Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Testing oil price volatility during Covid-19: Global economic impact

Lei Chang a, Zulfiqar Ali Baloch b, Hayot Berk Saydaliev c,d, Mansoor Hyder e,*, Azer Dilanchiev f

a School of Economics, Peking University, Beijing, 100871, China
b College of Economics and Management, Nanjing University of Aeronautics and Astronautics, 29 Jiangsu Avenue, Nanjing, 211106, China
c Business School, Suleyman Demirel University, Kaskelen, Almaty, 040900, Kazakhstan
d Mathematical Methods in Economics, Tashkent State University of Economics, 100003, Tashkent, Uzbekistan
e Computer Science and Engineering Science, University of Cologne, Gebäude-Nr.: 100 Albertus-Magnus-Platz, D- 50923, Köln, Germany
f International Black Sea University, Georgia

* Corresponding author.
E-mail addresses: chang06@mail.ustc.edu.cn (L. Chang), balochzulfiqarali@nuaa.edu.cn (Z.A. Baloch), h.saydaliev@tsue.uz (H.B. Saydaliev), rsahito@uni-koeln.de (M. Hyder), adilanchiev@ibsu.ge (A. Dilanchiev).

https://doi.org/10.1016/j.resourpol.2022.102891
Received 1 February 2022; Received in revised form 4 May 2022; Accepted 5 July 2022
Available online 7 July 2022
0301-4207/© 2022 Published by Elsevier Ltd.

A R T I C L E   I N F O
Keywords:
Oil price volatility
World economy
Covid-19
Economic recovery

A B S T R A C T
This paper is occasioned by the current events in the crude oil markets throughout the Covid pandemic time. The study analyzes the evolving nature of crude oil cost unpredictability caused by the variations that influence the crude sector throughout the current contagion. Every day’s dataset is within the first month of 2020 and December 30, 2021 were measured by applying VAR and GARCH models. The results corroborate that the current contagion has adverse effects on the crude sector, primarily in two ways. It resulted in the headwinds for demand and cut international demand for crude oil, increasing uncertainty for major advanced and developing nations. Next, it resulted in output headwinds as the pandemic caused hydrocarbons conflicts among the leading crude supplying countries. The two headwinds seem to have caused the more than necessary crude unpredictability. Moreover, it was found that the United States output, total requirements, and crude-levying demand shocks adversely affect the supply unpredictability of the United States and the extractive sectors. The findings depict that crude price instability responded significantly to the contagion caused by crude headwinds. Specifically, the study recorded the effect of uncertainty because of these headwinds beyond financiers’ concerns about crude price instability. This study indicates that spillovers do not have meaningful forecast data, igniting critical debates concerning the relevance of the spillover indicator for predicting at minimal sampling occurrence.

1. Introduction

The corona contagion is a once-lifetime pandemic the world has known (Akhtaruzzaman et al., 2021). The global economy has undergone substantial macroeconomic dislocations due to the onslaught of the Covid-19. Further, the investment and money markets experienced the worst event post the 1900s and additional common than the global financial crisis within the context of the size of the economies hit by the contagion (IMF, 2020). The IMF forecasted a negative 4.4 percent in 2020. To fight the contagion, governments worldwide announced fiscal stimulus packages of eleven billion United States dollars because of a shortfall of 14 percent of the global gross domestic product in 2020, an increase of 10 percent around 2019 levels (World Economic Outlook Update, 2020). Nevertheless, there is little attention to crude risk contact of investment and non-investment sectors as their positions as crude distributors, consumers, and infrastructure builders throughout the corona contagion (Klein and Walther, 2016). Equally, the energy is direly impacted by the contagion (Liu, 2021). Complete lockdown nations witnessed a fall of 25 percent, 18 percent in energy demand per week in mid-April (International Monetary Fund, 2021). Throughout the corona pandemic, predicting the exchange rate became a matter of keen interest for people in academics, businesses, financial institutions, and a host of stakeholders (Parbeeish et al., 2020).

Bourghelle et al. (2021) investigated how predictions are applied in policy formulation, and the pathway of policy in reverse influences the predictions of macroeconomic factors. For instance, an exchange rate prediction impacts the current account forecast and subsequently gross domestic product expansion in the long term. Nevertheless, exchange rates seem challenging to predict by applying the macroeconomic market dynamics, mainly out of sample, plus a theoretical equation (Köse and Ünal, 2021). This problem has attracted vast interest among scholars within the last three decades. Rossi (2013) presented a crucial
evaluation of the current research on exchange rate prediction. According to (Diaz et al., 2016), the overall conclusion is foreseeable and relies on the decisions of forecasters, prediction timeframes, sample timeframes, equations, and prediction evaluation approach. Even though it is cumbersome to arrive at a common ground, available results within the study can be stated as below: (i) The Taylor rule or net foreign asset equations act better than conventional market forces such as interest rate, money, and productivity differentials; (ii) Straight line modes function better above non-straight-line models, particularly when a small number of variables are approximated; plus (iii) Random walk excluding flow is yet the complex equation to crack (Chatziantoniou et al., 2021).

