How Do Different Oil Price Shocks Affect the Relationship Between Oil and Stock Markets?

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Abstract

This paper investigates the effect of different types of oil price shocks on the time varying correlation between oil and stock markets, and compares this effect in the oil importer and oil exporter countries for the period of 1996:1- 2014:2. To this end, the paper uses SVAR, cDCC and MS models which introduced by Kilian (2009), Aielli (2011) and Hamilton (1989), respectively. These models help us to apply nonlinear and dynamic linkages in estimating relationship between oil price shocks and the correlations between oil and stock markets. Our results show that correlation between oil and stock markets does not depend on oil price shocks origins and being oil importer or oil exporter countries. We also conclude that the relationship between oil price returns and stock index returns are time varying for selected countries. Considering the results, it is obvious that international investors could not hedge oil price shocks' risks in their global portfolio by diversification and managing their portfolio of oil importer and oil exporter stock markets. Hence, it is suggested they use other substituted policies and investing strategies, like future contracts.

Keywords: Oil Price Shocks, Stock Markets, Oil Importing Countries, Oil Exporting Countries, consistent DCC model, Markov Switching model

JEL Classification: C32, C34, C58, G1, Q43

1. Introduction

Since 1970s, the structure of oil market has changed from a primary manufacturing activity to a complex financial market. This expansion of the oil market and its volatility makes an extensive range of effects on oil producers, oil traders, oil companies, and oil consumers. On the other hand, oil price volatilities affect stock market through various channels such as inflation, interest rates, costs of production, income, economic growth (Arouri, 2001; Moya-Martínez et al., 2014). This effect can be different based on oil prices shocks' origins (Kilian, 2009) and countries' type, for example, for oil import-countries and oil-export ones (Wang et al., 2013). Hence, we extend the work of Kilian (2009) and Kilian and Park (2009) by assessing the dynamic effects of different types of oil price shocks on stock markets in selected oil-importer and oil-exporter countries from January 1996 to February 2014. To examine the aforementioned dynamic relationship, we extract the time series of different types of oil price shocks, and then examine the effects of oil price shocks on the dynamic conditional correlation between oil price and stock market return.

The study of oil prices and macroeconomic indicators was first initiated by Hamilton (1983) and Darby (1982). Since then, the studies explaining the significant impact of oil price on economic variables has been widely spread (see e.g., Brown and Yücel, 2002; Burbidge and Harrison, 1984; Cunado and Pérez de Gracia, 2003; Cunado and Pérez de Gracia, 2005; Cologniand Manera, 2008; Du et al., 2010; Gisser and Goodwin, 1986; Hamilton, 2008; Hamilton and Herrera, 2004; Hooker and Mark, 1996; Lee et al., 1995; Lee et al., 2001; Mork, 1989; Mork, 1994; Mork et al., 1994; and Tang et al., 2010 among others). In the meantime, the relationship between oil price and stock markets has been dramatically increased over the last two decades. As a pioneering paper based on a standard cash-flow dividend valuation model, Jones and Kaul (1996) attempt to investigate the effects of oil price shocks on the stock markets of four developed equity markets: the U.S., Canada, Japan and the U.K. They show that oil price shocks affect these markets significantly and negatively during the post-World War II period. After that, some studies have found similar results (see e.g., Aloui and Jammazi, 2009; Cifarelli and Paladino, 2010; Miller and Ratti, 2009; Nandha and Faff, 2008; Papapetrou, 2001; Park and Ratti, 2008; Sadorsky, 1999 among others). In contrast, some other studies have concluded that there is a positive relationship between oil prices and stock market (see e.g., Arouri and Rault, 2012; El-Sharif et al., 2005; Li et al., 2012; Lescaroux and Mignon, 2008; and Zhu et al., 2011 among others). Some studies, however, have failed to draw significant linkage between the two markets (see e.g., Apergis and Miller, 2009; Cong et al., 2008; Huang et al., 1996; Mohanty et al., 2010; and Sari and Soytas, 2006 among others). Therefore, there is no consensus on the nature of the relation between oil price and stock markets. On the other hand, many studies in the literature focus on the U.S. economy and oil importing countries more than oil exporting ones (Wang et al., 2013) and only a few studies have examined the impact of oil prices on the stock market for both groups of oil importers and oil exporters simultaneously (see e.g., Filis et al., 2011; Wang et al., 2013; and Creti et al., 2014). Filis et al. (2011) employs multivariate asymmetric generalized autoregressive conditional heteroskedasticity with dynamic conditional correlation approach (DCC-GARCH-GJR) to investigate the time-varying correlation between stock market prices and oil prices for both oil-importing and oil-exporting countries. They show that time-varying correlation is the same for both groups of countries. They also find that important demand and precautionary demand shocks affect this time-varying correlation greater than supply-side oil price shocks. Wang et al. (2013) use structural vector autoregressive (SVAR) model to show how decomposition of oil price shocks impact on oil-export and oil-import countries' stock markets. They also conclude that the magnitudes, durations and even directions of stock market reactions are different for the two groups of countries and this effect can be different based on whether oil price shocks are supply-side shocks or aggregate demand shocks. Creti et al. (2014) investigate the degree of reciprocal dependency between oil price shocks and stock market for both oil-export and oil-import countries. They use frequency approach to distinguish between short and medium-run dependency and apply co-integration procedure for analyzing long-run dependency. They confirm that interdependence between oil price and stock market is stronger in oil-exporting countries than oil-importing ones. They also find that oil shocks are more persistent in the importing countries than in the exporting ones for long-run.

This paper however, focuses on the effect of oil price shocks on the dynamic relationship between oil and stock markets. In general, we want to show how oil price shocks change this dynamic correlation between the two markets and are these changes the same for oil exporter countries and oil importer ones. To achieve these goals, first, we separate the origins of oil price shocks based on Hamilton (2009 a,b) and Kilian (2009). These authors distinguish among the origins of oil price shocks, and explain that supply-side and demand-side shocks make different results in economic and financial variables. Following Kilian (2009), we use SVAR to extract three types of oil price shocks, including aggregate demand shocks, precautionary demand shocks (or oil-market specific demand shocks) and supply-side shocks. Aggregate demand shock originates from an increase in world aggregate demand and the global business cycle's fluctuations. Precautionary demand shock occurs due to an increase in demand originated from an uncertainty about the future of oil supply. Supply-side shock occurs due to the changes in crude oil availability.

Second, we extract time series of dynamic correlation between oil prices and stock markets using the consistent dynamic conditional correlation (cDCC) model of Aielli (2011). We use cDCC model instead of DCC model, due to the advantages of this model: cDCC is more consistent than DCC model, since the interpretation of the parameters in DCC model may mislead the policy makers. Moreover, the expanded model of cDCC is applicable, as the sufficient stability conditions are explained by Aielli (2011).

Third, we use the Markov Switching (MS) model to explore the effects of oil price shocks on the dynamic relationship between oil and stock markets of oil-import and oil-export countries, which is novelty of our paper. Nonlinear models, such as MS models, have different advantages in comparison to linear models: MS models can estimate a permanent change or some temporary changes in the variable. Moreover, exact time points of frequent structural changes and breaks can be determined endogenously, in contrast to structural changes models which estimate occasional exogenous changes. Finally, this model imposes less constraint on the variables' distributions (Hamilton, 1989 and 2005).

Our results show that different types of oil price shocks do not have significant effects on the correlation between oil and stock markets. These negligible effects of oil price shocks are also different in oil importing and oil exporting countries. We also find that origins of oil shocks cannot determine how it affects the correlation between oil and stock markets.

The rest of the paper is structured as follows: Section 2 briefly describes the econometric methodologies that we use in this study. Section 3 explains the data. Section 4 presents the empirical results and their interpretations, and finally, section 5 concludes the paper.

2. Methodology and data

The aim of this paper is to study the effect of different types of oil price shocks on the time varying correlation between oil and stock markets, and compare this effect in oil-importer and oil-exporter countries. To analyze the effect of oil price shocks on dynamic correlation between oil and stock price returns in oil-importer and oil-exporter countries, we first decompose oil price to three types of shocks by using a SVAR model. Then, we use a cDCC model to estimate the dynamic correlation between oil and stock markets in the countries under investigation. Finally, we estimate a MS model to analyze the effect of oil price shocks on the correlation series between oil and stock markets.

