t-1}} \quad (\boldsymbol{4b})$$

$$\boldsymbol{h_{22,t} = \alpha_{03} + \alpha_{33}\varepsilon^2_{2,t-1} + \beta_{33}h_{22,t-1}} \quad (\boldsymbol{4c})$$

where $\mathbf{h_{11,t}}$ and $\mathbf{h_{22,t}}$ are conditional variances for the series oil and stock index in each country, or oil and world stock index, each representing the GARCH (1,1) process used in assessing the impact of one-series shock on its volatility. $\mathbf{h_{12,t}}$ is the conditional covariance equation, which could simultaneously assess the effect of the shocks and volatility impact on both series capturing the impact of transmission between the two series of oil price and stock market return, as against the one-direction test exhibited by the conditional variance process. Further, α_{01}, α_{02} and α_{03} are the constant coefficients testing the mean return of the different series. Further, α_{11} and α_{33} are coefficients for the autoregressive conditional heteroskedasticity (ARCH) terms. Next, β_{11} and β_{33} are coefficients for the GARCH terms. The notations $\varepsilon^2{}_1$ and $\varepsilon^2{}_2$ are unexpected volatility or shocks, capturing the effect of news on each model or series and seen as a direct effect of the shock; $\varepsilon^2{}_{t-1}$ is past volatility news or shock; and $\varepsilon_{1,t}$ $\varepsilon_{2,t}$ is the cross-effect of news, as originated from any of the series and affecting the other, seen as indirect effect of news. All coefficients capture the level of impact of the shocks being measured.

We implement the ARIMA model to account for the future price pattern of crude oil. This procedure potentially provides a hedge potential to the problem of oil price volatility and offers oil revenue export-dependent countries a revenue improvement approach. Finally, we implement the break tests of Perron and Vogelsang (1992) to investigate the existence of possible structural break(s). The structural break(s) identification is important in implementing our main BEKK model as we aim to vary the data analysis to reflect financial crises and other likely break periods. Thus, it is crucial to understand whether the periods influenced our applied variables to attain a more robust outcome.

5. DATA ANALYSIS, RESULTS AND DISCUSSION

For the sake of analysis, the applied variables are represented with their acronyms in parentheses: Oil spot (OIL), oil futures (OIF), oil reserve of the crude oil export revenue-dependent countries included in the sample are defined as follows: Canada Oil Reserve (CNR), Russia Oil Reserve (RSR), Mexico Oil Reserve (MXR), Nigeria Oil Reserve (NGR), Norway Oil Reserve (NWR), Qatar Oil Reserve (QAR), Venezuela Oil Reserve (VER), UAE Oil

Reserve (UAR) and Saudi Arabia Oil Reserve (SAR). Gold spot is GLD and World stock index is WOS. The stock indices of nine crude oil export revenue-dependent countries are labelled as follows: Canada (CAS), Mexico (MES), Nigeria (NIS), Norway (NOS), Qatar (QAS), Russia (RUS), Saudi Arabia (SAS), the UAE (UAS), and Venezuela (VES). We transformed all stock prices and oil price in their natural logarithms forms to allow for uniformity in the analyses. We carried out varying levels of checks and diagnostic processes on the data sample to ensure suitability for the analysis.

5.1 Preliminary data sample assessment

Simple data checks on our data sample reveal that most of the stock indices are volatile as per the descriptive statistics in Table 1 below. For instance, the stock indices of Mexico and Nigeria are the most volatile as they returned the highest standard deviations. Gold spot was relatively more stable than the stock indices. Although oil spot witnessed fluctuations over the observed period, it has low variation compared to the stock indices.

[INSERT TABLE 1 HERE]

The outcome of the descriptive statistics in Table 1 above suggested unstable oil and stock indices in some countries; this confirmed the susceptibility of the variables to price volatility. We implemented a breakpoint test to determine possible structural break(s) in the data series which could affect the data analysis outcome. Diaz et al. (2016) and Ewing and Malik (2016) examined and identified structural break(s) in their studies, an outcome which they adopted in shaping their subsequent data analysis. Table 2 below presents the outcome of breakpoint tests which indicates more of the analyzed countries' samples as having a major break during the third quarter of 2008, a period which coincides with the financial crisis period. These identified break periods relate to Canada, Qatar, and the UAE, thus indicating that these countries' stock markets are affected by the financial crisis. Thus, the outcome here indicates a potential to change the course of our main data analysis outcome. We responded to this situation by stratifying our main data analysis into sub-samples which isolated the financial crisis period from pre-and post-financial crisis periods.[15]

[INSERT TABLE 2 HERE]

The Toda-Yamamoto (1995) causality process was implemented to increase the rigor of the empirical processes. The technique suggested using modified Wald (M-Wald) test statistics, a procedure which is not conditional upon the cointegration and stationarity properties of series but has the standard asymptotic distribution. We also employ variables in levels, a position which mitigates the risk of wrongly identifying the order of variables' integration (I). Table 3 shows the outcome of the Toda-Yamamoto test for our data series in panels A to I. From the table, we can see oil price has influence on other associating variables for all applied countries' data series, except in Venezuela and the UAE. Specifically, oil price is significant in explaining (i.e. causing) the variation in the stock's indices of Mexico, Norway, Qatar, Russia, and Saudi Arabia. Even though causality does not imply economic significance, we can assert that this outcome is not surprising for these countries whose economies are dependent on oil export revenues. As for the remaining four economies of Nigeria, Canada, the UAE, and Venezuela, it is also not very surprising that oil does not cause their stock indices despite their heavy economic dependence on the commodity's revenue. The reason for this could be that these economies are at best internally more diversified or at worst failing to allow their major sectors to benefit from the impact of oil revenue. Another expected finding is that the world stock

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[15] This is following our adoption of period in our data series before1 January2007 as the pre-financial crisis period, 1 January 2007 – 31 December 2011 as the financial crisis period and 1 January 2012 – 30 September 2019 as the post-financial crisis period. This approach in data series demarcation is increasingly used in extant literature; see the examples in Choudhry et al. (2015) and Kang et al. (2017).

index very strongly causes individual country stock market indices in all countries except Mexico and Venezuela.[16]

[INSERT TABLE 3 HERE]

Hence, the application of the breakpoint test and Toda-Yamamoto procedures brings additional rigor to our main model of application and at the same time demonstrates methodological innovation – if not novelty – in our results. We thus move to implement the BEKK and the DCC models as complemented by the ARIMA forecast in the next section with confidence in the overall process and using the information from this section as a guide.

5.2 Examining volatility transmission among applied variables

Following the determination of causality direction between oil spot and other markets in the sample, the focus here is to determine volatility transmissions between returns in the selected markets. The diagonal BEKK models are applied to analyze the conditional variance of the series to determine how volatility in each data series affects itself. We also determine the conditional covariance between oil prices and stock indices, thus determining volatility transmissions between the said variables. We mainly estimated ten GARCH models in each case containing oil returns and the corresponding stock markets returns, examining them for volatility transmission during the pre-crisis, crisis, and post-crisis periods, in addition to the whole sample analysis. The breakpoint tests we conducted for the countries' data series suggested the reoccurrence of structural break(s) during the financial crisis period of 2008 in

[16] Furthermore, gold price appears to significantly cause market indices in Canada, Norway, Qatar, Russia, and Saudi Arabia only. The other notable finding is that gold price is being caused by the stock market movements in Canada, Qatar, and Saudi Arabia whereas oil price is being caused by the stock market movements in Canada, Norway, Russia, the UAE and Venezuela. Finally, two-way causality between gold and oil prices is reported in Canada, Mexico, and Qatar.

more of the countries' samples. Thus, in addition to the total sample data-series testing, we split the BEKK analyses into three separate periods, respectively representing pre-financial crisis period, during financial crisis period, and post-financial crisis period. Choudhry et al. (2015) and Kang et al. (2017) both apply the GARCH methods in their analyses.