However, the international economic downturn of 2008 and the Great Recession have caused theoretical advancements in macroeconomic frameworks that entail investment markets. For instance (Jarrett et al., 2019), augmented a global macroeconomic equation alongside an investment sector associated with imperfect intermediations and random merchants. (Rosnawintang et al., 2021) found that the investment headwind occasioned by foreign asset requirement, alongside conventional macroeconomic headwinds, could produce flows amongst parameters and exchange rates, determining various problems within the global investment architecture studies. In this scenario, Awan et al. (2021) implied that a direct headwind to crude cost unpredictability brings a direct headwind to foreign asset requirements. The market actors whose earnings rely on crude hedge expansion risk by buying reduced risky foreign assets to grow their portfolios. This headwind requirement for foreign assets results in the overdue contradiction of uncovered interest rate parity. Modifications to the balanced investment and the intertemporal budget restraints form the pathway of exchange rates. Hence, the crude cost unpredictability is a rationale for predicting exchange rate flows, particularly for crude suppliers (Nonejad, 2020).

There are essential demerits in applying the crude costs and unpredictability for exchange rate prediction. (Guan et al., 2021) studied small open nations that supplied crude oil and applied a reduced-kind equation to precisely make the prediction. Notably, these countries can be considered price takers in the international crude market. Hence, hydrocarbon price variations can be detected, plus exogenous headwinds to their currencies. Next, crude costs and unpredictability are noticed in the actual period, different from the macroeconomic market forces. For instance, gross domestic product (GDP), financial aggregation, plus changes in prices of goods and services are liable to revision. The conventional wisdom is that the application of modified data can overstate their predictability capability. (Zhang and Hamori, 2021) revealed that the crude costs are accessible at everyday incidence. The preexisting research on exchange rate prediction applies four every weeks and every three months because macro market forces such as changes in prices of goods and services plus gross domestic product are solely accessible at these reduced incidences (Shehzad et al., 2021). (Chatziantoniou et al., 2021) they proposed that the exchange rate forecastability significantly stayed at similar levels every four weeks and three months of incidence.

Nevertheless, every four weeks and every three months are accumulated from every day’s incidences. When we draw an analogy to every four weeks or every three-month dataset, we can find the functions of data accumulation acts in exchange rate prediction. Further, everyday incidents such as crude cost instability could be a macroeconomic news statement (Aghiem, 2018). A comparison with every four weeks occurrence maximum rate if the media reports diminish over time (Tanveer, 2021) and (Rahman, 2021).

Further broadens the exchange rate predictability to comprise directional variation. That is, decrease or increase of currency (Plante, 2019). Whereas the central task of research centers on generating precise point predictions for the stocks of exchange rates, the aim of the financier within the foreign exchange market is varied. A gainful merchandising plan of action can occur from thriving and forecasting the direction of exchange rates flows even without precise prediction. Hence, Pesaranas and Timmerman’s (1992) directional precision analysis determines the prediction exactness for directional variations. The following approach is, for scholars interested in detail prediction from equations, we encourage the application of GroupWise analysis (Bugshan et al., 2021), which paces the whole study units’ equations, as suggested to pairwise analysis that entails the temporal choices of benchmark equation.

This study endeavors to encompass the present public health crisis that has impacted crude costs and evaluate its effects on crude oil price instability. Because of this, we investigate crude cost instability concerning a headwind that affected demand and supply in the context of the pandemic utilizing the Vector Autoregression, GARCH, ADF Analysis, and Philip Perron analyses to estimate the crude oil unpredictability plus global economic effects throughout the pandemic. In addition, investigating the dataset linked to these headwinds, we equally think it is doable to advance predictions of the future evolving characteristics of crude price instability. That is crucial to assist financiers and policy formulators in better understanding crude price dynamics within the same health challenges. Hence as far as we know, there is little scholarly work up to current times on this matter. Indeed, the quick spread of the corona contagion obtained a critical effect on the countries that already bear the brunt of crude instability. (Adekeji et al., 2021) and Jawadi and Sellami (2021) evaluated the associations between the quick movement of the variables, crude cost unpredictability, the stock markets, and economic policy doubts. To evaluate the impact of the pandemic on crude cost instability, we investigated the correlations between crude cost instability and economic policy insecurity. Indeed, the corona contagion seems to have caused headwinds to consumption and production market forces, alongside the two headwinds growing the anxiety. Hence, concentrating on economic system policy anxiety made us extra encapsulate the contagion’s impacts through the insecurity avenues. Ultimately, we did a vector autoregression equation to estimate the impacts of the contagion on crude cost unpredictability. This analysis suggests crude cost instability be the novel fundamental for exchange rate prediction.