2.1 The SVAR model and oil shocks extraction

Following Kilian (2009), we apply SVAR model for decomposing unpredictable changes in oil price. The SVAR model represents as follows:

$$A_0 z_t = \alpha + \sum_{i=1}^{p} A_i z_{t-i} + \varepsilon_t, \tag{1}$$

Where z_t = (ΔLPROD, ΔGEA, ΔLROP)', and LPROD is logarithm of global oil production, GEA is the global economic activity index and LROP is the logarithm of real oil price. Δ shows the first order difference of the variables. In equation (1), A_i are coefficient matrices of order [3 × 3]. p denotes the lag length of the estimated SVAR model chosen by AIC. ε_t is a vector of serially uncorrelated structural disturbances. A_0 denotes the [3 × 3] matrix identifying the structural relationships which is used to decompose reduced form errors e_t according to $e_t = A_0^{-1}\varepsilon_t$. We can achieve to the reduced form of VAR model by multiplying both sides of equation (1) with A_0^{-1}. Decomposition of reduced form error terms (e_t) is as follows:

$$e_t = \begin{pmatrix} e_t^{\Delta LPROD} \\ e_t^{\Delta GEA} \\ e_t^{\Delta LROP} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{pmatrix} \varepsilon_t^{oil\ supply\ shock} \\ \varepsilon_t^{aggregate\ demand\ shock} \\ \varepsilon_t^{precautionary\ demand\ shock} \end{pmatrix} \tag{2}$$

Following Kilian (2009), A_0^{-1} is restricted as follows which are based on short term assumptions[1]:

- Crude oil supply shocks (expressed as oil supply shock) are due to unpredictable innovations in global oil production as a proxy of oil supply ($e_t^{\Delta LPROD} = a_{11}\varepsilon_t^{oil\ supply\ shock}$). In other words, crude oil supply does not respond to changes in oil demand within the same month. Therefore, the oil supply shocks are treated as exogenous.
- Aggregate demand shocks are real economic activity disturbances which are not explained by oil supply shocks ($e_t^{\Delta GEA} - a_{21}\varepsilon_t^{oil\ supply\ shock} = a_{22}\varepsilon_t^{aggregate\ demand\ shock}$). Regarding slow-moving reaction of global economic activity to other oil-specific shocks, it is clear that restrictions which imply increases in the real oil price by shocks of oil-specific market will not decrease global economic activity immediately, but with a lagged effect behind (kilian, 2009).
- Precautionary demand shocks (oil-market specific demand shocks), are due to unexpected oil price innovations which are not explained by oil supply or aggregate demand shocks ($e_t^{\Delta LROP} - a_{31}\varepsilon_t^{oil\ supply\ shock} - a_{32}\varepsilon_t^{aggregate\ demand\ shock} = a_{33}\varepsilon_t^{precautionary\ demand\ shock}$). This type of shocks occurs due to the existence of uncertainty in the future oil supply.

Since shocks are derived from using the global measures of oil production, economic activity and oil prices, the series of shocks are global and the same oil shock series are applied for both groups of oil importer and oil exporter countries.

2.2 The cDCC Model

In recent decades, conditional covariance matrix is utilized to assess correlations between assets. However, there are different types of models with different targets of estimating covariance matrix and correlations directly and indirectly: for example, BEKK model of Engle and Kroner (1995), CCC model of Bollerslev (1990), DCC model of Engle (2002) and cDCC model of Aielli (2011). The models which calculate covariance are used to determine Value at Risk (VaR) but other models which estimate correlations are used to portfolio optimization (Caporin and McAleer, 2010). However, regarding to the aim of this paper and the advantages of dynamic correlation models, we use cDCC model to estimate correlations between oil and stock markets in oil importing and oil exporting countries.

In order to explain DCC model, consider the vector of asset returns including $y_t = [y_{i,t}\ ,\ \Delta LROP_t]'$, in which $y_{i,t}$ indicates logarithm of stock return series of i^{th} selected oil importing and oil exporting countries, and $\Delta LROP_t$ shows the logarithm of real oil price return at time t. The conditional mean and covariance matrix of y_t is explained by conditional expectations on y_t, y_{t-1},

[1] More detailed explanation of different types of shocks can be found in kilian (2009).

… respectively as E_{t-1} $[y_t] = 0$ and E_{t-1} $[y_t y_t'] = H_t$. The conditional covariance matrix of the asset vector of y_t in DCC model can be expressed as:

$$H_t = D_t^{1/2} R_t D_t^{1/2} \tag{3}$$

Where R_t and D_t are the conditional correlation matrix and the diagonal conditional variance matrix of the asset, respectively. Engle (2002) defines the right hand side of the equation (3) as follows:

$$R_t = diag\left(q_{11,t}^{-\frac{1}{2}} \dots q_{NN,t}^{-\frac{1}{2}}\right) Q_t diag\left(q_{11,t}^{-\frac{1}{2}} \dots q_{NN,t}^{-\frac{1}{2}}\right) \tag{4}$$

$$Q_t = (1 - \alpha - \beta)\bar{Q} + \alpha\varepsilon_{t-1}\varepsilon'_{t-1} + \beta Q_{t-1} \tag{5}$$

Where $Q_t = (q_{ij,t})$ is the N×N symmetric positive definite matrix of unconditional variance of u_t and $\varepsilon_{it} = u_{it}/\sqrt{h_{iit}}$ is the standardized residuals of mean equations. The parameters α and β are scalar, non-negative and $\alpha + \beta < 1$. The estimated model of equation (5) is called DCC. While Aielli (2011) recently shows that $E[u_t u_t] = E[E[u_t' u_t|\Omega_{t-1}] = E[R_t] \neq E[Q_t]$, and therefore, the estimated Q as the correlation matrix of u_t is not consistent. By extending the dynamic correlation models, Aielli (2011) presents a more tractable multivariate GARCH model of correlation estimating models, called cDCC. The cDCC model takes the following form for the N×N symmetric positive definite matrix $Q_t = (q_{ij,t})$ to solve the inconsistency problem of DCC model:

$$Q_t = (1 - \alpha - \beta)\bar{Q} + \alpha\varepsilon_{t-1}^{*}\varepsilon_{t-1}^{*'} + \beta Q_{t-1} \tag{6}$$

In Eq. (6), $\varepsilon_t = P_t u_t$, where $P_t = diag\ (q_{11,t}^{1/2} \dots q_{NN,t}^{1/2})$. Since $E[\varepsilon_t^{*}\varepsilon_t^{*}{}'|\Omega_{t-1}] = Q_t$, Q_t indicates the unconditional variance matrix of ε_t^{*}. In this model, α and β are the estimated parameters of model that are nonnegative scalars and the condition of $\alpha + \beta < 1$ is established.

2.3 The MS Model

The linear models are prevalent in the literature, but they cannot be used to estimate asymmetric models or to classify volatilities. According to the aim of this paper, we use MS model which is a common applicable nonlinear model. It estimates several structures in the form of several equations. Each of the equations represents different regimes.

The most general case of the MS models are known as MSIAXH(k)-ARX(p,q) model, where all the estimated parameters of constant, autoregressive, exogenous variables and residuals' variance are switching, but it is possible to change the model so that only some of the parameters are regime switching. The MSIAXH(k)-ARX(p,q) model is as following:

$$y_t = c(s_t) + \textstyle\sum_i^p a_i(s_t)y_{t-i} + \sum_j^q b_i(s_t)x_{t-i} + u_t(s_t)$$

$$u_t \sim NID(0, \sigma^2(s_t)) \tag{7}$$

Where, y_t represents the dependent variable, u_t is the error term which distributed independently with 0 mean and $\sigma^2(s_t)$ variance, and c is the constant parameter. In this model, estimated parameters depend on the state variable s_t which is a discrete random variable and changes due to the structural changes. The state variable, s_t can take k different states. s_t is an unobservable variable and only the probabilities of each regime can be calculated. In other words, it is not possible to determine the exact occurred regime in a time point t, but we can calculate its probability. Moreover, the probabilities of transition between regimes are based on a first order Markov Chain which is written as follows:

$$s_t \in \{1,2,\dots,k\}, \quad P(s_t = j | s_{t-1} = i, \xi_t) = p_{ij}, \quad \sum_{j=1}^{k} p_{ij} = 1 \qquad (8)$$

Consequently, the transition probabilities matrix of order k×k is obtained, in which the elements (p_{ij}) show the transition probabilities between regimes i and j. To determine the lags p and q and the number of k regimes in the MSIAXH(k)-ARX(p,q) model, the model is estimated with different number of lags and regimes and the optimized model is selected according to the Akaike Information Criteria (AIC) and the value of constant parameters of different regimes.

