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ORIGINAL PAPER

Symmetric and asymmetric GARCH estimations of the impact of oil price uncertainty on output growth: evidence from the G7

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Abstract
Crude oil is an essential source of energy. Without access to energy, output growth is impossible. As a result of this link, volatility in oil prices has the ability to induce fluctuations in the output of both developed and developing economies. Moreover, factors such as business cycles and policy changes often introduce nonlinearity into the transmission mechanism of oil price shocks. This study therefore examines not only the interconnectedness of oil price volatility and output growth, but also the nonlinear, asymmetric impact of oil price volatility on output growth in the countries making up the Group of Seven. To this end, monthly data on West Texas Intermediate oil price and industrial production indices of the Group of Seven countries over the period 1990:01 to 2019:08 is used for empirical analysis. The study employs the DCC and cDCC-GARCH techniques for symmetric empirical analysis. The asymmetric empirical analysis is also conducted via GJR-GARCH, FIEGARCH, HYGARCH and cDCC-GARCH techniques. The findings reveal disparities in the magnitudes of the positive and negative (asymmetric) effects of oil price shocks on output growth. The results also reveal that past news and lagged volatility have a significant impact on the current conditional volatility of the output growth of the Group of Seven countries. The study concludes that the impact of oil price volatility on output growth in the selected economies is asymmetric, the volatility is highly persistent and clustered, and the asymmetric GARCH models outperform the symmetric GARCH models.

Keywords Oil prices · Industrial production index · Symmetric GARCH · Asymmetric GARCH · G7

JEL Classification C50 · E39 · F41

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1 Introduction

A clear understanding of the effect of oil price fluctuations on output growth (industrial production) is vital, not only for the developing world but also for the most industrialized countries. Unexpected shocks in the most industrialized countries send resultant waves across the world, especially in the global productivity and oil market (Hamilton 1983; Alhassan and Kilishi 2016; Olanipekun et al. 2019; Balcilar et al. 2017, 2022a; Jelilov et al. 2020; Lee et al. 2021; Olasehinde-Williams 2021; Ringim et al. 2022). Also, oil irrelevance in the manufacturing and industrial sectors is widely speculated in the nearest future, as countries continue to introduce policies that discourage fossil fuel consumption (Meckling and Nahm 2019; Dong et al. 2022; Liu and Chao 2022). This study therefore explores the impact of oil price volatility on the output growth of the most industrialized countries—United States (US), United Kingdom (UK), France, Germany, Canada, Italy and Japan. The study is motivated by the fact that very few studies have so far adopted symmetric and asymmetric GARCH modelling in analyzing the impact of oil price movements on industrial production. This is quite an important issue as it has been established that symmetric modelling of the transmission mechanism of oil price volatility does not sufficiently capture the impact of economic cycles and policy changes (Donayre and Wilmot 2016). Nonlinear asymmetric modelling of oil price movements, as employed in this study, is thus becoming increasingly popular.

This study has two main objectives. First, it examines the interconnectedness between oil price volatility and output growth. Second, it investigates the asymmetric impact of oil price volatility. The study therefore contributes to the existing literature by focusing on the output growth and oil market of the G7, which are the most industrialized countries. The asymmetric or non-symmetric estimation measures the responsiveness of the industrial production index to negative and positive shocks in oil price. The high volume of oil exports and imports by the G7 countries help maintain their giant economies and also provide them with sufficient energy to power their industrial/manufacturing hubs. While some of these nations produce and export huge volumes of oil for profit, others require large quantities of oil to maintain their economic growth and power their industries. US, a member of G7, ranks as one of the top 2 oil importers (with 12% of world oil imports) as well as one of the top 4 oil exporters (with 7.6% of world oil exports), while Canada and UK, also members, are ranked the 6th and 13th largest oil exporters with 7.2% and 2.4% of global oil exports respectively [International Trade Centre (ITC), 2020]. With regards to oil imports, UK, Germany, France, Japan and Italy account for 2.3%, 4%, 1.8%, 6.4% and 2.4% of world oil imports respectively (ITC 2020).