The remaining part of the paper is structured as follows; section two combed the literature regarding the study area, and the unit describes the dataset and methodological approach. Unit four contains results and analysis, and unit five concludes with policy recommendations.

2. Literature review

Recently one of the favored methods for the studies relating to the supply instability of economic expansion has become the GARCH model. For instance, (2020) utilize a GARCH (1, 1) framework to approximate supply instability and evaluate the relationship between supply increases and instability. (Klein and Walther, 2016) deploy multiple regression GARCH equations to catalog the origin, scale, and duration of instability spillovers within the group of seven nations. Their analysis shows the existence of direct in-country gross domestic expansion diffusion amongst every nation and crosswise gross domestic product expansion diffusion amongst a majority of the group of seven nations. (Ewing and Malik, 2017) applied a GARCH equation to estimate the instability of supply expansion of 180 nations from 1990 to 2010, and it was found that supply instability is harmful to economic expansion. (Thiem, 2018) investigated the growth-instability of thirteen economic cooperation and development organizations utilizing a backed GARCH-M equation and differentiated among in-country plus foreign instability. Further, it was revealed that domestic instability is directly associated with supply expansion, and foreign instability is adversely linked to expansion.

Apart from the GARCH equations, (2019) used the Vector Auto Regression (VAR)–focused spillover indicator method to investigate the associations amongst supply expansion and revealed that instability headwinds result in reduced economic expansion. In contrast, economic expansion equally brings about decreases in supply constraints. (An
et al., 2020) discovered that the broadening and the relationship generally elucidate commodity suppliers’ supply value instability. These categorizing presumptions could entail the whole VAR; hence the whole causal correlations within the equation are stated explicitly or differently, and only a particular causal relationship is recognized (Wen et al., 2018). A structural VAR equation has vital merits over different equations that apply sole or VAR equations (Youssef and Mokni, 2020). (Alam et al., 2019) also instituted a causality via applying a yearly dataset comprising the timeframe between 1960-and 2015. It was discovered that there existed a one-way correlation going through from the crude cost to changes in prices of goods and services plus from inflations to financial institutions’ profit margins. (David-Wayas et al., 2021) conducted their analysis using a straight line plus non-straight-line Auto regression distribution lag (ARDL) equations every four weeks - around January 2009 to the first quarter of 2020. It was revealed that variations in the crude cost generated imbalance impact changes in prices of goods within the short run.

Further (Aydın and Ari, 2020), indicated that reports concerning the flow of the contagion-ignited crude cost unpredictability by applying the Waveset; the writers demonstrated the differences of the pandemic risks within the short and the long horizon. They conclude that the media’s news and dataset continuously played an essential part in spreading economic headwinds crosswise the markets. There is time-changing reliance amongst stock markets and crude cost within the corona settings throughout the contagion. (Adejeji et al., 2021) depicted that the stock market cost insecurity has a meaningful adverse impact on crude hydrocarbon investments. Moreover (Jawadi and Sellami, 2021), exhibited a quick increase in crude cost due to insecurity, while (Le et al., 2021) contended the contagion causes cost instability on headwind according to expressive reactions.

Prabhesh et al. (2020) analyzed the relationship between oil prices and stock markets in the top ten net oil-exporting countries using the DCCGARCH to discover dynamic dependence utilizing daily data from the COVID-19. The authors found a positive time-changing relationship between oil returns and stock returns, with thresholds generally coinciding with the advent of an oil price war and a worldwide stock market meltdown. Moreover, the paper concludes that falling oil prices cause stock returns to fall due to lower future revenues for oil companies, indicating a reduction in aggregate demand and economic activity in oil-exporting countries.

Further, gradually growing the crude costs decreased crude cost unpredictability throughout 2009 and 2010. Nevertheless, for a short period in the other half of 2011, crude cost instability changed a bit at a given level when crude costs spiked. When crude costs began to fall further within the other half of 2014, OVX (oil volatility index) witnessed a consistent expansion, even though on a reduced magnitude throughout the downturn. The first months of 2016 were associated with increased instability alongside comparatively reduced costs, while ongoing crude costs with a steeply reducing crude costs unpredictability indicator were noticed in the last month of 2016. In summary, a negative correlation between crude costs and unpredictability is ordinary, and there are significant timeframes in which the correlation phases out (Atri et al., 2021).

The existing research gives a concrete experiential examination and a usual reference to comprehending the supply instability of economies and the correlation between crude costs and economic supply; however, specific concerns are yet to be investigated. The literature analysis usually concentrates on the macroeconomic-level supply in the form of economic productivity of the nations and specific significant sectors. Nevertheless, manufacturing and utility companies rarely assume a concentrated outlook on the United States energy and mining sectors. Moreover, past analysis on the examination of supply instability solely deploys a traditional GARCH regression equation that overlooked the investment attributes of supply expansion rates in the form of the leptokurtosis plus fat and tail, leading to a vague approximation of supply instability. Ultimately, analysis in the literature hardly disengages the effects of crude variables from the impacts of international factors on supply instability of the crude and natural gas and mining sectors. There is not much evaluation of the varied effects of the United States crude output and the non-United States crude distribution headwinds on the supply instability. Within this paper, the study seeks to close these studies’ deficits.