Tables 4a, 4b, 4c and 4d present the BEKK results. The oil conditional variance is described by $\mathbf{h_{11}}$ in the estimates with each representing the GARCH (1, 1); $\mathbf{h_{22,t}}$ presents the conditional variance of stock market; $h_{12,t}$ is conditional covariance between oil returns and its corresponding stock returns as all defined in Equations 4a, 4b and 4c. This is qualified either by the news (shock) effect ε^2 within the oil or equity markets (in each model case) or the cross values of the error terms $\boldsymbol{\varepsilon_{t-1}^2}$ which represents news effect originating either from the oil or equity market. Figures in parentheses are the *z*-statistics.

Table 4a presents the BEKK results for the total sample. The ARCH coefficients for oil price and stock indices ($\boldsymbol{\alpha_{11}}$ and $\boldsymbol{\alpha_{33}}$) are significant, and less than unity in most cases. The significance of ARCH coefficients implies the existence of the ARCH process in the error term which suggests volatility clustering around the variables. Also, as the ARCH coefficients are mostly less than unity (absolute value) in size, this is a situation which indicates a non-explosive magnitude of the effect imposed by the lagged error terms ($\boldsymbol{\varepsilon_{1,t-1}^2}$ and $\boldsymbol{\varepsilon_{2,t-1}^2}$) on the conditional variances $\boldsymbol{h_{11}}$ and $\boldsymbol{h_{22}}$. Also, the results indicate that the GARCH coefficients ($\boldsymbol{\beta_{11}}$ and $\boldsymbol{\beta_{33}}$) in all tests are significant, implying the persistence in the series' volatility process. The coefficient $\boldsymbol{\delta_1}$ measures the effect of returns in the stock market on the oil market returns and $\boldsymbol{\delta_2}$ measures vice versa. Both coefficients are positive and significant in each test. The oil market return tends to impose a larger effect on the stock market.

The BEKK results in Tables 4b, 4c and 4d are the outcomes from pre-financial crisis, the financial crisis data series, and the post-financial crisis periods, respectively. The ARCH and GARCH results are similar to those for the total sample period results. The effect of returns between the stock market and the oil market are mostly positive and significant. In very few cases, the ARCH effect and the GARCH effect are negative and significant, implying non clustering volatility. Only in the case of Qatar during the pre-financial and post financial periods $\boldsymbol{\delta_1}$ and $\boldsymbol{\delta_2}$ are negative and significant. These results imply oil market returns and stock market returns of Qatar inversely affect each other.

Our results show the evidence of significant conditional covariance between the two variables of oil spot and stock indices in most of the examined cases. The total sample and pre-crisis periods provide the most evidence of a significant conditional covariance. This evidence is found especially between world stock index and the oil prices and using the Canadian data. The Gulf countries in our sample provide ample evidence of volatility transmission with Saudi Arabia providing the least evidence. On the other hand, Venezuela presents little evidence of transmission. Thus, we provide evidence of volatility transmission between the oil market and the stock markets of the countries under this study.[17]

Therefore, the outcome of the above BEKK process has established the existence of volatility transmissions between the series under study and thus hedging potential for the oil revenue of crude oil revenue export-dependent countries. This is consistent with extant studies; for example, in the related case of Arouri et al. (2011), the authors found evidence of volatility transmission between oil price and the stock markets of oil export dependent GCC countries.

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[17] There is also evidence of volatility spillover between the oil market and the gold market during the whole sample and pre-crisis period.

This is confirmed in the case of all Gulf countries present in our sample (Qatar, Saudi Arabia, and the UAE). We find a similar pattern of results between the BEKK outcome and the earlier finding in the Toda-Yamamoto causality test outcome. Thus, the process outcomes confirm each other.

Consistent with the approach in Basher and Sadorsky (2016), we verify the outcome of the BEKK model for both conformity and robustness by employing the DCC GARCH model. Estimations of the ARCH and GARCH coefficients are somewhat like the BEKK results. Both the ARCH and GARCH coefficients are positive and less than unity in size. The results remained positive and significant, even when we isolated and tested the data series separately in respect of pre-financial crisis data series, the financial crisis data series, and the post-financial crisis data series. This is except in the case which represents GARCH 1 process for Qatar's financial data series interaction where the *z*-statistic returned an insignificant figure of GARCH equation term in the $\mathbf{h_{11,t}}$ (i.e., 0.08).

[INSERT TABLES 4a-4d HERE]

The results indicate conditional covariance relationship between oil prices and the other variables are equally significant in all instances of the data series, except for the cases of the entire sample tests for Nigeria. Oil price and Venezuela stock index also returned insignificant results during the total sample and the during the crisis sample periods. Finally, the covariance relationships between oil prices and Mexico and the UAE's stock indices are insignificant during pre-financial crisis period. The DCC model shows significant volatility spillover between the oil and the gold markets during all four periods. Both the BEKK and the DCC models provide similar results regarding the volatility spillover, though the DCC models do provide little more evidence of the volatility transmission (DCC results are not reported but available on request). Most of the evidence is provided during the post crisis period.

5.3 Forward selling of oil reserves

The second contribution of this paper examines whether forward selling of oil reserves could lead to an optimal revenue yield for oil revenue-dependent countries. We provide the details of the relevant implications in the next section. Here, we make good of the approach in Mohammadi and Su (2010), Kang and Yoon (2013) and Cheng et al. (2019) by forecasting the forward selling potential of oil revenue-dependent countries reserves.

Governments can play active roles in the oil risk markets owing to the volatile oil prices. The consumption or production oil prices, for instance, can be fixed by the governments of the oil-exporting and oil-importing countries via hedging transactions. These positions can stabilise the cost and sales revenue streams in the national accounts of such countries (Daniel, 2002). In addition, it is shown that taking short positions in crude oil futures and long positions in crude oil spot tend to be beneficial for the oil producing economies (Chang et al., 2011). Wang et al. (2020) study the importance of crude oil exporting countries' political risks in order to manage financial risks stemming from importing crude oil via forward oil purchases, implying also that forward oil sales are appropriate for the oil-exporting economies. The literature further shows why crude oil futures trading is reasonable during turbulent and uncertain times. By selling forward oil, oil-exporting economies benefit from the forecast of their future revenues (Borensztein et al., 2013; Czudaj, 2019).

Figure 1 below presents a time-varying movement of the sample countries' oil reserves. We can see that the oil reserves in most of the countries are increasing over time, thus suggesting the potential to forward sale without inhibiting or depleting the reserve levels.