In extant literature, there is hardly any information on the symmetric/asymmetric spill-over from oil prices to output growth in the G7. Most studies focus mainly on the reaction of equity markets to oil price volatility. So far, only Alao and Payaslioglu (2021) has empirically examined the oil price and industrial production co-movement. This research thus uniquely fills this lacuna in the existing literature. The study is crucial as it makes an impactful contribution to the growing literature on the resultant effect of oil price on output growth in the G7. The findings will furnish the leadership of the G7, energy researchers/economists and petroleum engineers with necessary information. The following questions are answered: (i) how does the output growth of the G7 respond to volatilities in oil prices? (ii) are the asymmetric analyses truly asymmetric?

The remaining part of the study is structured as follows: section two provides the literature review. Section three documents the research method. Section four presents the data and preliminary analysis. Section five discusses the results, while section six contains the conclusion, policy implication and future directions.

2 Literature review

Several studies have employed the GARCH-type models in evaluating the stochastic properties of macroeconomic fundamentals such as inflation, exchange rate, interest rate and output (see Alhassan and Kilishi 2016; Iorember et al. 2018; Dabwor et al. 2022). There are also numerous studies with diverse findings on the link between oil price movements and the economy of oil exporters/producers and oil importers/consumers. For instance, Cai et al. (2020), Emenogu et al. (2020), Wajdi et al. (2020), Yang and Zhou (2020), Alao and Payaslioglu (2021) provide new perspectives on the issue using various symmetric–asymmetric GARCH models.

This research however considers the early studies of Hamilton (1983) and Mork et al. (1994) as pioneers on the subject matter. The seminal study of Hamilton (1983) is regarded as the first to report the macroeconomic effect of oil price shocks in the US economy, and states that recessions are usually preceded by oil price volatility. Mork et al. (1994) further establish that the relationship between oil prices and output fluctuations is asymmetric in countries such as the US, Canada, Japan, Germany, France and the UK, and that the relationship is predominantly negative. More recently, studies by Ahmed et al. (2012), Pinno and Serletis (2013), Elder (2018), Alao and Payaslioglu (2021) have also investigated the impact of oil price volatility on the output growth of the US, through various GARCH models. For instance, Ahmed et al. (2012), considering asymmetric effects, investigate the impact of oil price uncertainty on the output growth of the US using a component CGARCH model. The study outcome shows that higher transitory volatility of oil prices has a prolonged dampening effect on the country's industrial production. Pinno and Serletis (2013) likewise examine whether oil price uncertainty impacts output growth in the US. Employing the M-GARCH VAR with BEKK model, the authors conclude that oil prices have a time-varying effect on the aggregate economy. Similarly, Balcilar et al. (2017) study the asymmetric effect of oil price changes on South African GDP growth using A Bayesian Markov Switching-VAR Model, and come to the conclusion that oil price predicts GDP growth in the low growth regime.

Adding to the literature, Balcilar et al. (2022b) show that oil supply shocks induced by oil price increases are recessionary and stronger during periods of financial distress, and that positive oil demand shocks, on the other hand, are expansionary. The study of Ali et al. (2019) examines the G7, using non-asymmetric and asymmetric GARCH models. The findings state that past news and lagged volatility play a significant part in the conditional volatility of the countries' stock markets. It is clear from the previous studies that the focus has mostly been on the control of oil price volatility/fluctuation on stock markets of all nations, ranging from developed to developing countries. Although extant literature provides insight into the oil price volatility and industrial production nexus, it is yet to properly establish the dynamic correlation and price co-movement of the series in the G7, within a nonlinear framework. This gap is what this study fills through the study of the G7 countries, using symmetric and asymmetric GARCH models.

3 Method

The method is twofold. Symmetric and asymmetric GARCH estimation techniques are employed for empirical analysis. The symmetric estimations are conducted using dynamic conditional correlation (DCC) and consistent DCC GARCH (cDCC-GARCH) techniques. The asymmetric estimations are conducted using Glosten–Jagannathan–Runkle GARCH (GJR-GARCH), Fractionally Integrated Exponential GARCH (FIEGARCH), Hyperbolic GARCH (HY-GARCH) and cDCC-GARCH techniques.