3. Data and methodology

3.1. Volatility measure

Generally, media reports and financial analysts’ predictions of these events cause time series to vary. The effects of different media stories apply the equation of the conditional variance of returns proposed by Bourghelle et al. (2021). The unobserved media reports are presumed to attain the dual, not similar aspects, standard and not regular media reports. This information on innovations is grouped according to their effect on return instability. Specifically, the effect of latent good reports on innovation is presumed to be contained by the return innovations aspect (\(e_{1,t}\)). This aspect of the news report procedures brings smooth dynamic variations within the variance returns (Nwosu, 2021). The next aspect of the unobserved information process is presumed to produce not frequent huge variations in returns, \(e_{2t}\). We begin by explaining the parts of returns. Such that dataset at time \(t-1\), that comprises of history of returns \(r_{t-1} = (r_{t-1} \ldots, r_1)\), the dual stochastic innovations, \(e_1\) and \(e_2\), ascertain the returns as stated below,

\[ r_t = \mu + e_{1,t} + e_{2,t} \]  

(1)

here \(e_{1,t}\) is a standard GARCH error parameter in that \(\text{E}\{e_{1,t}\}\varphi t-1\) = 0, \(e_2\), this is a leap of innovation and a standard stochastic compelling procedure given that \(\text{E}\{e_{2,t}\|r_{t-1}\} = 0\), \(e_1\), this concurrently not reliant on \(e_2\). The conditional variance of returns is broken down into two parts. These are dynamics smooth conditional variance parts linked to the spillovers of news impacts and the conditional variance correlated to the different features dataset arrival process, which causes the leaps (Jareño et al., 2021). Thus, the conditional variance of returns is stated below:

\[ \text{Var}\{r_t|\varphi_{t-1}\} = \text{Var}\{e_{1,t}|\varphi_{t-1}\} + \text{Var}\{e_{2,t}|\varphi_{t-1}\} \]  

(2)

The initial part of the conditional variance is \(\sigma^2 = \text{Var}\{e_{1,t}|\varphi_{t-1}\}\) formulated to be a GARCH equation of previous returns to innovations, \(\sigma_{t-1}^2 = \omega + g (\varphi_\alpha + \varphi_\beta \cdot \hat{r}_{t-1}) + \beta \sigma_{t-1}^2 \)  

(3)

here \(g (\cdot)\) represents an equation of the variable vector \(\varphi\) or the feedback factor figures of previous return innovations, and \(\hat{r}_{t-1} = e_{1,t-1} + e_{2,t-1}\) and \(\cdot\) represent the cumulative return on innovation at time \(t-1\). The GARCH volatility aspect ensures previous headwinds to enforce impact on anticipated instability. The news affects the smooth autoregression variations afterward within the forecastable conditional variances. The other part of the conditional variance is linked to the leap in innovation.

\[ \text{Var}\{e_{2,t}|\varphi_{t-1}\} = (\theta + \delta)\lambda_t \]  

(4)

here \(\theta\) depicts the number of leaps and possible clustering or the leap-persistence coefficient, \(\delta\) depicts the leap-size natural deviation variable, plus \(\lambda\) is the conditional leap intensity. According to model four, the contribution to the conditional variance from the leaps will vary over time since the conditional intensity changes. Because volatility is a latent variable, we apply the OVX as a substitute variable for the costs of crude volatility. Thus, it is curious to see if the prediction performance varies individually; we utilized another estimate for instability. Indeed, that is not avoidable if we examine a prediction analysis overtime before OVX was instituted around May 2007 (Chien et al., 2021). So, the GARCH equation and its alternatives have been illustrated to give better accurate forecasting concerning crude cost instability (Herrera et al.,...
As a result, we formulated a substitute variable for the unpredictability of the GARCH estimation and drew an analogy with predictions produced by the OVX regarding a sensitivity analysis. To consider the imbalance impact of direct and adverse headwinds on the restricted variance, we applied the Exponential GARCH or EGARCH to demonstrate for clarity’s sake. An EGARCH (1,1) assumes the ensuing model:

\[
\begin{align*}
\Delta p_t &= \mu_t + \epsilon_t, \\
\epsilon_t &= \sqrt{h_t} \eta_t, \quad \eta_t \sim iid(0, 1) \\
\log(h_t) &= a_0 + a_1 \left( \frac{\epsilon_{t-1}}{\sqrt{h_{t-1}}} - \xi \right) + \gamma \epsilon_{t-1} + \phi \log(h_{t-1}),
\end{align*}
\]