[INSERT FIGURE 1 HERE]

We forecast the forward sales potentials of oil spot and futures using the ARIMA model. Figures 2 and 3 below are the respective one-year constant forecasts of oil spot and futures which indicate steady and stable upward movement pattern over the forecast periods. This is against the actual prices which were susceptible to volatility over time as they indicate adverse upward and downward movements. This outcome is generally indicative of useful information for forward sales of oil reserves.

[INSERT FIGURES 2-3 HERE]

Figure 4 is the constant forecast of oil futures with oil spot as the exogenous variable and Figure 5 indicates the constant forecast of oil spot with oil futures as the exogenous variable. Both figures suggest a further stable and steady upward movement, which literally indicates better pricing of the commodity.

[INSERT FIGURES 4-5 HERE]

6. POLICY IMPLICATIONS

Crude oil revenue-dependent countries' reliance on the commodity's income for budgetary and other expenditure may prove unhealthy - this is largely due to associated price volatility as demonstrated in van der Ploeg (2010). An oil revenue-dependent country may contemplate a policy to forward sale part of its reserves to meet revenue obligations or guarantee future sales of the commodity, or even to manage an associated price volatility problem. This contemplation may work in favour of the oil revenue-dependent countries' fiscal balance – or not: that is, in favour if the forward sales are optimal against the spot sales, but against if otherwise. What has become evident from the empirical results of this paper is that selling forward could be favourable to the oil revenue-dependent countries; this is given the outcome of oil spot and futures which indicate steady and stable upward movement pattern over the forecast periods.

Also, the decision taken by oil-dependent countries on whether it is optimal to invest the oil revenue proceeds in their own stock markets represents an important policy outcome for this paper. This is owing to the volatility transmission outcome which suggests that oil revenue-dependent countries' stock markets can provide a hedge potential for oil price volatility. Hence, oil revenue-dependent countries' refusal to invest their own oil proceeds in their stock markets is a rather suboptimal approach. The recent listing of Saudi Aramco's shares in Tadawul will go a long way to bring to bear the practical implications of an oil revenue-dependent country investing its revenue in its domestic stock exchange, a decision which the empirical findings of this paper support.

Again, given the discovery of volatility transmissions between oil price and stock indices of crude oil export revenue-dependent countries, and oil price and world stock index, and these countries may consider setting up derivative trading platforms. Such platforms should exist alongside the domestic stock exchanges, which would further deepen the interaction between oil spot and stock exchanges of oil revenue-dependent countries. At present, most of the oil revenue-dependent countries examined in our sample do not have any existing derivative trading platforms. The policy implication of having such a platform in place is that it will help to domesticate the process risk transfer usually associated with the uncertain nature of oil trading. Equally, it will provide the trading window for the forward selling of the crude oil reserve which is part of our empirical finding suggested has the potential to help reduce the revenue uncertainty associated with oil trading. It will also provide a budget benchmarking platform for the countries, thereby reducing the incidences of budget variances for the countries.

On balance, most of the oil revenue-dependent countries belong to a cartel or trade agreement like the Organisation of Petroleum Exporting Countries (OPEC) which may cap the volume of sales per period. This example of cartel agreement may hinder the decision on whether to forward sell or not. Also, the current trade war raging between the United States of America and China may imply negotiations which could force China, for example, to buy oil from the US. This is because the USA now holds the status of net exporter of the commodity and this occurrence will reduce demand from the oil revenue-dependent countries, particularly given China's tendency for high oil consumption. The major policy thrust to counter this likely scenario is to deploy a proactive strategy which could inform any of the above as guided by the empirical evidence.

7. CONCLUSION

This paper examined volatility transmissions between the oil market and stock markets of nine oil exporting countries. The countries under study are Canada, Mexico, Nigeria, Norway, Qatar, Russia, Saudi Arabia, the United Arab Emirates (UAE) and Venezuela. Thus, we study the ability of these countries' stock market to hedge the risk in the oil market. The paper contributes to the literature in two major ways which investigated not only the transmission of the volatility between the individual stock markets and oil market, but also the effects of the financial crisis of 2008-09 on the volatility transmission. Additionally, we examined forward selling of oil reserves for optimal revenue yield and hedge potential for the oil price volatility problem of oil revenue export-dependent countries.

The ability of the world stock index to hedge against the oil market risk is also investigated. We employed daily data with different time range for each country but all sample end on 30 September 2019. The empirical investigation is conducted by means of the Toda-Yamamoto causality procedure, and two GARCH models (diagonal BEKK and DCC). The volatility transmission process is investigated during three periods: i.e., pre-financial crisis, during crisis, and post-crisis periods. This way, the change in the hedging ability of the stock market before, during and after the crisis may be analyzed. We further examined forward sales' potential for crude oil export revenue-dependent countries' oil reserves. This examines whether forward selling of oil reserves could lead to optimal revenue yield and attain a hedge potential for the oil price volatility problem of oil revenue export-dependent countries.

Overall, we established the existence of volatility transmissions between oil price and stock indices of the nine countries under study and between oil price and world stock index. Further scrutiny of the applied data series suggested that the financial crisis period is amenable to volatility transmission between oil price and examined countries' stock indices. Thus, we provide evidence of the stock markets of these countries being a good hedge against risk in the oil market during all periods under study, including the pre-crisis and crisis periods. This result is backed by both GARCH models (BEKK and DCC) and the causality tests. Equally, forecast outcome of oil reserves indicates a favourable outlook for forward sales. A key implication of this result is that crude oil revenue-dependent countries may be able to forward sell oil reserves to manage the effect of oil price volatility and earn better revenue.

The outcomes of this paper's empirical investigation are diverse policy suggestions for oil export revenue-dependent countries. For instance, for an oil revenue-dependent country like Norway, investing 60% of its GPFG into foreign equity may not be optimal given the outcome of this paper's empirical process, which suggests that the Norwegian domestic stock index would provide a better hedging mechanism for oil price. However, we must point out here that the world stock index could also help to diversify oil revenue investments. Another policy suggestion of this paper's finding is that, outside periods of financial crisis, there is also evidence of volatility spillover between the oil and the stock markets. The implication of this outcome is that we have hedge potential in financial crisis as compared to outside crisis periods. A further policy dimension here is the need for the different oil export revenue-dependent countries to understand the extent of their economies' tendency to depend on crude oil revenue for growth. This will enable them to deal with the issue of crude oil price changes based on their need, particularly as we know that different oil export revenue-dependent countries are endowed with different economic characteristics.

Finally, our overall empirical findings have diverse implications for further academic studies. For instance, this paper's empirical process could be extended towards finding out whether the oil revenue export revenue-dependent countries' stock markets have the capacity to accommodate substantial oil revenue investments of the oil export revenue-dependent countries. Also, in extending the current paper, future studies may examine economies with expected similar reactions to oil price volatility like OPEC in relation to their cartel position. Again, oil-exporting countries' current interest in investing their oil proceeds into the Sovereign Wealth Fund (SWF) could be empirically examined.

Data availability statement

Data subject to third party restrictions:

The data that support the findings of this study are available from Refinitiv/Thomson Reuters Datastream. Restrictions apply to the availability of these data, which were used under institutional license for this study. Data can be available from the authors conditional upon the permission of Refinitiv/Thomson Reuters.