To assess the changes in the correlation series between oil and stock markets and to decompose the correlation series to different regimes, we use MS model. Hence, we assume that the correlation series are affected by unobservable random state variable s_t. These regimes are determined by exogenous variables' effects. Considering explanatory variables, the estimated model expresses as follows:

$$COR_{it} = \beta_{0,i}^{s} + \beta_{1,i}^{s} X_{1,t} + \cdots + \beta_{k,i}^{s} X_{k,t} + \beta_{k+1,i} X_{k+1,t} + \cdots + \beta_{j,i} X_{j,t} + \varepsilon_{it}^{s} \qquad s_t = 1,2 \qquad (9)$$

Where the COR is the correlation series between oil and stock markets of i[th] oil-importer or oil-exporter country. In this paper, Correlation series between oil and stock markets of selected oil exporter and oil importer countries are defined as CCO, CRO, CSAO, CVO, CNO, CBO, CIO, CKO, CNHO, and CTO for Canada, Russia, Saudi Arabia, Venezuela, Norway, Belgium, India, Korea, Netherlands, and Taiwan, respectively. The explanatory variables are the oil price shocks' series extracted from the SVAR model. The variables with parameters $\beta_{l,i}^{s}$ are regime switching variables and the variables with parameters $\beta_{m,i}$ are non-regime switching.

2.4 Data description

We use monthly data including oil prices and stock indices in major oil importing and exporting countries starting from January 1996 through to February 2014. The selected oil-exporting countries includes Russia, Saudi Arabia, Venezuela (as the developing countries); Norway, Canada (as the developed economies) and the oil-importing countries includes Belgium, Netherlands, Taiwan, Korea (as the developed economies) and India (as the developing). We use the main stock index as a proxy for the stock markets returns: For the oil-exporter countries, we select OSEAX (Norway), MICEX (Russia), TADAWUL All Share (Saudi Arabia), IBVC

(Venezuela) and S&P/TSX Composite (Canada), and for the oil-importer ones, we choose BFX (Belgium), CNX NIFTY (India), KOSPI Composite (Korea), AEX (Netherlands) and TSEC weighted index (Taiwan). The selected oil exporter and oil importer countries' stock market indices are distinguished as the following symbols, respectively: LRN, LRR, LRSA, LRV, LRC, LRB, LRI, LRK, LRNH, and LRT.

The indices are in logarithm of return form of stock market indices. For selecting oil importing and oil exporting countries, we follow these measures:

1. Countries have been selected among 15 top importer and exporter of oil.
2. Stock market index data is available during the period of study.
3. Oil revenues have the greatest impact on their economies. For this aim, we sort countries based upon the ratio which indicate importance of oil price in their economy. We calculated this ratio by using Wang et al. (2014) method for the period of our study.
4. Selected countries include combination of both developed and developing oil exporter and oil importer countries.
5. They have a well-established stock market.

In this study, we separate unexpected oil price changes to three types of shocks, including supply side, aggregate demand and precautionary demand shocks. To extract these shocks, we use global oil production as a proxy for oil supply, and global economic activity index, as a proxy for oil demand. Moreover, since Brent crude oil indicates 60% of the daily world oil consumption (Broadstock and Filis, 2014) and 65% of the daily world oil production (Creti et al., 2014), we use its price as the global oil price.

Monthly data of Brent crude oil price and global oil production have been extracted from the Energy Information Administration. Global economic activity index of kilian (2009) based on the global dry cargo freight rates have been obtained from kilian's personal website[2].

Table 1 shows the descriptive statistics of the variables under investigation. According to the value of standard deviation (Std. dev.), oil exporter countries' stock returns have higher volatilities in comparison to the oil importer ones. Coincidently, assessing mean of stock returns show that oil exporter countries have higher returns in comparing with oil importer ones. Oil price shocks series approximately have the same mean and standard deviation. The correlation series of oil exporter countries have higher average correlation than oil importer countries. For oil importers, correlation time series have negative means but it is positive for oil exporters. The average of Std. dev. for oil exporters and oil importers are approximately the same. In other words, volatility of correlation time series is the same for oil importer and oil exporter countries. The Jarque-Berra statistics indicate that the null hypothesis of normality is rejected for all variables at 5% significance level, except for ΔLPROD, CCO, CVO, and CNO.

Table 1 about here

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[2]http://www-personal.umich.edu/~lkilian/

3. Empirical results and discussions

This paper compares the effects of oil shocks on dynamic correlation series between oil and stock markets in oil importer and oil exporter countries. For this purpose, we first test the unit root and multiple structural breakpoints in the utilized variables. Second, we decompose oil price shocks to three types by using SVAR model. Then, we employ cDCC model to extract time varying correlation between oil and stock markets. Finally, we utilize MS model to assess the nonlinear relationship between the three oil price shocks and dynamic correlation between oil and stock markets.

3.1 Unit root and multiple structural breakpoint tests

In order to determine the structural breaks in the variables under investigation, we use Bai and Perron (2003) multiple structural breakpoint test. Bai and Perron (2003) test results indicate that all variables except CRO, CNO, CBO, CKO, and CNHO do not have structural breakpoints. Hence, we use the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests in order to test for stationarity of variables without structural breaks. Since ADF and PP unit root tests do not apply structural breaks and unit root may exist due to disregarding structural breaks of the variables (Perron, 1989), we utilize Zivot-Andrews (1992) (ZA) and Lumsdaine-Papell (1997) (LP) unit root tests for variables with structural breaks. The results of unit root tests are reported in table 2. According to the results of ADF and PP unit root tests, it can be rejected the null hypothesis of unit root for all variables, except for CRO, CNO, CBO, CKO, and CNHO (which have structural breaks). The results of ZA and LP unit root tests show that these variables also are stationary. Therefore, all variables are stationary at 1% level of significance.

Table 2 about here

3.2 Oil price shocks and dynamic correlation between oil and stock markets

According to the aim of this study, we extract time series of three types of oil price shocks including supply side shocks, aggregate demand shocks, and precautionary demand shocks from SVAR model. The extracted shocks' time series are available in fig. 1. This figure exhibits cumulative effects of oil price shocks on real oil price returns based on decomposition of shocks origins. It also indicates that three types of oil price shocks' effects on the real oil price return are varying over time. The main effects of oil price shocks are related to supply-side shocks and precautionary shocks. It can be seen that supply-side shocks has significant and positive effects on oil prices during their occurring periods (e.g. OPEC quotas' cuts in 1998, 1999, 2002, 2003, 2004, and 2008; pdVSA strike in 2002; and attacks in Nigeria in 2006). It is also noticeable that during the global financial crisis of 2007/2009 the aggregate demand shocks' effect on oil prices is negative and significant.

Fig. 1 about here

We use cDCC model to obtain time series of dynamic correlations between oil price returns and stock indices returns in oil importing and oil exporting countries. The estimated correlation time series for oil exporter and oil importer countries are illustrated in Fig. 2 and 3, respectively. Fig. 2 and 3 indicate that the correlation between oil price and stock markets in oil exporter and oil importer countries is dynamic over the period of study. It is also obvious that the sign of correlation between oil and stock markets changes in addition to the amount of correlation in oil importing and oil exporting countries, except in Venezuela which is always positive. The results of cDCC model for oil exporting countries indicate that the correlation between oil and stock markets fluctuates around zero in Canada and Saudi Arabia. But the correlation between oil and stock markets in Norway and Russia does not fluctuate after 2007 and it changes to positive since 2007. The dynamic conditional correlation between oil and stock markets in oil importing countries also indicates that the correlation fluctuates around zero in India and its pattern changes in Belgium and Netherlands since 2009, and Korea and Taiwan since 2007.