Here spot crude prices are depicted by the first difference of its log \(\Delta p_t\), \(\mu_t\) depicts the time-change restricted average \(a_0\), \(\alpha_1, \xi, \) and \(\gamma\) stands for the variables for the GARCH. Hence, in producing out-of-sample predictions for the exchange rate, the same process used without that, we ought to derive the approximated instability sequence \(h_t\) about the already chosen EGARCH equation, fill in the approximated \(h_t\), \(h^{R}_t\) + 1. We initially consider the Canadian dollar and the United States Dollar rate for everyday occurrence. Applying the EGARCH as a substitute variable results in a more significant SR overall, leading to meaningful DA statistics for the augmented equation if \(x = 0,8, \ldots, 9\). But differently; an augmented equation can predict the directional variation meaningfulness and precisely do so above the commodity cost equation. The findings are also hugely similar: the augmented equation is yet meaningful forecast content in the sample. However, the Meese-Rogoff conundrum is available from the sample (Gharib et al., 2021); (Mensi et al., 2021).

3.2. Vector autoregressive (VAR)

Applying the VAR equation (2020), the study evaluated the interlinkages among the time series, making a parameter rely on its past values and independent parameters. Interestingly, this framework also tackles a vector of two or extra parameters distinguishing between endogenous and exogenous parameters. Ultimately, the study did the following four-dimensional VAR equation to demonstrate the evolving nature of crude instability (Frelichil et al., 2020):

\[
Y_t = \Phi_0 + \Phi_1 Y_{t-1} + \ldots + \Phi_p Y_{t-p} + \epsilon_t
\]

\[
\text{where: } Y_t = \begin{bmatrix} OV \\ EPU \\ ERMEPU \\ FSI \end{bmatrix}, \quad \epsilon_t = \begin{bmatrix} \epsilon_{t0} \\ \epsilon_{t1} \\ \epsilon_{t2} \\ \epsilon_{t3} \end{bmatrix}, \quad \Phi = \begin{bmatrix} a^0_0 & a^0_1 & a^0_2 & a^0_3 \\ a^1_0 & a^1_1 & a^1_2 & a^1_3 \\ a^2_0 & a^2_1 & a^2_2 & a^2_3 \\ a^3_0 & a^3_1 & a^3_2 & a^3_3 \end{bmatrix}, \quad \epsilon_{t-1,i.i.d}(0, \Sigma).
\]

Note: OV, EPU, EMREEPU, FSI show crude instability, economic policy insecurity, equity market EPU and a financial stress indicator; correspondingly, \(\epsilon_{t,i}(i = 1, \ldots, 4)\) represent innovations. Parameters included in the VAR equation ought to be without unit root to ensure they precisely approximate the equation’s variables mentioned above. The number of lags should be stated for the Vector Auto Regression equation dataset procedure. In reality, the optimal value of the p ought to be reduced to the information procedure figures. Nevertheless, the maximum likelihood rate analysis ought to be utilized to verify twice the lags number specification of the VAR equation. The other point to approximate the variables, we usually approximate the VAR by applying the Maximum Likelihood approach. Aside from that, it is recommended to check for causality among the variables included in the VAR equation. The correlations are to be anticipated together with the VAR equation, whereas bi-directional causality correlations exist. That is, the two endogenous and exogenous parameters Granger cause one another is an indication of response impacts amongst these parameters. It is equally plausible to support the Vector Auto Regression equation with specific exogenous parameters that complemented the independent parameters, resulting in a VAR approximation. This evaluation is specifically pertinent to investigating the impacts of macroeconomic programs.

3.3. The data

The analysis aims to ascertain the evolving nature of crude costs unpredictability caused by the variations that influence crude the sector throughout the current contagion. For this reason, we investigated every day’s dataset in period two within the first month of 2020 and December 30, 2021 that we gathered from the reserve of Bank of Saint Louis. The study unit is relevant to investigating the crude cost instability from the beginning of the United States Sahel shake-up in 2014 to the current pandemic contagion. The application of everyday data is specifically essential to encompass information to construct crude oil cost development. It applied the crude coast standard, the WTI, concerning the crude dataset. According to United States news magazines, the study uses the everyday Economics Policy Uncertainty(EPU) unit indicator information about ten leading United States Media papers to examine the insecurity through which we could explicitly encompass the impacts of crude distribution and consumption headwinds caused by the contagion. That is, the USA Today, Maimi Herald, Chicago Tribune, Washington Post, Los Angeles Times, to mention but a few, using the following principal words. “economic” or economy’ “uncertainty” uncertain” as well as one of the more “congress’ deficit” Federal Reserve’ White House”. The EPU indicator essentially captures insecurity correlated to economic programs. We also applied another substitute variable for uncertainty applying the Equity Market-related Economic Uncertainty Indicator (EMREPU). The Economic Policy Unit indicator index accumulates information correlated to stress from the varied market index and estimates the inherent financial system pressure. Correspondingly, whereas the application indicator comprises uncertainty over economic policies correlated to a distribution headwind, the EMREPU and the FSI indicators are vital to evaluate the impacts of financiers’ behavior plus confidences and information equilibrium, including information equilibrium susceptibility that are additionally reliant on headwinds on consumption.