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TABLE 1 Descriptive Statistics

Series	Mean	Median	Maximum	Minimum	Std. Dev.
CAS	9520.98	9287.40	16899.69	3009.91	4149.86
MES	19892.76	11864.42	51713.38	417.43	17509.99
NIS	27274.14	25851.50	66371.19	5395.50	12013.46
NOS	348.01	236.68	1079.15	42.34	266.57
QAS	796.77	787.09	1248.92	375.30	160.36
RUS	915.21	930.39	2487.92	38.53	603.66
VES	1097.70	25.67	25458.74	0.01	3378.85
SAS	6647.02	6808.45	20624.84	1313.58	3275.49
UAS	3207.31	3072.35	8484.63	1000.00	1553.14
OIF	49.26	38.27	146.08	9.64	33.20
OIL	49.32	39.40	145.61	9.55	33.07
WOS	1169.47	1152.02	2248.93	423.15	456.76
GLD	247.69	247.03	1101.48	148.00	271.24

Notes. Oil spot = OIL, OIF = Oil futures, Gold spot = GLD, World stock index = WOS. Stock indices of the crude oil export revenue-dependent countries in our sample are labelled as follows: Canada = CAS, Mexico = MES, Nigeria = NIS, Norway = NOS, Qatar = QAS, Russia = RUS, Saudi Arabia = SAS, the UAE = UAS and Venezuela = VES. See footnote 1 for the definition criteria in selecting the crude oil-dependent countries in our sample.

TABLE 2 Break point Test (Intercept Only)

Test at Level				Test at First Differences			
Data Series	**Lag Length**	**ADF *t*-stat**	**Break point**	**Data Series**	**Lag Length**	**ADF *t*-stat**	**Break point**
$\boldsymbol{CAS_t}$	0	-2.4811	09/10/2002	$\Delta \boldsymbol{CAS_t}$	0	-82.3190*	20/11/2008
$\boldsymbol{MES_t}$	2	-4.0267	01/04/2003	$\Delta \boldsymbol{MES_t}$	1	-58.9040*	27/10/1997
$\boldsymbol{NIS_t}$	2	-3.0877	20/12/2002	$\Delta \boldsymbol{NIS_t}$	1	-41.6430*	01/01/2015
$\boldsymbol{NOS_t}$	0	-3.2722	25/02/2003	$\Delta \boldsymbol{NOS_t}$	0	-81.0787*	27/08/1992
$\boldsymbol{QAS_t}$	1	-2.5090	31/10/2005	$\Delta \boldsymbol{QAS_t}$	0	-52.4971*	15/09/2008
$\boldsymbol{RUS_t}$	4	-3.2306	08/10/2001	$\Delta \boldsymbol{RUS_t}$	0	-89.8318*	03/01/2001
$\boldsymbol{SAS_t}$	1	-3.5888	17/03/2003	$\Delta \boldsymbol{SAS_t}$	0	-65.2168*	12/05/2006
$\boldsymbol{UAS_t}$	6	-3.1949	02/03/2009	$\Delta \boldsymbol{UAS_t}$	4	-28.2881*	28/11/2008
$\boldsymbol{VES_t}$	5	-2.1399	18/01/2012	$\Delta \boldsymbol{VES_t}$	4	-30.1098*	22/05/2015
$\boldsymbol{OIL_t}$	0	-3.4757	19/09/2003	$\Delta \boldsymbol{OIL_t}$	0	-83.8936*	17/01/1991
$\boldsymbol{WOS_t}$	2	-2.5014	23/01/1995	$\Delta \boldsymbol{WOS_t}$	1	-58.9087*	06/10/2008
$\boldsymbol{GLD_t}$	0	-3.5107	30/08/2005	$\Delta \boldsymbol{GLD_t}$	0	-84.7543*	15/4/2013

Notes. Variables on the left panel are presented in levels whereas the variables on the right panel are presented in first differences. Tests (including lag length) were determined based on the Schwarz information criterion (SC). The asterisk * indicates statistical significance at the 1% level. The augmented Dickey-Fuller (ADF) test is applied to examine the stochastic structure of the variables involved. The results indicate that all series are stationary at first differences at the 1% significance level. In both panels and for all countries, identifying a structural break point has been possible.

TABLE 3 Toda Yamamoto (T-Y) procedure for Granger causality

Panel A: Canada	**CAS**	**GLD**	**OIL**	**WOS**
CAS	-	10.6261*	5.1072	59.9060***
OIL	42.2766***	9.9625*	-	3.5133
WOS	14.1953**	7.8489	12.7103**	-

Panel B: Mexico	**MES**	**GLD**	**OIL**	**WOS**
MES	-	3.6991	12.4949**	8.2425
OIL	4.4583	11.638**	-	20.2607***
WOS	28.5241***	5.8002	11.9327**	-

Panel C: Nigeria	**NIS**	**GLD**	**OIL**	**WOS**
NIS	-	7.0344	5.9554	18.6964***
OIL	6.5669	7.8736	-	41.1975***
WOS	3.4850	6.6149	4.2097	-

Panel D: Norway	**NOS**	**GLD**	**OIL**	**WOS**
NOS	-	15.2488***	32.0682***	461.403***
OIL	12.050**	12.426**	-	32.6060***
WOS	43.1798***	5.3056	8.0685	-

Panel E: Qatar	**QAS**	**GLD**	**OIL**	**WOS**
QAS	-	21.4420***	12.8130**	195.244***
OIL	4.0736	12.806**	-	54.2904***
WOS	10.7486*	12.002**	5.6434	-

Panel F: Russia	**RUS**	**GLD**	**OIL**	**WOS**
RUS	-	18.3861***	18.5439***	167.423***
OIL	9.5174*	8.9084	-	50.939***
WOS	10.9687*	6.7733	2.0887	-

Panel G: S. Arabia	**SAS**	**GLD**	**OIL**	**WOS**
SAS	-	9.7276*	20.9732***	77.5037***
OIL	0.5303	7.8535	-	47.10543***
WOS	15.634***	5.1583	3.2616	-

Panel H: UAE	**UAS**	**GLD**	**OIL**	**WOS**
UAS	-	6.4888	3.5391	96.9597***
OIL	12.643**	10.059*	-	49.755***
WOS				-

Panel I: Venezuela	**VES**	**GLD**	**OIL**	**WOS**
VES	-	7.6287	3.8791	8.1153
OIL	9.93623*	9.0491	-	40.7930***
WOS	5.3057	5.7148	1.1773	-

Notes. The asterisks *** (**) (*) indicate statistical significance (presence of causality) at the 1%, 5% and 10% levels, respectively. We report the M-Wald statistic that has $\chi 2$ distribution.