3.1 Symmetric estimation

3.1.1 DCC-GARCH model

The approach by Engle (2002) is employed to estimate the linkages/spillovers between oil price and industrial production, following Filis et al. (2011), Arouri et al. (2012), Lin et al. (2014), Aydoğan et al. (2017), Alao and Payaslioglu (2021). The conditional variance for the GARCH model is given as follows:

$$\sigma_t^2 = \varphi + \delta\varepsilon_{t-1}^2 + \gamma\sigma_{t-1}^2 \tag{1}$$

The variance–covariance matrix in DCC is specified thus:

$$H_t = D_t R_t D_t \tag{2}$$

where $D_t = diag\left\{\sqrt{h_{i,t}}\right\}$
or

$$R = D_t^{-1} H_t D_t^{-1} = E_{t-1}\left(\varepsilon_t \varepsilon_t'\right) \quad since\ \varepsilon_t = D_t^{-1} r_t \tag{3}$$

where h represents a uni-GARCH model and R is referred to as the unconditional correlation matrix. The DCC estimator is obtainable and positive-definite as the covariance matrix, Q_t:

$$\rho_{IPI,oil,t} = \frac{q_{IPI,oil,t}}{\sqrt{q_{IPI,IPI,t}q_{oil,oil,t}}} \quad (4)$$

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

where $L = (1 - \alpha - \beta)\overline{Q};\overline{Q} = E(\varepsilon_t\varepsilon_t^{'})$ is *nbyn* unconditional variance matrix of ε_t which contains the standardized residuals and must satisfy the less-than-unity condition ($\alpha+\beta<1$ and $\alpha+\beta > 0$) to establish that the DCC model is mean-reverting. α and β are nonnegative scalar parameters. Finally, the dynamic conditional correlation model is generated as presented below:

$$Q_t = (1 - \alpha - \beta)\overline{Q} + \alpha\varepsilon_{t-1}\varepsilon'_{t-1} + \beta Q_{t-1} \quad (6)$$

where Q_t represents a symmetric positive definite matrix.

3.1.2 cDCC-GARCH model

The Aielli (2008) DCC model as well as the Aielli (2013) consistent DCC model, which are improvements on the work of Engle (2002), are further employed for empirical analysis due to their amenability. A key advantage of the cDCC model is that it confers higher consistency. The improved cDCC as introduced by Aielli (2013) is therefore given thus:

$$Q_t = (1 - \alpha - \beta)\overline{Q} + \alpha\varepsilon^*_{t-1}\varepsilon^{*'}_{t-1} + \beta Q_{t-1} \quad (7)$$

Similar to what holds in Eq. (6), the parameters α, β share the same less-than-one unity condition ($\alpha + \beta < 1$). Models (6) and (7).

3.2 Asymmetric (GARCH) estimations

3.2.1 GJR-GARCH model

Proposed by Glosten et al. (1993), this model adequately captures the asymmetric responsiveness of returns to shocks. The shocks can be of equal magnitude with different signs—positive or negative—and is widely used in economics and finance research to measure additional asymmetric risks. In most cases, GJR, i.e. third from right hand side of Eq. (8) outperforms GARCH and improves forecasting ability (Ali et al. 2019; Jiang et al. 2019; Alao and Payaslioglu 2021). Transforming Eq. (1), the GJR model is shown below:

$$\sigma_t^2 = \varphi + \alpha\varepsilon_{t-1}^2 + \eta\varepsilon_{t-1}^2 d_{t-1} + \beta\sigma_{t-1}^2 \quad (8)$$

where d_{t-1} denotes dummy variable: $\varepsilon^2_{t-1} < 0$, $d_{t-1} = 1$, otherwise, $d_{t-1} = 0$. If $\eta(gamma) \neq 0$, fulfilling non-negativity, then a leverage effect exists, but if $\eta(gamma) = 0$, then Eq. 8 displays no leverage effect and therefore simplifies to a symmetric model. This is an indication that the news impact curve is not asymmetric, further indicating that past positive shocks have the same effect on current volatility. A unique characteristic of this model is that the null hypothesis of no leverage effect can be tested with ease.

3.3 FIGARCH model

The fractional integrated GARCH (FIGARCH) bivariate model was introduced by Brunetti and Gilbert (2000) as an attempt to provide a more flexible class of processes for the conditional variance, that can easily explain observed temporal dependencies in financial market volatility. The model embeds elements of mean and conditional variance of GARCH model with respect to fractionally integrated processes.

$$\sigma = \frac{\alpha}{1-\beta(L)} + 1 - \frac{(1-\emptyset(L)(1-L)^{d}}{1-\beta(L)} \tag{9}$$

where d indicates the extent of geometric or hyperbolic decay. There are three cases for d: 0, 1 and ($0<d<1$). First, there is a geometric decay if $d=0$, second, there is infinite persistence if $d=1$, and third if d lies in between the first and second scenarios, then there is intermediate value/range of persistence.