4. Results and discussion

4.1. VAR analysis

The findings reveal that the West Texas Intermediates indicator and the three substitutes of uncertainty plus stress parameters given under the analyzed subject matter include observed fascinating results. According to the results obtained, the West Texas intermediates depicted a similar profile in 2020 and 2014. Nevertheless, in 2014, the crude costs correction linked to the shale shakeup and the West Texas Intermediate was constructed to forty United States dollars, around April 2020. There was a robust plus an unexpected correction owing to the demand headwind ignited by the contagion that sent the West Texas Intermediates to overshoot the stage of twenty United States dollars. Fascinatingly, the twin crude costs headwinds increased drastically at the level of the insecurity about economic programs and stress plus equity-associated insecurity for financiers. To evaluate the interface thoroughly among crude costs instability, stress, and the uncertainty indexes, the study applies Granger causality analysis, investigating the null hypothesis of “no causality against the alternative hypothesis of the existence of causality. The key results are given in Table 1. Correspondingly, we detect extra proofs of meaningful bilateral casualty.
correlation amongst uncertainty indexes plus crude costs instability, implying that information emanating from uncertainty may give us the leeway to predict the future dynamism of crude costs unpredictability of crude costs. Furthermore, the financial stress does not Granger cause crude costs instability, and we detected that it attains a meaningful causality impact on uncertainty. Subsequently, it is not anticipated that financiers’ stress could probably influence crude cost unpredictability as this passes via the uncertainty avenue.

Bearing in mind the results arrived at within the following approach, we run a trio-variable VARX equation. We evaluated the interface among crude prices unpredictability, Economic Policy Unit, plus EMREPU. We modeled the VAR equations by applying the information criteria to ascertain the correct number of lags within the initial approach. After various estimations, the most appropriate specification was a twofold VARX equation with two past figures. We backed with two explained parameters from the economic policy unit plus financial stress Indexes. We presented the key findings in Table 5. Hence, we observed additional proofs of memory impacts within the dynamics of crude costs instability, implying that the last one stays consistent. This finding aligns with a recent analysis by Gil-Alana and Monge (2020), who depicted a causal connection whereby the pandemic grew uncertainty via the double headwinds of crude costs unpredictability. The results conform with the past evaluations on crude costs instability, and we detected that it attains a meaningful significance at 1% statistical level.

### 4.2. Oil price smooth and jump components

Thus, the restrictive variance is an amalgamation of smoothly dynamic GARCH aspects. Restrictive on the kind plus the relevance of the information carried by the media reports, the Jump size might be adverse, direct, robust, or moderate. Subsequently, the crude price volatility might mirror good or bad media reports. Thus, the volatility is ascertained via this analysis by the time-changing ratio of jump size, disequilibrium, and unpredictability clustering. Table 3 summarizes the approximation output of the GARCH equation for crude price unpredictability. The coefficient linked to the number of jumps (θ) seems direct and meaningful, demonstrating the diversity of volatility happenings influencing the crude market.

Furthermore, the jump-size average coefficient (δ) looks adverse,
proposing that jumps, on the mean, attained overshadowed the strange good news. The coefficients that rule the persistence of jumps and the possible jump grouping effect of innovation (β and γ) correspondingly. The effect of innovations on the jump intensity (γ), looks direct and meaningful.

Table 3 shows that considerable variations in crude costs concur with unpredicted happenings. Many principal aspects of political happenings are essential for the supply and demand market dynamics are presented within the table below comprising: Global Financial Crisis (2008) the Libyan upheavals (2011); the Crimean upheavals (2014); the phase of expanded catastrophes amongst the United States as well as China resulting to a fall within the crude demand; the expiration of the United States crude waivers making China, India plus different crude importation countries to carry on importation activity from Iran. This direction attains a harmful impact on Iran’s crude earnings, the growth of budget shorts in Saudi Arabia, and increased socio-economic and political upheaval in Venezuela. (January 2019). The reduced output from Venezuela will, in no small measure, increase crude costs beyond crash United States refiners that import huge quantities from Venezuela daily.