TABLE 4 The BEKK results

TABLE 4a: Entire Series										
Parameters	**OIL_CAS**	**OIL_MES**	**OIL_NIS**	**OIL_NOS**	**OIL_QAS**	**OIL_RUS**	**OIL_SAS**	**OIL_UAS**	**OIL_VES**	**OIL_WOS**
$\boldsymbol{\delta_1}$	0.8159	1.7×10^{-5}	2.4×10^{-5}	0.0012	0.1507	0.0003	0.5132	0.4114	0.2063	0.9376
	(33491.57)	(592.18)	(210.38)	(589.71)	(17.61)	(294.84)	(403.71)	(182.98)	(759.03)	(1931.83)
$\boldsymbol{\delta_2}$	1.1881	3.0942	1.3888	2.3160	0.3349	2.8444	1.9273	2.3464	4.8330	1.0655
	(385.71)	(672.31)	(217.87)	(603.35)	(21.77)	(293.48)	(477.69)	(187.84)	(790.67)	(1495.26)
$\boldsymbol{\alpha_{01}}$	8.5×10^{-8}	2.6×10^{-5}	2.3×10^{-5}	1.3×10^{-5}	4.4×10^{-5}	2.5×10^{-5}	6.9×10^{-6}	6.0×10^{-6}	7.7×10^{-6}	6.0×10^{-6}
	(4.88)	(21.72)	(10.49)	(14.23)	(19.72)	(18.76)	(5.16)	(2.88)	(3.75)	(7.73)
$\boldsymbol{\alpha_{11}}$	0.6032	0.8983	0.6981	0.7318	1.0110	0.7320	0.4129	0.3980	0.4914	0.5071
	(43.95)	(34.45)	(33.67)	(43.12)	(18.48)	(40.12)	(38.12)	(35.55)	(41.60)	(50.40)
$\boldsymbol{\beta_{11}}$	0.8152	0.5329	0.7507	0.7143	0.3913	0.7038	0.9115	0.9173	0.8837	0.8625
	(184.50)	(59.66)	(110.63)	(137.82)	(26.06)	(107.59)	(281.12)	(256.76)	(270.12)	(257.58)
$\boldsymbol{\alpha_{03}}$	1.1×10^{-5}	0.0002	3.0×10^{-5}	7.6×10^{-5}	5.4×10^{-5}	0.0002	2.6×10^{-5}	2.7×10^{-5}	0.0002	1.0×10^{-5}
	(17.47)	(27.75)	(7.46)	(22.58)	(18.87)	(17.15)	(4.87)	(2.44)	(3.87)	(8.66)
$\boldsymbol{\alpha_{33}}$	0.6000	0.8975	0.6917	0.7310	1.0007	0.7338	0.4117	0.3951	0.4929	0.4982
	(44.11)	(34.51)	(33.44)	(43.16)	(18.30)	(40.21)	(37.89)	(35.26)	(41.63)	(49.92)
$\boldsymbol{\beta_{33}}$	0.8161	0.5311	0.7548	0.7143	0.4194	0.7029	0.9121	0.9187	0.8830	0.8670
	(187.16)	(59.58)	(112.09)	(136.89)	(27.05)	(107.06)	(281.64)	(260.52)	(268.05)	(265.37)
$\boldsymbol{\alpha_{02}}$	-4.3×10^{-7}	4.4×10^{-6}	-1.2×10^{-5}	-5.4×10^{-6}	-1.5×10^{-6}	-2.2×10^{-5}	-9.6×10^{-6}	-9.3×10^{-6}	-3.0×10^{-5}	-4.4×10^{-6}
	(-5.18)	(1.76)	(-4.91)	(-4.10)	(-0.78)	(-7.65)	(-4.04)	(-2.07)	(-3.22)	(-5.21)
$\boldsymbol{\alpha_{22}}$	0.9413	0.0419	0.1255	0.9550	-0.087	-0.020	0.029	0.043	0.006	-1.119
	(12.30)	(1.59)	(1.86)	(38.87)	(-1.05)	(-0.33)	(4.55)	(0.756)	(1.99)	(-11.53)
$\boldsymbol{\beta_{22}}$	0.0239	-0.077	0.0099	0.0530	-0.154	-0.462	-0.008	-0.121	0.027	-0.081
	(2.30)	(-7.613)	(0.54)	(6.13)	(-3.89)	(-8.466)	(-2.982)	(-3.69)	(0.776)	(-4.91)
L	49743.28	23203.90	17231.27	26198.88	13777.33	17398.02	18939.10	12773.34	15796.03	36294.78

Notes: The results represent interaction between oil price and stock indices. Parameters indicates substituted parameters in Equations 3, 4a, 4b and 4c. L is the log likelihood function value. Figures in parentheses are z-statistics which measure level of significance. Header acronyms represents countries stock indices as follows; Oil Spot (OIL), Canada (CAS), Mexico (MES), Nigeria (NIS), Norway (NOS), Qatar (QAS), Russia (RUS), Saudi Arabia (SAS), the UAE (UAS), Venezuela (VES) and World (WOS).

TABLE 4b: Pre-financial crisis period

Parameters	OIL_CAS	OIL_MES	OIL_NIS	OIL_NOS	OIL_QAS	OIL_RUS	OIL_SAS	OIL_UAS	OIL_VES	OIL_WOS
$\boldsymbol{\delta_1}$	0.7527	$5.2\text{x}10^{-5}$	$1.1\text{x}10^{-5}$	0.0048	-0.2076	0.0003	0.2346	0.2433	0.2554	0.7958
	(377.16)	(425.55)	(25.00)	(521.55)	(-58.02)	(197.20)	(227.13)	(135.79)	(740.45)	(885.66)
$\boldsymbol{\delta_2}$	1.3145	2.6731	1.2198	1.5560	-4.5732	3.0920	4.1966	4.0387	3.9093	1.2452
	(511.99)	(299.77)	(32.06)	(387.32)	(-54.00)	(202.15)	(232.57)	(130.34)	(685.40)	(657.53)
$\boldsymbol{\alpha_{01}}$	$6.5\text{x}10^{-8}$	$1.8\text{x}10^{-5}$	$2.5\text{x}10^{-5}$	$8.2\text{x}10^{-6}$	$2.0\text{x}10^{-5}$	$3.9\text{x}10^{-5}$	$8.0\text{x}10^{-6}$	$8.0\text{x}10^{-5}$	$8.1\text{x}10^{-6}$	$9.1\text{x}10^{-6}$
	(5.14)	(13.03)	(5.66)	(13.23)	(2.60)	(16.81)	(3.03)	(2.75)	(4.88)	(8.42)
$\boldsymbol{\alpha_{11}}$	0.7162	0.9421	0.9527	0.7352	-0.5374	0.8782	0.4430	-0.5071	-0.4888	0.5751
	(30.68)	(20.77)	(6.97)	(31.57)	(-8.25)	(18.19)	(22.77)	(-11.62)	(-32.78)	(37.44)
$\boldsymbol{\beta_{11}}$	0.7508	0.4345	0.3247	0.7055	0.8057	0.5171	0.8938	0.8530	0.8733	0.8146
	(99.08)	(30.49)	(10.33)	(90.03)	(27.86)	(32.10)	(134.88)	(52.14)	(165.67)	(146.09)
$\boldsymbol{\alpha_{03}}$	$1.6\text{x}10^{-5}$	0.0002	0.0001	$5.6\text{x}10^{-5}$	0.0005	0.0004	0.0002	0.0002	0.0001	$2.1\text{x}10^{-5}$
	(13.38)	(24.06)	(3.38)	(16.06)	(3.00)	(16.42)	(3.46)	(2.79)	(5.20)	(8.40)
$\boldsymbol{\alpha_{33}}$	0.6749	0.9430	0.9950	0.7420	-0.5515	0.8925	0.4466	-0.4999	-0.4892	0.5660
	(31.09)	(20.87)	(6.97)	(31.78)	(-8.48)	(18.43)	(22.88)	(-11.56)	(-32.81)	(36.97)
$\boldsymbol{\beta_{33}}$	0.7659	0.4433	0.1002	0.6974	0.7973	0.4960	0.8927	0.8574	0.8732	0.8206
	(100.77)	(31.04)	(2.48)	(87.83)	(27.28)	(30.74)	(133.45)	(53.86)	(165.37)	(149.74)
$\boldsymbol{\alpha_{02}}$	$-2.1\text{x}10^{-7}$	$2.4\text{x}10^{-5}$	$-3.0\text{x}10^{-5}$	$3.8\text{x}10^{-7}$	$6.9\text{x}10^{-5}$	$-2.1\text{x}10^{-5}$	$-2.6\text{x}10^{-5}$	$-2.6\text{x}10^{-5}$	$-2.4\text{x}10^{-5}$	$-8.2\text{x}10^{-6}$
	(-1.98)	(8.10)	(-0.61)	(0.33)	(2.21)	(-3.44)	(-2.69)	(-2.41)	(-3.97)	(-5.84)
$\boldsymbol{\alpha_{22}}$	0.028	-0.010	0.033	0.042	-0.017	0.000	0.004	-0.036	-0.045	-0.016
	(1.73)	(-1.67)	(0.65)	(0.43)	(-1.45)	(0.99)	(0.64)	(-1.43)	(-1.40)	(-0.30)
$\boldsymbol{\beta_{22}}$	0.000	-0.003	-0.060	-0.046	0.056	-0.139	0.000	-0.066	0.034	-0.016
	(0.93)	(-1.25)	(-6.17)	(-1.80)	(0.92)	(-4.29)	(0.06)	(-2.69)	(1.93)	(-1.85)
L	30056.79	14134.67	4424.08	17438.07	1640.88	7793.15	6475.46	2754.48	11937.24	21354.07