3.4 EGARCH model

Another popular asymmetric model is the exponential GARCH or expo GARCH (EGARCH) model of Nelson (1991). The asymmetric EGARCH model is sensitive to the skewness of shocks (negative and positive) and captures leverage effects unaccounted for by ARCH and GARCH models. The $\gamma<(>)$ 0 indicates the existence or presence of asymmetric effect. The parametric indicator (γ) in Eq. 10 implies that negative (positive) shock(s) increase(s) volatility more than positive (negative) shocks of the same magnitude, and notably if parameter $\gamma=0$, then there is no asymmetric effect

$$\ln\left(\sigma_t^2\right) = \alpha + \beta\left|\frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}}}\right| + \gamma\frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}}} + \theta\ln\left(\sigma_{t-1}^2\right) \tag{10}$$

3.5 FIEGARCH model

Fusing FIGARCH and EGARCH yields FIEGARCH. The fractional integrated exponential GARCH model of Bollerslev and Mikkelsen (1999) is not different from other models, especially EGARCH, in estimation. In contrast, the FIEGARCH model simultaneously captures the finite persistence and degree of the shocks—positive or negative—and is further efficient in estimating the persistence of shocks on volatility and degree of the variable market deviation where parameter (γ) remains the same as in Eq. 10.

$$\emptyset(L)(1-L)^d \ln\left(\sigma_t^2\right) = \alpha + \beta\left|\frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}}}\right| + \gamma\frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}}} + \theta \ln\left(\sigma_{t-1}^2\right) \quad (11)$$

The stationarity of FIEGARCH model revolves round *d* with the following stationarity condition of $0 < d < 1$ (Bollerslev and Mikkelsen 1996).

3.6 HYGARCH model

The hyperbolic GARCH (HYGARCH) is a methodological extension of GARCH, FIGARCH and FIEGARCH, with the introduction of some tractable derivations and notations. This model captures long-range persistence of volatility that is otherwise impossible to capture with other asymmetric models, and so outperforms other GARCH variants (Ñíguez and Rubia 2006). The model, as constructed by Davidson (2004) and presented in a reduced form by Conrad (2007), is given thus:

$$\varphi_i^{HY} = \tau\varphi_i^{FI} + (1-\tau)\varphi_i^{GA} \quad for\ i = 1, 2, 3 \ldots \quad (12)$$

where *HY*, *FI* AND *GA* are HYGARCH, FIGARCH and GARCH respectively.

4 Data and preliminary analysis

The study employs monthly data from January 1990 to August 2019. The variables for which data was collected include West Texas Intermediate (WTI) oil price and industrial production, sourced from the databases of the FRED and OECD respectively. The oil price is measured in US dollars. The original forms of the data series are transformed into returns (growth) by taking log-differences. Specifically, the continuously compounded growth rate formula ($growth = log\ (s_t/s_{t-1})$) is used, where s_t represents the series.

Panel A of Table 1 presents the summary statistics of the data series. Expectedly, skewness of the series in Panel A is negative and the positive excess kurtosis reported is reflective of a leptokurtic shape. Unit root results are reported in Panel B, while Panels C and D show the results of the diagnostic tests and unconditional correlation respectively. The ARCH (5) and ARCH (10) results indicate the existence of an ARCH effect in the growth of the series at 1% significance level. The *p* values reject the null hypothesis of "no ARCH" effect, an indication that volatility exists in the returns series. The table further shows that all series are stationary, and also indicates the presence of serial correlation through Q^2 tests in squared residuals. The outcomes of these preliminary analyses therefore justify the use of GARCH models.