The changes in the correlations between oil and stock markets of oil importer and oil exporter countries are adapted to the three types of oil price shocks. Therefore, the main oil price shocks are presented on the correlation series illustrated in Fig. 2 and 3 by circles which are extracted from fig. 1 (e.g. OPEC production ceiling increase in 1997; Asian economic crisis and OPEC quotas' cuts in 1998; OPEC quotas' cuts in 1999; oil production increase of OPEC in 2000; terrorist attack in September 11, 2001; OPEC quotas' cuts and pdVSA strike in Venezuela in 2002; war in Iraq in 2003; OPEC various quotas' cuts in 2003 and 2004; Hurricane Ivan strike in 2004; militant attacks in Nigeria in 2006; global financial crisis in 2008; Gulf of Mexico oil spill or BP oil spill in 2010; and Mideast revolutions since 2011).

Against Filis et al. (2011), the marke oil price shocks' effect on the correlation between oil and stock markets is different for three types of oil price shocks in oil importer and/or oil exporter countries. On the other hand, the oil price shocks cause negligible changes in correlation between oil and stock markets. Therefore, to analyze the effects of supply-side shocks, aggregate demand shocks, and precautionary demand shocks on the correlation between oil and stock markets, and to compare this effect in oil importer and oil exporter countries, and also to assess the significance of the effect of oil price shocks on the correlation series, we estimate MS model.

Fig. 2 and 3 about here

As stated before, the changes in correlation series between oil and stock markets may be due to the oil price shocks. Therefore, we apply MS model to estimate the effects of the three types of oil shocks on the correlation series. Before estimating MS model, we test linearity with a Likelihood Ratio (LR) test. The results of these tests are reported in table 3 for oil exporter and oil importer countries. The results indicate that the null hypothesis of linearity is rejected against the alternative hypothesis of MS model at 1% level of significance.

Table 3 about here

For estimating MS model, we first determine the number of regimes based on the AIC. The results show that the value of the AIC for the model with 3 regimes is smaller than 2 regimes for all countries. Therefore, we estimate different kinds of MS models of 3 regimes for assessing the effects of oil price shocks on the correlation between oil and stock markets of oil importer and oil exporter countries. Simultaneously, we detect the lags of explanatory variables (supply side, aggregate demand and precautionary demand shocks) and the kind of MS model (that is the variables with or without regimes) based on the AIC values. The optimized number of lags is 1 for all shocks and all countries.

Fig. 4 illustrates the separated regimes on the correlation series between oil and stock markets in oil exporter countries. Based on illustrated dynamic correlations and their separation to 3 MS regimes, regime 0 is related to negative correlation, regime 1 implies low and positive correlation, and regime 2 is related to high and positive correlation in oil exporting countries, except in Venezuela in which regime 0 implies positive and low correlation, regime 1 shows approximately zero correlation and regime 2 indicates high and positive correlation.

Fig. 5 illustrates the extracted regimes of the correlation between oil and stock markets in oil importer countries. Considering the figures, regime 0 implies low and negative correlation, regime 1 exhibits approximately zero correlation, and regime 2 indicates positive and relatively high correlation.

Fig. 4 and 5 about here

The selected models' coefficients of oil exporter and oil importer countries are reported in tables 4 and 5, respectively. Comparing the results reported in tables 4 and 5 indicate that oil price shocks have insignificant effect on correlation between oil and stock markets, so that supply side shocks have significant effect on correlations only in Canada, Saudi Arabia, Belgium, and Netherlands. For Canada and Saudi Arabia (oil exporter countries), supply side shocks have negative effect on correlation between oil and stock markets and the magnitude of this effect is bigger for Saudi Arabia. For Belgium and Netherlands, supply side shocks have positive effect on correlation between oil and stock markets and the magnitude of this effect is a bit bigger for Netherlands. Aggregate demand shocks have significant effect on correlation series only for Canada and Saudi Arabia but with opposite directions in two countries. Aggregate demand shocks also have negative and significant effect on correlation between oil and stock markets in India and Netherlands. Precautionary demand shocks' effect on correlation between oil price and stock index returns is significant only in Saudi Arabia, Russia, India and Taiwan with different directions in effects.

Table 4 and 5 about here

Considering fig. 4 and 5 and comparing to fig. 2 and 3 imply that the changes in regimes does not depend on the type of the oil price shock. The estimated coefficients for three types of oil price shocks by MS model confirm the results of fig. 2 and 3 for oil exporting and oil importing countries. As illustrated in fig. 2 and 3, the changes in correlation series in the most shocks' occurring points are negligible in both groups of countries and the coefficients of three types of oil price shocks are insignificant at 1%, 5%, or 10% in the MS model. These results indicate that the correlation between oil and stock markets may be affected by different factors in addition to oil price shocks.

Table 6 indicates transition probabilities between 3 regimes in oil importer and oil exporter countries. The results of oil importer countries show the stability of regimes 0, 1 and 2 which means it stays in the same state of negative, zero or positive correlation between oil and stock markets with a high probability when it happens in time t. On the other hand, the probability of transition from a regime to another one is very low, so that, the average probability of transition from regimes 0 to 1, 0 to 2, 1 to 0, 1 to 2, 2 to 0, and 2 to 1 is respectively about 0.04, 0.02, 0.03, 0.03, 0, and 0.02 in average in oil importing countries (considering that regimes 0, 1, and 2 respectively indicate negative, approximately zero, and positive correlation between oil and stock markets in oil importing countries).

The results of transition probabilities in oil exporter countries indicate that each regime of correlation series between oil and stock markets is stable and it will stay in the same state of negative, low-positive and high-positive correlation between oil and stock markets when it occurs in time t. The probability of transition from regimes 0 to 1, 0 to 2, 1 to 0, 1 to 2, 2 to 0, and 2 to 1 is respectively about 0.03, 0.07, 0.02, 0.09, 0.03 and 0.10 in average in oil exporting countries (except Venezuela because of differences in regime states). The average transition probabilities indicate that the transition between regimes is weakly probable.

Table 6 about here

The number of expected observations in each regime, cumulative probability of each regime and duration of each regime in oil importer and oil exporter countries are reported in table 7. The results for cumulative probabilities in table 7 confirm the results of table 6 in average for oil importing and oil exporting countries. It explains that the relative frequency of occurrence of every state is approximately the same, during the under study period, regardless to the state of last time point.

The average duration of regimes 0 (the state of negative correlation between oil and stock markets), 1 (the state of zero correlation between oil and stock markets), and 2 (the state of positive correlation between oil and stock markets) are respectively about 49.93, 20.91, and 47.8 months in oil importing countries. In fact, it takes about 49.93, 20.91, or 47.8 months in average to exit the negative, zero, or positive correlation, respectively, after affecting the oil price shocks on the correlation between oil and stock markets in oil importing countries. The results indicate that the duration of negative and positive correlation between oil and stock markets are longer than the zero correlation's duration.

The average duration of regimes 0 (the state of negative correlation between oil and stock markets), 1 (the state of low and positive correlation between oil and stock markets), and 2 (the state of high and positive correlation between oil and stock markets) respectively equals to 41.28, 15.96, and 36.16 months in oil exporting countries. In other words, it takes 41.28, 15.96, or 36.16

months to exit the related negative, low and positive, or high and positive correlations, respectively, after affecting the different types of oil price shocks on the correlation between oil and stock markets in oil exporting countries. The results imply that the time needed to exit negative correlation regime is longer than the regime related to positive correlation between oil and stock markets and it is coincidently longer than the low and positive correlation regime.

Table 7 about here

Comparing the transition probabilities in oil importing and oil exporting countries shows that the regimes are stable in both groups of countries and the probability of transition between regimes are very weak. The results of cumulative probabilities of the three regimes in both groups of countries confirm the transition probabilities' results and are approximately equal in oil importing and oil exporting countries. The comparison of the duration of each regime in oil importing and oil exporting countries show that the time needed to exit from negative correlation between oil and stock markets in oil importing countries is longer than it in oil exporting countries. The duration of high and positive correlation between oil and stock markets is also longer in oil importing countries than oil exporting countries. These results imply that the oil exporting countries are more affected by the shocks and the relation between oil and stock markets changes rapidly with the shocks. On the other hand, the regimes of correlation between oil and stock markets are relatively stable in oil importing countries.