TABLE 4c: Financial crisis period

Parameters	OIL_CAS	OIL_MES	OIL_NIS	OIL_NOS	OIL_QAS	OIL_RUS	OIL_SAS	OIL_UAS	OIL_VES	OIL_WOS
$\boldsymbol{\delta_1}$	0.8564	$1.7\text{x}10^{-5}$	$4.3\text{x}10^{-6}$	0.0015	0.6250	0.0002	0.8137	0.2621	0.5940	0.7238
	(202003)	(72.66)	(18.48)	(159.45)	(114.13)	(140.10)	(111.57)	(91.73)	(134.10)	(210.68)
$\boldsymbol{\delta_2}$	1.1561	1.0338	0.4302	1.4494	1.5125	2.3335	1.1649	3.6609	1.6454	1.2898
	(163.49)	(37.42)	(14.10)	(125.82)	(134.22)	(114.56)	(106.85)	(104.59)	(116.05)	(136.63)
$\boldsymbol{\alpha_{01}}$	$2.8\text{x}10^{-8}$	$1.0\text{x}10^{-5}$	$7.2\text{x}10^{-5}$	$2.0\text{x}10^{-5}$	$1.2\text{x}10^{-5}$	$2.8\text{x}10^{-5}$	$2.4\text{x}10^{-5}$	$1.1\text{x}10^{-5}$	$1.2\text{x}10^{-5}$	$9.7\text{x}10^{-6}$
	(4.87)	(2.45)	(16.29)	(6.84)	(3.32)	(6.80)	(3.36)	(2.53)	(2.71)	(4.52)
$\boldsymbol{\alpha_{11}}$	0.7426	0.7543	1.0221	0.5563	0.5026	0.6620	0.5356	0.4169	0.4483	0.5268
	(15.13)	(7.85)	(5.87)	(18.82)	(19.63)	(20.91)	(19.72)	(18.74)	(18.20)	(21.08)
$\boldsymbol{\beta_{11}}$	0.6860	0.6696	-0.0341	0.8152	0.8692	0.7302	0.8444	0.9097	0.8938	0.8475
	(27.76)	(18.71)	(-1.15)	(62.77)	(93.89)	(49.65)	(91.20)	(116.40)	(105.31)	(94.91)
$\boldsymbol{\alpha_{03}}$	$1.1\text{x}10^{-5}$	0.0007	0.0001	$5.5\text{x}10^{-5}$	$3.4\text{x}10^{-5}$	0.0001	$4.1\text{x}10^{-5}$	0.0001	$3.3\text{x}10^{-5}$	$3.2\text{x}10^{-5}$
	(4.37)	(4.10)	(3.38)	(5.75)	(3.76)	(5.13)	(3.91)	(2.22)	(2.45)	(5.09)
$\boldsymbol{\alpha_{33}}$	0.3715	0.9574	1.0165	0.5197	0.5005	0.5905	0.5095	0.4217	0.4545	0.5099
	(14.20)	(8.94)	(5.81)	(18.85)	(18.91)	(18.88)	(19.00)	(18.81)	(18.40)	(20.65)
$\boldsymbol{\beta_{33}}$	0.9218	0.2307	0.0962	0.8341	0.8693	0.7984	0.8582	0.9080	0.8908	0.8567
	(105.33)	(5.28)	(2.97)	(74.01)	(90.21)	(60.75)	(95.92)	(114.98)	(102.89)	(99.57)
$\boldsymbol{\alpha_{02}}$	$9.9\text{x}10^{-8}$	$-5.6\text{x}10^{-5}$	$1.6\text{x}10^{-5}$	$-1.6\text{x}10^{-5}$	$-8.0\text{x}10^{-6}$	$-2.3\text{x}10^{-5}$	$-2.1\text{x}10^{-5}$	$-2.7\text{x}10^{-5}$	$-1.4\text{x}10^{-5}$	$-9.3\text{x}10^{-6}$
	(1.36)	(-1.38)	(1.96)	(-4.07)	(-1.84)	(-3.17)	(-2.74)	(-1.95)	(-2.04)	(-3.20)
$\boldsymbol{\alpha_{22}}$	-0.483	0.056	-0.017	-0.048	0.037	0.111	0.003	-0.131	-0.013	-0.139
	(-1.91)	(1.98)	(-1.37)	(-0.82)	(4.35)	(3.64)	(0.06)	(-1.47)	(-0.99)	(-2.60)
$\boldsymbol{\beta_{22}}$	-0.054	0.006	0.004	0.005	-0.034	0.138	0.004	-0.064	-0.024	0.010
	(2.79)	(0.70)	(0.46)	(0.62)	(-4.97)	(2.22)	(0.29)	(-1.08)	(-0.25)	(2.06)
L	10576.32	3814.61	4079.33	5979.77	5036.16	5450.70	5185.71	3690.44	4358.79	6068.93