4.3. Volatility in financial markets

The first effect of headwinds within the Equity Volatility Index (VIX) on achieved crude costs unpredictability as witnessed is direct via the timeframe of analysis; nevertheless, the impact is ubiquitous during the economic downturn that causes severe uncertainty around the world. Crude cost volatility is anticipated to react directly to an explicitly world’s financial market unpredictability headwind. A direct world financial market unpredictability headwind depicts increasing insecurity concerning future stock cost variations and adds to negative returns in global stock markets comprising crude return. Hence, a greater level of financial uncertainty indicates worsening economic ramifications conditions and is linked to greater crude cost unpredictability. We recognized the direct reaction from the achieved crude costs unpredictability throughout the meltdown in the early 1990s as well as the 2000s, throughout the months of the global financial crisis in 2008, and most currently, throughout the gaps that comprise the EU sovereign debt crisis, including the costs crush in 2014. The years showed the most significant direct reactions from the achieved crude cost unpredictability (Diebold and Yilmaz, 2012). The crude costs unpredictability to reach the summit when investment market unpredictability shows huge increases. For instance, the Persian Gulf War (1990–1991), the 2000 United States economic meltdown, the global financial crisis of 2008, the EU debt crisis of 2009, and the crude costs collapse of 2014. Subsequently, associating these global events of the investment uncertainty alongside the crude market, we observe that these events are correlated with the crash or temporary disruption of worldly crude prices. The only difference was noticed during the Persian Gulf War, where crude costs spiked rapidly and were associated with geopolitical upheavals. In turn, these happenings bring about price unpredictability to greater levels. The results associated with the meaningfulness of the VIX indicator have been documented by (Kristoufek, 2021).

Additionally, crude prices are anticipated to react favorably to a direct international interest rates headwind. A direct international interest headwind, a money market headwind, induces the borrowing costs to grow and disincentivizes financing. This incident triggers uncertainty in the world market and decreases total consumption. Hence, crude consumption and, consequently, crude costs are anticipated to decline, which means instability in crude prices (Barraza and Givelli, 2020); (Śmiech et al., 2019).

The ADF unit root and Philips-Peron (PP) unit root analysis are utilized beyond the significant findings in Table 4. The entire analysis robustly did not accept the null hypothesis of unit root, showing that these three parameters are without unit root.

Later, the TVAR analysis was applied, and from the analysis of the

| Variable | ADF (Trend) | ADF (No trend) | PP (Trend) | PP (No trend) |
|----------|-------------|----------------|-------------|---------------|
| WTI      | 0.0000      | 0.0000         | 0.0000      | 0.0000        |
| FPU      | 0.0000      | 0.0000         | 0.0000      | 0.0000        |
| MPU      | 0.0000      | 0.0000         | 0.0000      | 0.0000        |

Table 4

Table 5

AIC Minimum Criteria, the most suitable lag of TVAR was chosen at two. The initial analysis finding refutes the null hypothesis of straight-line VAR, signifying that at least one upper limit exists. The remainder of the double results illustrates that crude price unpredictability tends to be associated with one level rather than double or extra.

The other approach is to ascertain the level statistic, and the initial two rows differently show the initial level parameter, West Texas Intermediate, and the ordered level parameter. In the final row, when the SSR attains the minimum, the figure level parameter is 0.0019, which gives the whole sample into two systems. 34.33 percent of the entire observations are part of the initial system that needs crude prices unpredictability less than or equal to 0.0019. as well as is termed a “low crude unpredictability system”; 66.77 percent of the observations belong to the second regime. It needs a crude cost unpredictability greater than 0.0019, a “high-level crude cost regime”. It could be deduced that the world crude prices have shown a robust variation since the 21st century, which equally emphasizes this study’s meaningfulness. Similarly, crude supply headwinds, which are next to cause production consumption headwinds, include cumulative consumption headwinds. The influences of the four structural crude costs headwinds are more significant in the long run than in the short run. Within the short run, amidst the pandemic, the United States output headwinds can elucidate 52.77 percent of the changes in the supply instability of the hydrocarbon and the mining sectors. In the long run amidst the contagion, even though the explanatory power of the United States output headwinds for the supply unpredictability of the conventional energy sector. Nonetheless, these headwinds make up 45.5 percent of the changes within the supply unpredictability of the hydrocarbons and the extractive sectors. To compare, the non-United States output shocks have a reduced influence rate on the supply instability of the crude and mining sectors and makeup of a minute 0.12 percent at the prediction pace of eight weeks. In the long run, the non-United States headwinds have a more extraordinary predictive ability for the supply instability of the hydrocarbons and the extractive sector, which attains 1.24 percent. This elaborately corroborates our past deductions from the irf that the non-United States output headwinds have reduced effects on the supply instability. Thus, the predictive ability of crude-essential requirements headwinds on the supply instability is placed number two in several years. On the other hand, in the short run, the crude-focus demand headwinds have reduced predictive power for the supply instability of the crude and the extractive sectors. For instance, within the 5th month, the major part influence is solely 3.74 percent. Nonetheless, as the prediction expands, the rate influence of the crude-exact requirements headwinds equally increase, to 9.06 percent, within the last month of the year.