4. Conclusions and policy implications

The aim of this paper is to study the effects of oil price shocks of different origins on dynamic conditional correlation between oil price and stock index returns. In fact, we study the effects of different types of oil price shocks on oil and stock markets' co-movements. For this purpose, we first decompose oil price to three different types of oil price shocks. The shocks based on the origins of unexpected changes in oil prices classified to supply side shocks, aggregate demand shocks and precautionary demand shocks. The SVAR model is applied for decomposition of oil prices. Second, we extract the time series of correlations between oil price returns and stock index returns of selected oil importing and oil exporting countries utilizing cDCC model. Then, we adapted the changes in correlation series to the important oil price shocks of different types in oil exporting and oil importing countries. The selection of oil importing and oil exporting countries are based on importance of oil import and oil export values in their economy. Correlation series' changes are in intervals (-0.5, 0.6) and (-0.5, 0.75) in oil importing and oil exporting countries, respectively, and fluctuating around zero (except in Venezuela which is always positive). Finally, the MS model is used to assess the nonlinear impact of different types of oil price shocks on the relationship between oil and stock markets and compare the results for oil importing and oil exporting countries. This is the novelty of the paper, as previous studies have not focused on nonlinear time varying relationship between different types of oil price shocks and correlation between two markets (oil and stock markets). They also have not compared this relationship in oil importer and oil exporter countries.

Our results imply some important issues: First, our findings show that oil price returns and stock index returns have a dynamic correlation over the period of study. Second, our results show that oil price shocks have negligible effect on dynamic correlation between oil and stock markets and changes in correlation series may be due to the changes in other variables affected from shocks or other variables in addition to oil price shocks. Therefore, the shocks may affect indirectly on the correlation between oil and stock markets. Third, this insignificant impact of oil shocks does not have the same pattern in oil importing and oil exporting countries and it is different country by country. In other words, we cannot express a specific difference or similarity between oil shocks' effects on correlation series in oil importer and oil exporter countries. Fourth, a notable result is that the importance of oil import and oil export values in the oil importer and oil exporter countries' economies does not affect the results. A possible explanation is that changes in magnitude and direction of correlation series affected by different oil price shocks, does not depend on the importance of oil import and oil export values in the economy for the period of study. Fifth, our results explain that the oil price shocks' impact on correlations of different countries is insignificant. Therefore, investors managing global portfolio cannot hedge their risk with portfolio diversification of oil importing and oil exporting countries.

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Table 1. Descriptive statistics of the variables under investigation

Variable	Mean	Median	Max.	Min.	Std. dev.	Skewness	Kurtosis	JB statistic
LRB	0.314668	1.119332	13.51446	-24.0879	5.183906	-1.328883	6.340604	165.5288***
LRK	0.370454	0.555046	41.0616	-31.81042	8.676273	0.199483	5.644819	64.98435***
LRNH	0.27206	1.218181	14.56889	-22.62162	6.098808	-0.98733	5.016895	72.36825***
LRI	0.886611	1.194179	24.73758	-30.66649	7.449425	-0.430171	4.125604	18.23181***
LRT	0.23655	0.662982	22.52241	-21.50303	7.402218	-0.059683	3.78371	5.708416**
LRV	3.31325	1.983859	39.42007	-51.4268	10.89882	0.184411	6.639751	121.5697***
LRC	0.473577	1.104651	11.18717	-22.57499	4.599574	-1.273747	6.966815	201.8802***
LRR	1.2508	2.87199	44.45626	-82.45711	14.66956	-1.141573	8.240596	296.8125***
LRN	0.607252	1.014239	11.184535	-12.369599	8.073564	-1.360503	7.481637	249.6913***
LRSA	0.868808	1.351312	17.89515	-29.77534	6.90667	-0.902498	5.718293	96.71139***
ΔLROP	-1.566727	-1.719173	-0.502935	-2.814835	0.605788	0.067735	1.717593	16.76776***
ΔLPROD	0.001191	0.001552	0.025896	-0.024878	0.007923	-0.116126	3.915149	8.951535
ΔGEA	-0.008418	0.058311	36.52556	-41.0601	7.958612	-0.733579	9.617675	461.3762***
Shock1	-0.01098	0.031297	2.794661	-3.309818	0.987842	-0.281227	3.858904	9.574479***
Shock2	-0.009527	0.004076	4.512227	-4.269482	1.02E+00	-0.285366	8.00347	230.3574***
Shock3	-0.001758	0.13451	2.574337	-3.043474	1.015172	-0.365949	2.93905	4.899453*
CCO	0.108015	0.105739	0.461286	-0.303272	0.139308	-0.088838	3.046173	0.306115
CRO	0.089357	-0.034208	0.455651	-0.201708	0.213727	0.445419	1.504666	27.51903***
CSAO	0.157105	0.168888	0.741768	-0.468312	0.177665	-0.542803	4.366573	27.66840***
CVO	0.144828	0.144828	0.144852	0.144814	5.18E-06	1.336969	7.802972	274.4846***
CNO	0.199014	0.154309	0.759665	-0.378518	0.265612	0.476969	2.498506	10.55023*
CBO	-0.129291	-0.175541	0.276555	-0.458639	0.226229	0.431529	1.73406	21.32289***
CIO	0.002781	-0.010204	0.582546	-0.479712	0.181725	0.049169	3.782817	5.654126**
CKO	0.124967	0.08589	0.385367	-0.091439	0.132779	0.463097	2.002426	16.83130***
CNHO	-0.043574	-0.098512	0.275987	-0.285591	0.166438	0.592937	1.813354	25.56438***
CTO	0.017454	-0.020814	0.193246	-0.14085	0.101704	0.335508	1.603365	21.80773***

Notes :

1. Shock 1, 2, and 3 define as supply side, demand side and precautionary demand shocks, respectively.
2. *, **, and *** display statistical significance at the 10%, 5% and 1% levels, respectively.

Table 2. Unit root and stationary tests of ADF, PP, ZA, LP.

Variable	ADF_{α}	ADF_{β}	PP_{α}	PP_{β}	ZA(a)	ZA(b)	ZA(c)	LP
LRB	-11.77***	-11.76***	-12.03***	-12.01***				
LRC	-12.05***	-12.03***	-12.04***	-12.02***				
LRI	-14.61***	-14.64***	-14.67***	-14.64***				
LRK	-12.68***	-12.67***	-12.65***	-12.64***				
LRNH	-13.30***	-13.29***	-13.36***	-13.38***				
LRN	-13.33***	-13.30***	-13.39***	-13.36***				
LRR	-11.81***	-11.83***	-11.90***	-11.90***				
LRSA	-12.02***	-12.02***	-12.37***	-12.35***				
LRT	-13.75***	-13.72***	-13.75***	-13.72***				
LRV	-13.13***	-13.41***	-13.73***	-13.83***				
ΔLROP	-13.02***	-12.99***	-13.02***	-12.99***				
Shock1	-15.54***	-15.55***	-15.58***	-15.60***				
Shock2	-15.37***	-15.35***	-15.41***	-15.38***				
Shock3	-15.47***	-15.43***	-15.47***	-15.43***				
CCO	-5.31***	-5.59***	-5.38***	-5.72***				
CRO	-0.589397	-2.51	-0.30	-2.37	-4.44	-2.56	-4.14	-7.41***
CSAO	-6.96***	-6.95***	-6.96***	-6.94***				

CVO	-6.55***	-6.64***	-5.79***	-5.85***				
CNO	-1.72	-2.25	-1.61	-2.15	-3.85	-2.39	-4.52	-6.63*
CBO	-0.80	-2.78	-0.68	-2.56	-5.85***	-3.05	-5.88***	
CIO	-5.82***	-5.81***	-5.84***	-5.83***				
CKO	-1.03	-2.01	-1.03	-2.10	-4.59*	-3.02	-4.58	
CNHO	-0.59	-2.40	-0.59	-2.52	-5.50***	-2.91	-5.20**	
CTO	-0.66	-3.62**	-0.09	-3.35*				
ΔLPROD	-13.55***	-13.56***	-16.78***	-16.77***				
ΔGEA	-11.42***	-11.40***	-10.85***	-10.84***				

Notes: 1. In the ADF and PP unit root tests, α indicates the model with constant term and β implies the model with constant and time trend terms.

2. (a) denotes a pattern with changes in only constant term; (b) model with changes in deterministic time trend or in the other words the slope of trend function; and (c) model with changes in constant and deterministic trend.