TABLE 4d: Post financial crisis period

Parameters	OIL_CAS	OIL_MES	OIL_NIS	OIL_NOS	OIL_QAS	OIL_RUS	OIL_SAS	OIL_UAS	OIL_VES	OIL_WOS
$\boldsymbol{\delta_1}$	0.8822	$2.5\text{x}10^{-5}$	$5.6\text{x}10^{-6}$	0.0005	-0.0755	0.0001	0.0745	0.0540	-0.0650	0.5241
	(822810)	(150.03)	(15.93)	(239.53)	(-7.20)	(20.27)	(6.64)	(6.11)	(-70.01)	(537.80)
$\boldsymbol{\delta_2}$	1.1280	0.8634	0.6943	2.5228	-0.1573	0.4069	0.1428	0.0778	-13.864	1.8944
	(384.27)	(132.37)	(19.87)	(201.58)	(-6.47)	(8.57)	(5.38)	(1.85)	(-71.24)	(325.87)
$\boldsymbol{\alpha_{01}}$	$5.6\text{x}10^{-9}$	$2.5\text{x}10^{-5}$	$2.5\text{x}10^{-5}$	$4.5\text{x}10^{-6}$	$2.6\text{x}10^{-5}$	$2.6\text{x}10^{-5}$	$1.9\text{x}10^{-5}$	$2.4\text{x}10^{-5}$	$4.7\text{x}10^{-6}$	$3.0\text{x}10^{-6}$
	(12.08)	(5.52)	(15.37)	(6.97)	(15.38)	(17.11)	(15.70)	(20.27)	(1.79)	(5.38)
$\boldsymbol{\alpha_{11}}$	0.8952	0.5782	1.0170	0.5823	1.0396	0.9968	1.0043	0.9356	0.5679	0.6026
	(20.32)	(20.21)	(11.14)	(22.05)	(9.57)	(11.39)	(11.17)	(14.87)	(17.41)	(25.14)
$\boldsymbol{\beta_{11}}$	0.4449	0.8147	0.2861	0.8072	0.2550	-0.1939	0.2994	0.4162	0.8456	0.7880
	(16.92)	(74.82)	(8.85)	(78.39)	(8.73)	(-5.76)	(12.88)	(22.92)	(98.95)	(75.33)
$\boldsymbol{\alpha_{03}}$	$8.1\text{x}10^{-6}$	$2.2\text{x}10^{-5}$	$9.0\text{x}10^{-5}$	$4.2\text{x}10^{-5}$	$5.6\text{x}10^{-5}$	0.0002	$5.2\text{x}10^{-5}$	$6.4\text{x}10^{-5}$	0.0010	$2.8\text{x}10^{-5}$
	(7.77)	(5.84)	(13.70)	(6.70)	(18.60)	(14.44)	(16.05)	(12.82)	(1.88)	(6.82)
$\boldsymbol{\alpha_{33}}$	0.5116	0.5722	1.0177	0.6173	1.0417	0.9912	0.9952	0.9335	0.5707	0.6452
	(18.84)	(19.91)	(11.09)	(22.95)	(9.58)	(11.31)	(10.99	(14.83)	(17.48)	(26.00)
$\boldsymbol{\beta_{33}}$	0.8289	0.8168	0.2903	0.7853	0.2522	-0.2226	0.3369	0.4195	0.8442	0.7601
	(65.14)	(74.34)	(8.93)	(69.02)	(8.5)	(-6.61)	(13.32)	(23.30)	(98.23)	(66.79)
$\boldsymbol{\alpha_{02}}$	$1.7\text{x}10^{-9}$	$-1.5\text{x}10^{-5}$	$-8.9\text{x}10^{-6}$	$-4.0\text{x}10^{-6}$	$1.8\text{x}10^{-5}$	$-2.4\text{x}10^{-6}$	$3.9\text{x}10^{-6}$	$-2.2\text{x}10^{-6}$	$-3.9\text{x}10^{-5}$	$-3.5\text{x}10^{-6}$
	(0.13)	(-4.55)	(-4.07)	(-2.42)	(9.19)	(0.88)	(2.39)	(-1.32)	(1.22)	(-2.86)
$\boldsymbol{\alpha_{22}}$	0.016	-0.004	0.102	-0.012	0.001	0.01	0.071	0.170	-0.065	-0.055
	(0.34)	(-0.46)	(3.46)	(-0.48)	(0.01)	(1.25)	(1.13)	(7.41)	(-0.56)	(-0.14)
$\boldsymbol{\beta_{22}}$	-0.000	0.003	0.032	0.004	0.103	0.052	0.057	-0.102	0.059	0.050
	(-0.38)	(0.86)	(1.72)	(0.71)	(2.88)	(3.71)	(3.49)	(-0.64)	(0.69)	(1.15)
L	20354.96	9767.65	8120.15	9625.47	8491.43	7995.66	8402.17	7772.95	2603.91	11234.71

Figure 1: Sampled countries time-varying movement of oil reserves

(Source: Thomson Reuters Datastream; in millions of barrels, between 1980-2018)