Table 1 Descriptive statistics

Variables	WTI oil	G7
Panel A: Summary Stat		
Mean	0.002	0.0009
Max	0.392	0.02
Min	− 0.332	− 0.04
Std. Dev	0.085	0.01
Skewness	− 0.337	− 2.17
Excess Kurtosis	2.107	10.53
Jarque–Bera	72.55	1922.7
Panel B: Unit Root Tests		
ADF		
SCHMIDT-PHILLIPS	− 14***	− 6.3***
	− 249***	− 234**
Panel C: Diagnostics Test		
Q^2 (5)	26.64 (0.00)**	252 [0.00]**
Q^2(10)	30.60 (0.00)**	255 [0.00]**
ARCH (5)	3.65 (0.00)**	69.1 [0.00]**
ARCH (10)	3.81 (0.00)**	35.04 [0.00]**
Panel D: Unconditional Correlation		
WTI Oil	1.00	
G7	0.18	1.00

The *p* values are in (); Q/LB, autocorrelation; Q^2 (10) up to 5 and 10 lags; ARCH, autoregressive conditional heteroskedasticity: (5) and (10) for presence of ARCH up to 5 and 10 lags; ADF, Augmented Dickey–Fuller; WTI, West Texas Intermediate; ***, ** and * denote 1%, 5% and 10% levels of significance, respectively

5 Results and discussion

5.1 Symmetric analysis

The second and third columns in Table 2 report the symmetric GARCH results for the G7 countries. The reported coefficients of the symmetric GARCH show that past shocks in the industrial production of the G7 countries have a significant effect on the current conditional volatility of their industrial production. It is further observed that coefficients of GARCH are higher than those of ARCH across both symmetric and asymmetric estimations. This thus leads to the conclusion that volatility is highly clustered and persistent. Table 2 further indicates that the past shocks in the G7 industrial production growth and oil market exert a significant effect on their current conditional volatility, and thus the current conditional volatility responds to the lagged volatility in the industrial production. In the third column of Table 2, the cDCC results confirm the DCC estimates for the G7 industrial production.

5.2 Asymmetric analysis

Columns 4–9 of Table 2 show the results obtained from the asymmetric estimations—GJR-GARCH, FIEGARCH and HYGARCH. In this second category of asymmetric analysis (for both DCC and cDCC), the fourth and seventh columns of Table 2 present the GJR estimations, which depict the current conditional volatility (CCV) as they respond significantly to past shocks in the respective oil prices and industrial production indices. The Table documents the coefficients of GJR for the G7 (0.20) industrial production indices. As indicated by indices in the G7 countries, the adverse effects are statistically significant with high magnitudes. Notably, the asymmetric cDCC in the seventh column confirms the asymmetric DCC estimations of the fourth. The fifth and eighth columns on fractionally integrated exponential GARCH statistical values in Table 2 present intermediate range of persistence of volatility with reference to magnitude of negative cum positive shocks on CCV. The significant results of FIEGARCH depict that the industrial production and oil prices both provide evidence of an intermediate range of persistence of shocks on conditional volatility, while other countries including the G7 show mixed significant results. The statistical values of HY-GARCH in columns six and nine present the long range of persistent volatility.

The results of the symmetric and asymmetric estimations are in conformity with the findings of Filis et al. (2011), Aydoğan et al. (2017), Sarwar et al. (2019), Shahid et al. (2019), Alao and Payaslioglu (2021). The results are also similar to the findings of and Alao (2012), Yang and Zhou (2020), Alao et al. (2022), Alao and Alola (2022) who provide evidence to support the existence of correlations and asymmetry.

6 Conclusion, policy and future directions

This study investigates the impact of oil price volatility on the industrial production of the G7 countries, using symmetric and asymmetric models. Both approaches provide evidence in support of the existence of a connection between the oil market and output growth in the G7. It is however worthy of mention that the asymmetric approach provides superior results when compared with the symmetric approach. The findings also reveal that the coefficients of tGARCH are higher than those of ARCH in both symmetric and asymmetric estimations. This leads to the conclusion that volatility is highly persistent and clustered in the G7 nations.

Stemming from the study findings, irrespective of their individual positions as either oil importers or oil exporters, policymakers in the G7 countries are encouraged to introduce strong and effective oil price shock absorbers to protect against the adverse effects of oil price volatility. They should also design ways to limit future oil price uncertainties, as well as establish long-lasting policy checks to protect their economies from being negatively affected by future price fluctuations such as those witnessed during the COVID-19 pandemic. The oil-exporting G7 countries are encouraged to aggressively invest in the non-oil sectors of their economies so as to jerk up non-oil sector