3. *, ** and *** denote the rejection of the null hypothesis of unit root tests at the significance level of 10%, 5% and 1%, respectively.

Table 3. The linearity tests of oil exporter and oil importer countries

Oil importer countries	X^2 statistics	Oil exporter countries	X^2 statistics
Belgium	708.08***	Canada	202.11***
India	145.29***	Norway	403.65***
Korea	428.80***	Saudi Arabia	156.27***
Netherland	610. 67***	Venezuela	290.17***
Taiwan	522.95***	Russia	704.82***

Note: ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

Table 4. Estimation results of MS model for oil exporting countries

Countries / Variables	Canada	Norway	Saudi Arabia	Venezuela	Russia
$Shock1_{0t}$	0.011 (1.05)	-	-0.0335 (-1.42)	-	-
$Shock1_{0t-1}$	-	-	-0.014 (-0.660)	-	-
$Shock1_{1t}$	-0.009 (-1.22)	-	-0.0405*** (-4.20)	-	-
$Shock1_{1t-1}$	-	-	-0.023*** (-2.72)	-	-
$Shock1_{2t}$	-0.019** (-2.13)	-	0.014 (1.13)	-	-
$Shock1_{2t-1}$	-	-	0.010 (0.754)	-	-
$Shock2_{0t}$	0.018** (2.01)	-	-0.051 (-1.53)	-	-
$Shock2_{0t-1}$	-	-	-0.0655** (-1.99)	-	-
$Shock2_{1t}$	0.003 (0.434)	-	0.002 (0.280)	-	-
$Shock2_{1t-1}$	-	-	0.0125 (1.53)	-	-
$Shock2_{2t}$	0.025**	-	-0.003	-	-

	(2.17)		(-0.273)		
$Shock2_{2t-1}$	-	-	-0.027** (-2.12)	-	-
$Shock3_{0t}$	-0.006 (-0.501)	-	-0.005 (-0.236)	-	-
$Shock3_{0t-1}$	-	-	-0.061*** (-2.63)	-	-
$Shock3_{1t}$	0.011 (0.970)	-	0.021** (2.16)	-	-
$Shock3_{1t-1}$	-	-	0.034*** (3.47)	-	-
$Shock3_{2t}$	-0.011 (-1.22)	-	-0.061*** (-4.40)	-	-
$Shock3_{2t-1}$	-	-	-0.103*** (-7.24)	-	-
C_0	-0.039*** (-3.09)	-0.063*** (-4.84)	-0.208*** (-9.33)	0.176*** (45.6)	-0.084*** (-20.3)
C_1	0.107*** (12.4)	0.164*** (22.7)	0.190*** (19.4)	0.094*** (27.3)	0.173*** (22.8)
C_2	0.263*** (21.2)	0.537*** (29.1)	0.191*** (13.9)	0.283*** (47.9)	0.383*** (103.0)
h_0	0.084*** (10.8)	0.103*** (12.0)	-	-	0.046*** (15.6)
h_1	0.050*** (6.47)	0.056*** (11.0)	-	-	0.041*** (7.54)
h_2	0.068*** (10.0)	0.149*** (11.4)	-	-	0.030*** (11.3)
$Shock1_t$	-	-0.009* (-1.59)	-	-0.002 (-1.01)	-0.004 (-1.31)
$Shock1_{t-1}$	-	-	-	-0.002 (-1.10)	-
$Shock2_t$	-	0.005 (0.650)	-	-0.0026 (-1.28)	-0.001 (-0.297)
$Shock2_{t-1}$	-	-	-	-0.0027 (-1.34)	-
$Shock3_t$	-	0.001 (0.175)	-	-0.0005 (-0.234)	0.005** (1.96)
$Shock3_{t-1}$	-	-	-	0.001 (0.594)	-
h_t	-	-	0.085*** (17.7)	0.029*** (19.4)	-

Note: 1. $SHOCK1_{i,t-j}$ denotes j^{th} lag of supply side shocks in i^{th} regime, and the same is $SHOCK2_{i,t-j}$ and $SHOCK3_{i,t-j}$. C_i and h_i indicates constant coefficients and residual variance in i^{th} regime, respectively.
2. Variables without i indicate variables without regimes.
3. () indicates t-Student statistics.
4. ***, ** and * indicate the statistical significance at 1%, 5% and 10% level, respectively.

Table 5. Estimation results of MS model for oil importing countries

Countries / Variables	Belgium	India	Korea	Netherland	Taiwan
$Shock1_{0t}$	-	-	-	0.008** (1.83)	0.002 (0.73)
$Shock1_{0t-1}$	-	-	-	-	-

$Shock1_{1t}$	-	-	-	0.007 (1.57)	0.006 (1.50)
$Shock1_{1t-1}$	-	-	-	-	-
$Shock1_{2t}$	-	-	-	-0.006 (-1.04)	-0.005 (-1.19)
$Shock1_{2t-1}$	-	-	-	-	-
$Shock2_{0t}$	-	-	-	-0.010 (-1.29)	-0.007 (-1.24)
$Shock2_{0t-1}$	-	-	-	-	-
$Shock2_{1t}$	-	-	-	-0.022*** (-3.32)	-0.008 (-1.53)
$Shock2_{1t-1}$	-	-	-	-	-
$Shock2_{2t}$	-	-	-	-0.001 (-0.22)	0.000 (0.16)
$Shock2_{2t-1}$	-	-	-	-	-
$Shock3_{0t}$	-	-	-	-0.000 (-0.06)	0.006** (1.98)
$Shock3_{0t-1}$	-	-	-	-	-
$Shock3_{1t}$	-	-	-	0.003 (0.51)	0.009* (1.89)
$Shock3_{1t-1}$	-	-	-	-	-
$Shock3_{2t}$	-	-	-	-0.002 (-0.41)	-0.003 (-0.71)
$Shock3_{2t-1}$	-	-	-	-	-
C_0	-0.344*** (-51.0)	-0.245*** (-8.16)	0.201*** (32.0)	-0.188*** (-46.2)	-0.063*** (-20.7)
C_1	-0.154*** (-27.0)	-0.034*** (-4.02)	0.022*** (5.16)	-0.075*** (-14.5)	0.066*** (17.2)
C_2	0.191*** (56.2)	0.143*** (8.62)	0.350*** (43.3)	0.196*** (42.9)	0.152*** (48.3)
h_0	0.057*** (11.9)	0.110*** (5.75)	-	-	0.034*** (15.7)
h_1	0.038*** (9.00)	0.052*** (6.48)	-	-	0.021*** (7.60)
h_2	0.027*** (11.2)	0.126*** (11.3)	-	-	0.025*** (11.3)
$Shock1_t$	0.006** (2.04)	-0.004 (-0.54)	0.001 (0.31)	-	-
$Shock1_{t-1}$	-	0.002 (0.22)	-	-	-
$Shock2_t$	0.001 (0.707)	-0.020*** (-3.23)	0.001 (0.34)	-	-
$Shock2_{t-1}$	-	-0.018*** (-2.96)	-	-	-
$Shock3_t$	-0.003 (-1.10)	-0.020*** (-2.70)	(0.003) 0.78	-	-
$Shock3_{t-1}$	-	-0.017** (-2.20)	-	-	-
h_t	-	-	0.046*** (20.6)	0.036*** (20.4)	-

Note: 1. $SHOCK1_{i,t-j}$ denotes j^{th} lag of supply side shocks in i^{th} regime, and the same is $SHOCK2_{i,t-j}$ and $SHOCK3_{i,t-j}$. C_i and h_i indicates constant coefficients and residual variance in i^{th} regime, respectively.
2. Variables without i indicate variables without regimes.

3. () indicates t-Student statistics.
4. ***, ** and * indicate the statistical significance at 1%, 5% and 10% level, respectively.