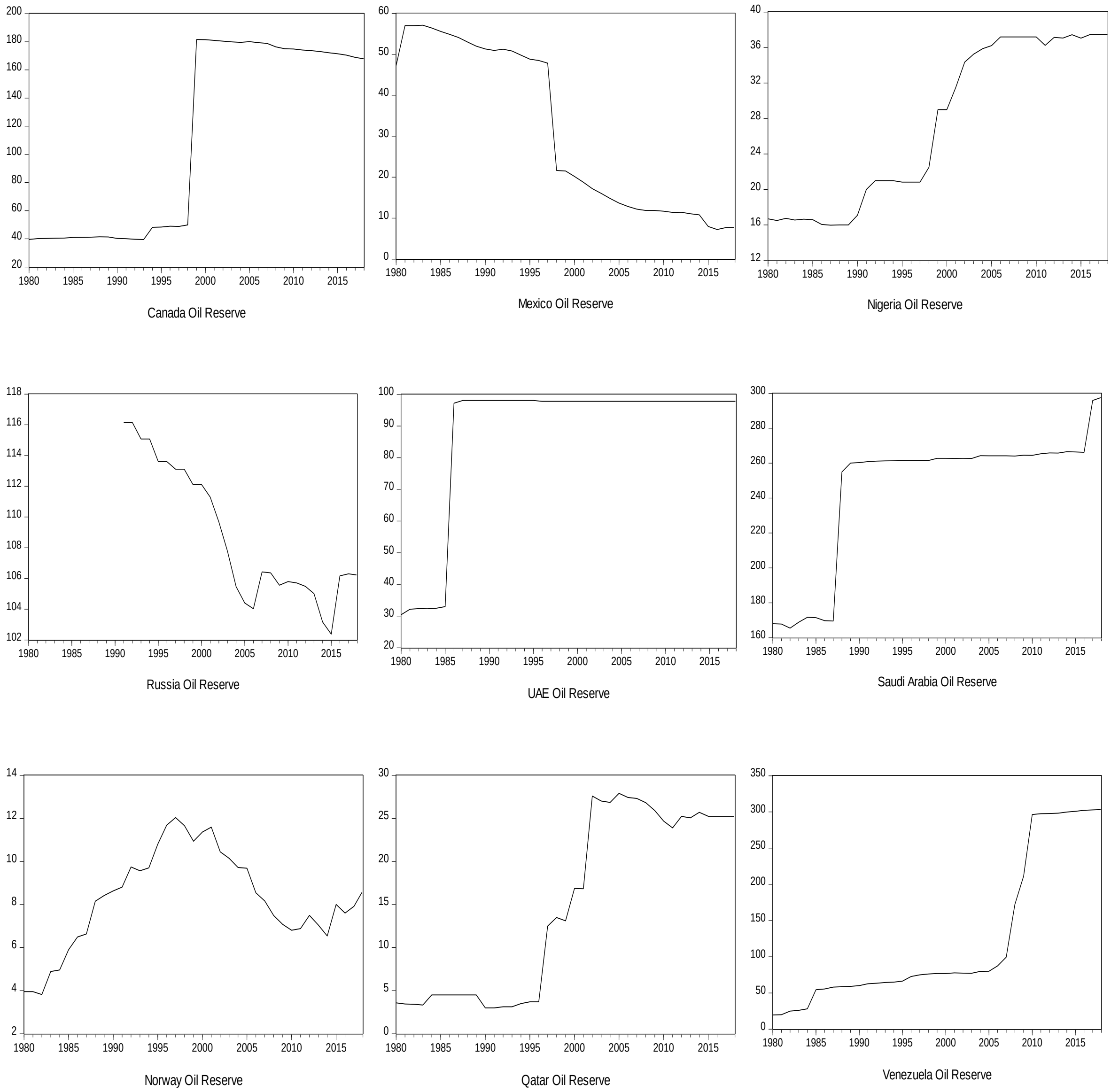

FIGURE 2. Oil futures, one year constant forecast

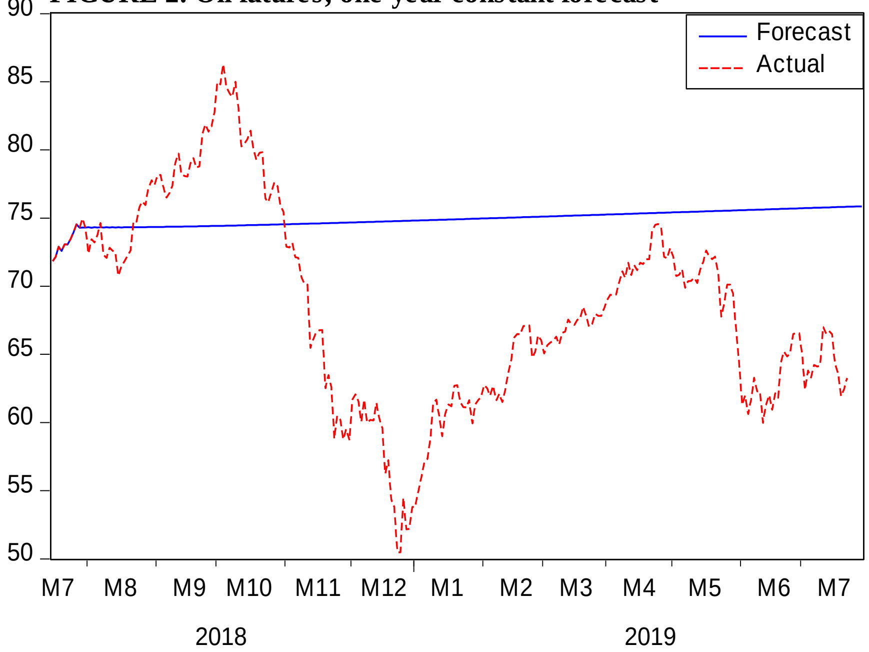

FIGURE 3. Oil spot, one year constant forecast

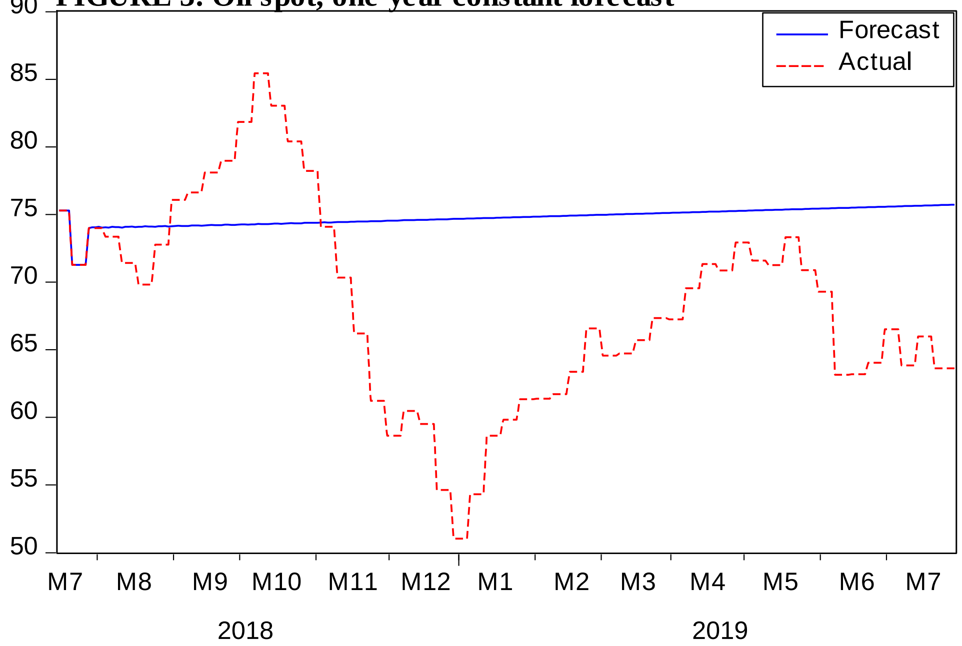

FIGURE 4. Oil futures, one year constant forecast with oil spot as exogenous variable

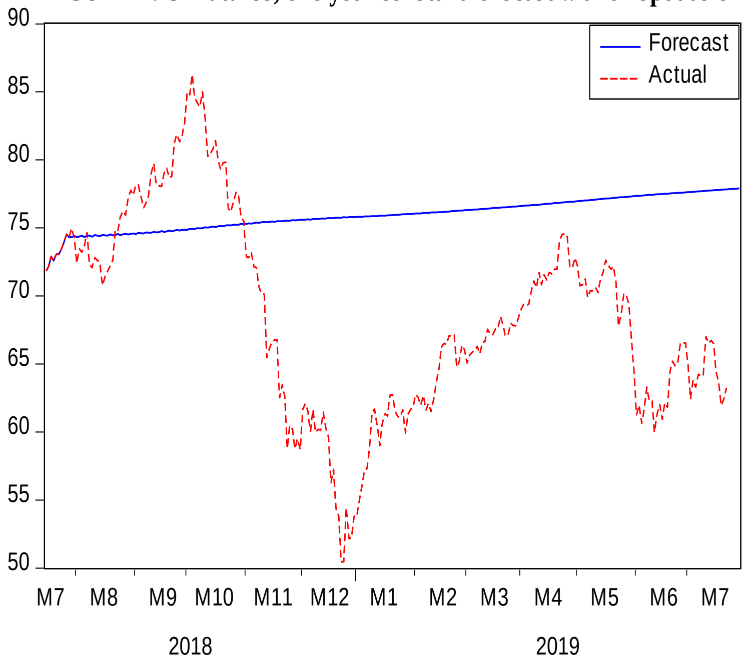

FIGURE 5. Oil spot, one year constant forecast with oil futures as exogenous variable