Table 2 G7 Countries estimation for Oil and IP index

	Symmetric		Asymmetric-DCC			Asymmetric-cDCC		
	DCC	cDCC	GJR-GARCH	FIEGARCH	HYGARCH	GJR-GARCH	FIEGARCH	HYGARCH
Mean (oil)	0.007309**	0.007140**	0.006573	0.010447***	0.007829*	0.006440	0.005330	0.007657*
Mean (IPI)	0.001772	0.001744***	0.001705***	0.001886***	0.001813***	0.001681***	0.001575***	0.001784***
Cst (oil)	0.001214***	0.001220***	0.001231***	14.656670***	0.001314***	0.001235***	−5.144951***	0.001328***
Cst (IPI)	7.289659***	7.275794***	6.212466***	−0.001105	0.821013	6.208762***	−0.001100	0.830145
Alpha/Phil (oil, oil)	0.181361***	0.180346***	0.136686**	−1.013597***	0.285843***	0.134972***	−0.907949***	0.281795***
Alpha/Phil (IPI, IPI)	0.172221***	0.172289***	−0.029068	1.993673**	−0.160946	−0.028829	0.829970***	−0.165925
Beta (oil, oil)	0.652027***	0.651379***	0.645562	1.004312***	0.614629***	0.645542***	0.846912***	0.612422***
Beta (IPI, IPI)	0.620527***	0.620152***	0.715554	0.717347***	0.951856***	0.715540***	0.990495***	0.951241***
GJR (oil)			0.085642			0.086434		
GJR (IPI)			0.204644***			0.204711***		
d-FIGARCH (oil)				−0.026781	0.682162***		0.517524**	0.685178***
d-FIGARCH (IPI)				−0.350533***	1.295906***		−0.023468	1.297608***
EGARCH(Theta 1) (oil)				−2.477359			−0.206785***	
EGARCH(Theta 2) (oil)				6.465263***			0.263537***	
EGARCH(Theta 1) (IPI)				−1.038622			0.044378	
EGARCH(Theta 2) (IPI)				1.911126***			0.476235***	
Log Alpha (HY) (oil)					−0.218049*			−0.222921**
Log Alpha (HY) (IPI)					−0.032095			−0.032262
Residual diagnostics: Log likelihood	1745.745	1745.597	1749.083	1716.535	1746.774	1748.983	1673.916	1746.615
Conditional Correlation	0.074609	0.077239	0.073893	0.088537	0.075128	0.074941	0.079221	0.078065

The p values in (), ***, ** and * denote 1%, 5% and 10% levels of significance, respectively; Oil indicates WTI oil price; IPI indicates industrial production index; Cst denotes constant; Alpha indicates autoregressive conditional heteroscedasticity; Beta indicates generalized autoregressive conditional heteroscedasticity; d-FI indicates hyperbolic decay/memory parameter-fractionally integrated; DCC indicates dynamic condition correlation; cDCC indicates corrected dynamic condition correlation; GJR indicates Glosten–Jagannathan–Runkle; FIE indicates fractionally integrated exponential; HY indicates hyperbolic; GARCH indicates generalized autoregressive conditional heteroscedasticity

Table 3 Definition of variables

Variables	Meaning	Source
Oil	Oil price	U.S. energy information administration, FRED Louis (2019)
G7	Industrial Prod. Index (IPI) of G7	OECD Website (2019)
lnOil	Log of Oil Price	Log transformation
lnG7	Log of G7 IP	Log transformation
rOil	Returns on Oil Price	Growth
rG7	Returns on G7 IP	Growth

revenues. By doing this, the adverse impact of oil price volatility would be limited. On the other hand, the oil-importing G7 countries are encouraged to prioritize transitioning from fossil fuel consumption to renewable alternatives. It is imperative for both oil-exporting and oil-importing G7 countries to quickly introduce policies that can help prevent the recurrence of significant economic challenges, the likes of which was experienced during the outbreak of the COVID-19 pandemic when oil price almost reduced to zero dollar ($0). During the COVID-19 outbreak, the global lockdown forced oil production/exports and imports (demand) to a global halt from OPEC, OPEC + members and oil importers. Finally, the G7 countries are strongly advised to minimize their dependence on oil trade as oil relevance is gradually dimming due to the advent of energy-efficient products and renewable energy alternatives.

Future researchers may compare the industrial production index with other related indices to capture the symmetric and asymmetric effects. Secondly, industrial production data is exclusive of developing countries. Therefore, as data on developing nations become available, future studies can expand the scope of the empirical analysis by including them. Thirdly, there should be an extension to checkmate the effect of volatility via News Impact curves.

Appendix

See Tables 1, 2 and 3.

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