Table 6- transition probability matrices of oil importer and oil exporter countries

t / t+1		Oil importer countries			t / t+1		Oil exporter countries		
		Regime 0	Regime 1	Regime 2			Regime 0	Regime 1	Regime 2
Belgium	Regime 0	0.977	0.015	0.000	Canada	Regime 0	0.915	0.037	0.040
	Regime 1	0.022	0.970	0.000		Regime 1	0.085	0.870	0.072
	Regime 2	0.000	0.015	1.000		Regime 2	0.000	0.092	0.887
India	Regime 0	0.800	0.109	0.000	Norway	Regime 0	0.959	0.039	0.000
	Regime 1	0.130	0.801	0.104		Regime 1	0.041	0.948	0.000
	Regime 2	0.069	0.090	0.896		Regime 2	0.000	0.013	1.000
Korea	Regime 0	0.967	0.016	0.000	Russia	Regime 0	0.992	0.000	0.000
	Regime 1	0.016	0.983	0.000		Regime 1	0.008	0.965	0.000
	Regime 2	0.016	0.000	1.000		Regime 2	0.000	0.0345	1.000
Netherlands	Regime 0	0.968	0.034	0.000	Saudi Arabia	Regime 0	0.714	0.000	0.099
	Regime 1	0.032	0.950	0.000		Regime 1	0.000	0.795	0.311
	Regime 2	0.000	0.016	1.000		Regime 2	0.286	0.205	0.590
Taiwan	Regime 0	0.992	0.000	0.000	Venezuela	Regime 0	0.909	0.033	0.113
	Regime 1	0.008	0.967	0.000		Regime 1	0.054	0.967	0.000
	Regime 2	0.000	0.033	1.000		Regime 2	0.037	0.000	0.887

Table 7- the number of expected observations, cumulative probability and duration of each regime

Oil importer countries	regimes	The number of expected observations	Cumulative probability	Regime duration	Oil exporter countries	regimes	The number of expected observations	Cumulative probability	Regime duration
Belgium	Regime 0	88	0.40	44.00	Canada	Regime 0	67	0.31	13.40
	Regime 1	66	0.30	33.00		Regime 1	85	0.39	8.50
	Regime 2	64	0.30	64.00		Regime 2	66	0.30	11.00
India	Regime 0	41	0.19	5.13	Norway	Regime 0	75	0.34	25
	Regime 1	80	0.37	5.71		Regime 1	77	0.35	19.25
	Regime 2	96	0.44	12.00		Regime 2	66	0.30	66.00
Korea	Regime 0	61	0.28	30.50	Russia	Regime 0	123	0.57	123.00
	Regime 1	121	0.56	60.50		Regime 1	29	0.13	29.00
	Regime 2	35	0.16	35.00		Regime 2	65	0.30	65.00
Netherlands	Regime 0	93	0.43	31.00	Saudi Arabia	Regime 0	26	0.12	3.71
	Regime 1	61	0.28	20.33		Regime 1	128	0.59	7.11
	Regime 2	64	0.29	64.00		Regime 2	63	0.29	2.63
Taiwan	Regime 0	124	0.57	124	Venezuela	Regime 0	81	0.37	11.57
	Regime 1	30	0.14	30		Regime 1	109	0.50	27.25
	Regime 2	64	0.29	64		Regime 2	27	0.12	9.00

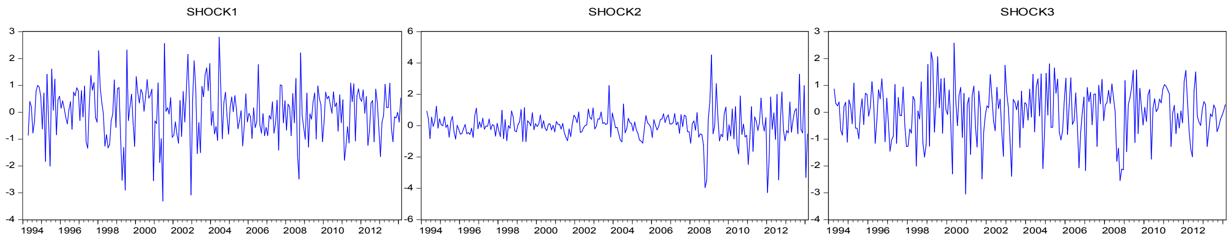

Fig. 1. Historical decomposition of real oil price of oil: 1994:4 – 2014:2.

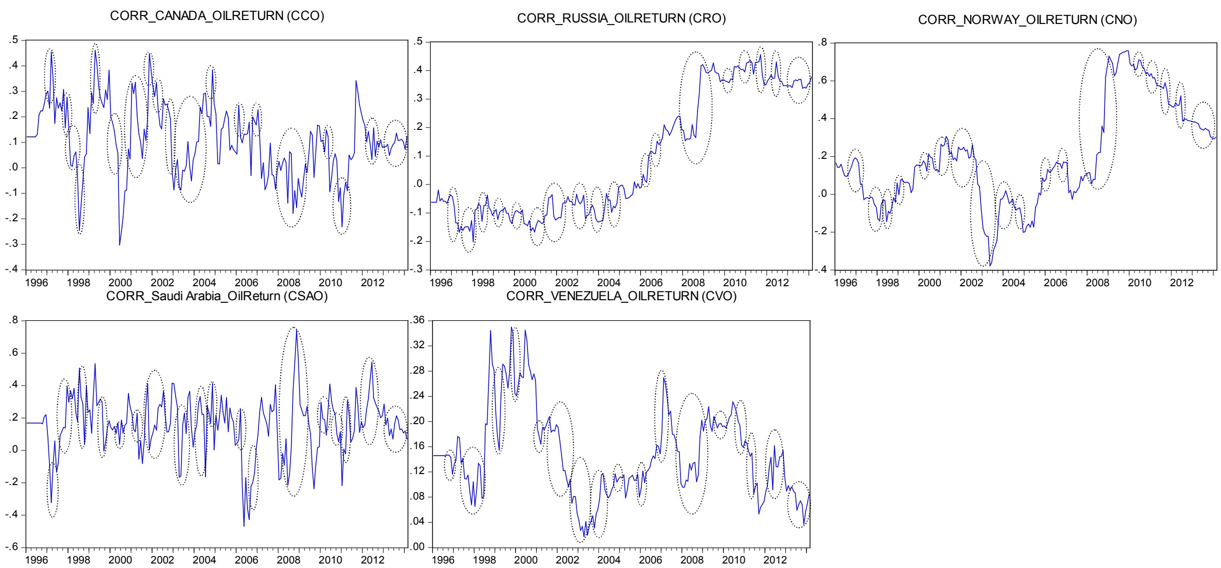

Fig. 2. Dynamic conditional correlations between oil price and stock indices of oil exporter countries estimated by cDCC model

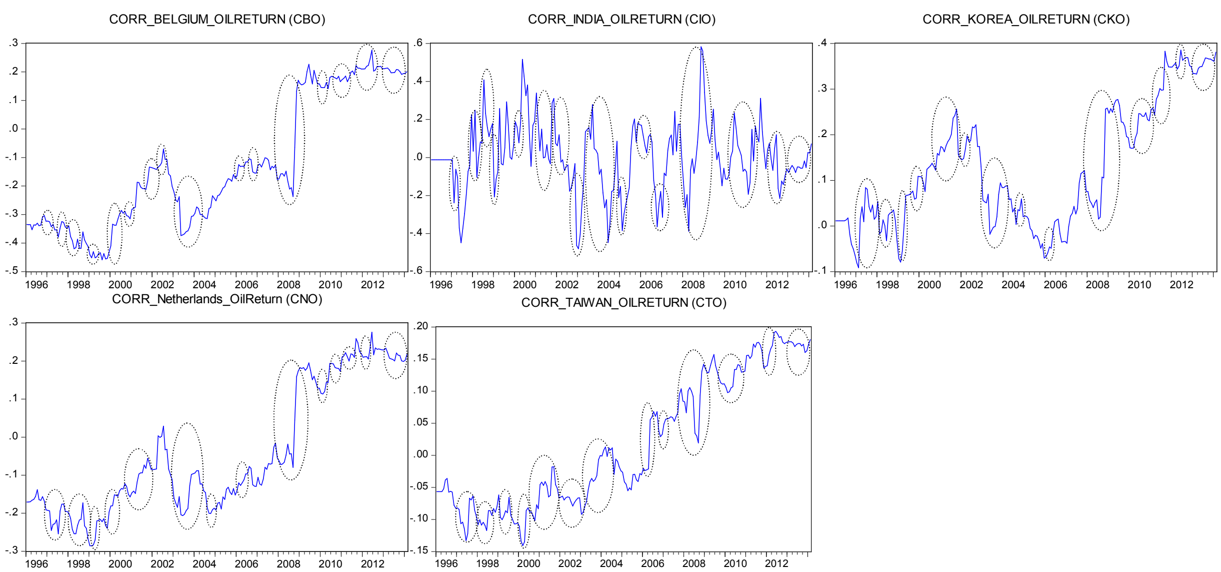

Fig. 3. Dynamic conditional correlations between oil price and stock indices of oil importer countries estimated by cDCC model

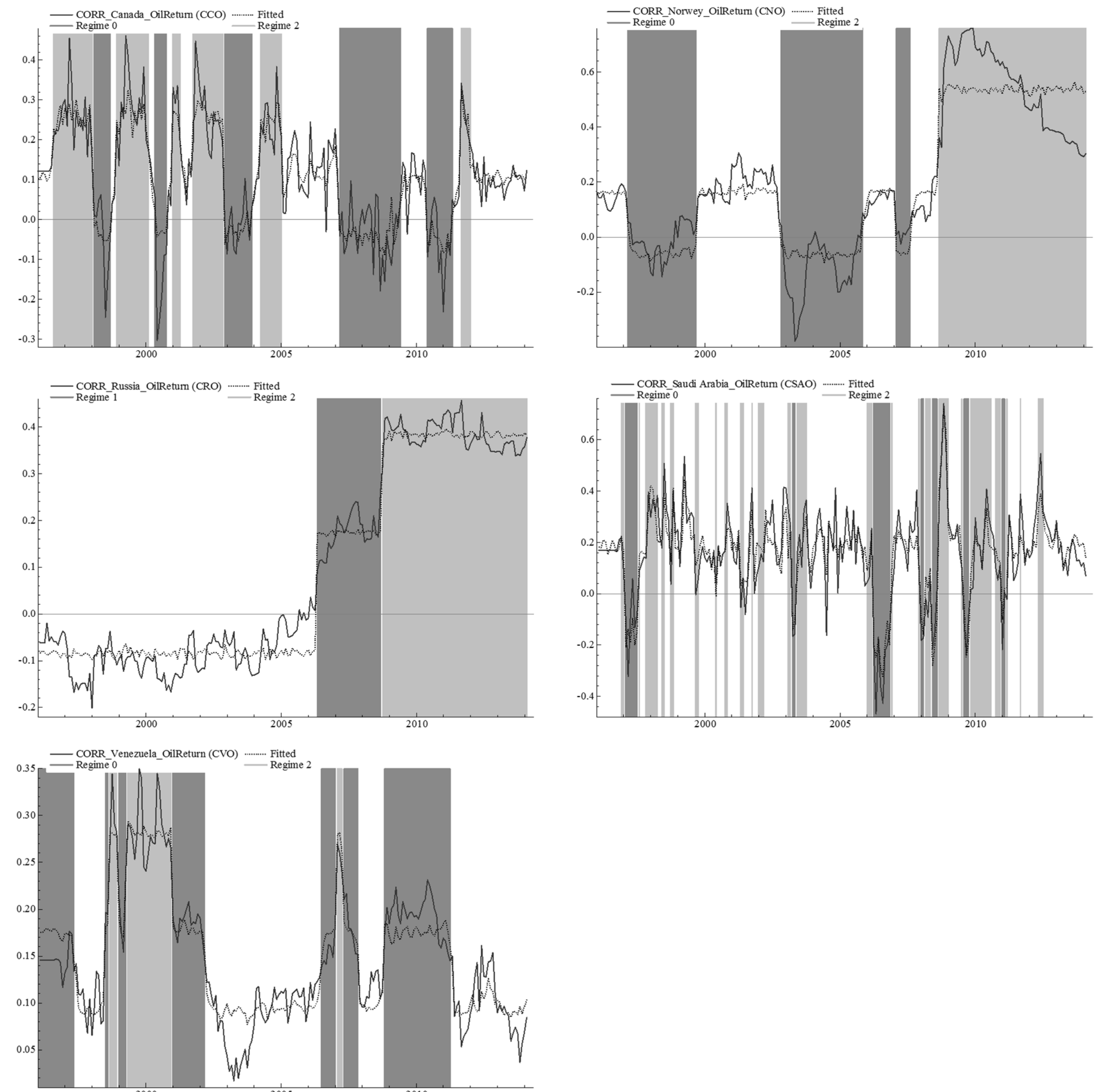

Fig. 4. Dynamic correlation and MS regimes of oil exporter countries

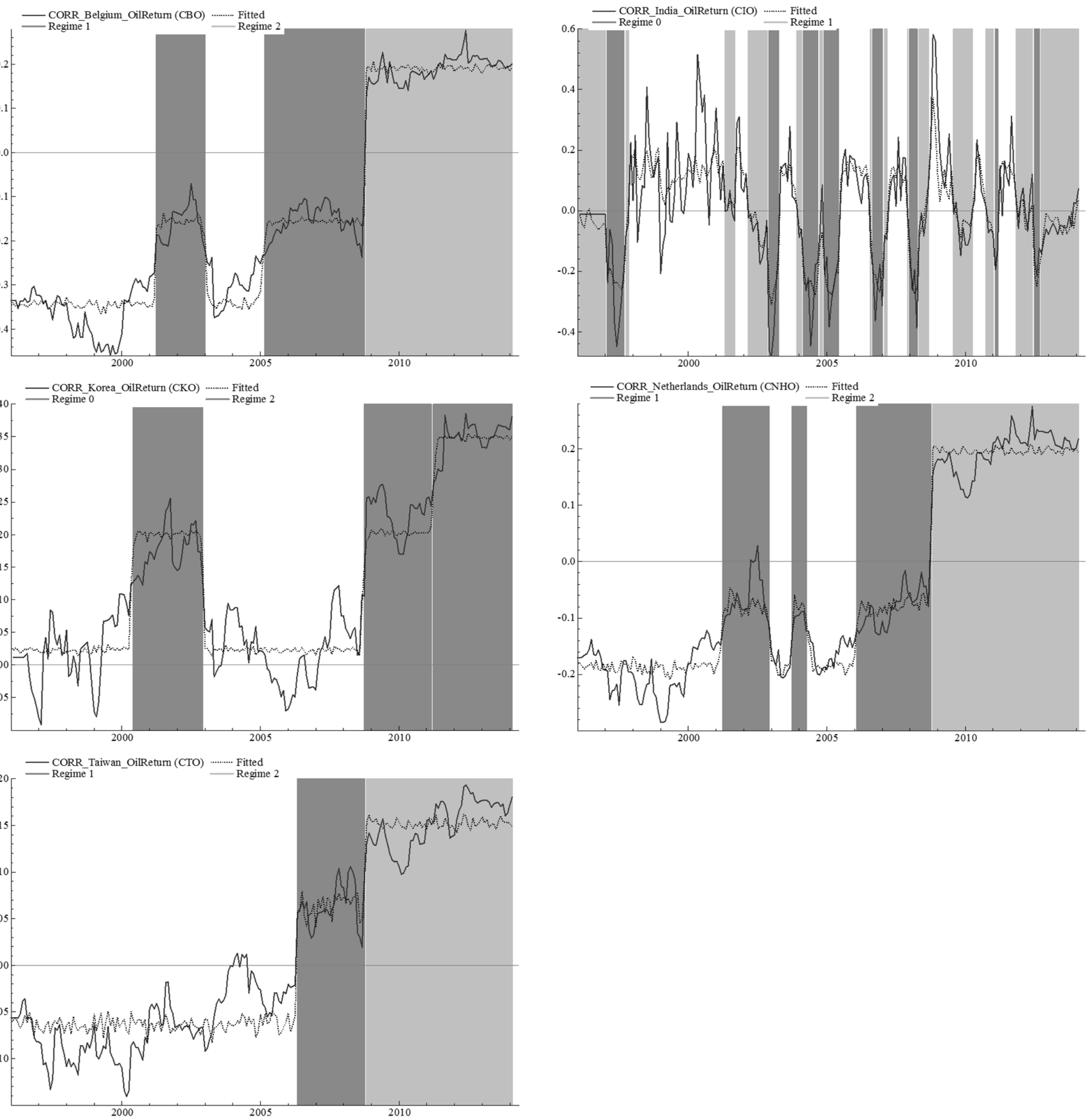

Fig. 5. Dynamic correlation and MS regimes of oil importer countries