4.4. Robustness analysis

This study shows that an expansion in crude costs supply by the organization of petroleum exporting countries can adversely influence crude costs unpredictability and might be persistent. Of course, an
output shock or cut is formulated to grow the simple process, compelling the prices to correct their dynamic via a cut in crude costs instability. Nevertheless, as stated earlier, the effect of this output headwind is not as robust as in the bygones years due to the development of shake. This is obvious thus via the steadiness of the crude cost unpredictability equation. On the other hand, expanding the United States’ crude demand could affect crude cost instability. (Ince et al., 2019).

nonetheless, about a quarter of a month postponement and its effects can diminish rapidly. This is the rationale for the United States’ crude demand as it is solely a share of international crude demand (20 percent). Nevertheless, assuming the twofold impacts collectively, we can confirm that the current output and demand headwinds within the crude sector resulted from the pandemic and had a meaningful effect on crude price unpredictability (Table 6).

The SR is yet majorly within the EGARCH substitutes variables, leading to meaningful l DA statistics among the values of π -relative to nine out of fourteen statistics of π applying OVX CW analysis are slightly lower, but stays meaningful among all the figures π. The Durbin-Watson statistics equally incline to be lower within the MAE and MSE, leading to feeble outdilution of the augmented equation standard. The statistics are meaningful for the lower set of π. Within every four weeks occurrence, the findings are hugely similar within the OVX or EGARCH. The MCS findings in Table 7 conform with pairwise results. Within every occurrence days, the commodity costs equation lean to exchange the augmented equation to be the single suitable equation within the loss equation under the dual loss functions. Every four weeks, findings stay hugely.

In summary, applying the GARCH to be the substitute variables looks a little bit denting the precision of their predictions. (Haque, 2020) observed a caveat in applying a GARCH equation to estimate the unpredictability; that is, this estimate mirrors the dispersion in the prediction error produced by the econometric equation utilized in the past dataset and might not capture promising parts of uncertainty not parameterized within the equation. Put differently, OVX depicts anticipations of the volatility of the USO and, hence, is encouraging. It is likely that irrespective of attaining extra forecast content, OVX, as a market-oriented indicator, might equally have extra noise since merchants are seen to respond to media reports. Subsequently, the encouraging kind of OVX might enhance point predictability, while its comparative noise causes it to be below par in predicting directional variations. This aspect of the discourse is subject to future studies. We leave this question to future research.

4.5. Discussion and summary of findings

Generally, the study reports that our set of potential casual factors seems to impact the achieved crude costs unpredictability. Our analysis contributes to the evaluation of crude prices’ unpredictability performance. Moreover, we contend that fundamental and investment headwinds underpin the achieved crude cost unpredictability and robust effect on crude costs unpredictability. The study discovers that a shared theme of the analysis is linked to the effects of reaction of our probably international casual factors that seem to be anticipated. The past effects assume nearly ten months further to diminish and die off gradually. We can then conclude that the short-run impacts can be linked to crude market fundamentals that seem to highlight these impacts due to consumption and production disequilibrium.

Additionally, financial indexes entail information content that causes crude prices to drift away from the equilibrium and produce the same impacts. Nevertheless, the crude costs have the means to change novel

| Table 6 |

| Forecast evaluation during (April 8, 2020 to June 1, 2021). |
|---|---|---|---|---|
| **Augmented** | **Price** |
| **DM (MAE)** | **DM (MSE)** | **CW** | **SR** | **DM (MAE)** | **DM (MSE)** | **CW** |
| Daily (April 8, 2020 to June 1, 2021) | | | | | | |
| 0.1 | 55.40% | 0.12 | 1.41 | 3.25 ** | 57.1% * | 0.27 | 1.21 | 2.8 ** |
| 0.2 | 56% ** | 1.16 | 2.33 * | 4.41 *** | 57.4% *** | 1.17 | 2.22 * | 4.07 *** |
| 0.4 | 55.5% ** | 2.65 ** | 3.96 *** | 6.05 *** | 57.8% *** | 2.43 ** | 3.3 *** | 5.33 *** |
| 0.6 | 53.6% * | 2.35 ** | 3.49 *** | 5.68 *** | 55.3% ** | 2.19 * | 2.98 ** | 5.1 ** |
| 0.8 | 52.4% ** | 2.39 ** | 3.63 *** | 5.91 *** | 53.7% ** | 2.01 * | 2.99 ** | 5.19 ** |
| 1 | 51.90% | 2.07 * | 3.46 *** | 5.98 *** | 52.7% * | 1.72 * | 2.77 ** | 5.11 ** |
| 2 | 51.40% | 0.86 | 2.55 ** | 6.05 *** | 53.7% ** | 1.09 | 2.47 ** | 5.39 ** |
| 3 | 52% * | 1 | 2.65 ** | 6.42 *** | 53.4% ** | 1.2 | 2.4 ** | 5.55 *** |
| 4 | 51.70% | 0.87 | 2.43 ** | 6.42 *** | 53.3% ** | 0.98 | 2.11 * | 5.4 ** |
| 5 | 52.7% ** | 0.49 | 1.69 * | 6.01 *** | 52.7% ** | 1.05 | 1.92 * | 5.47 ** |
| 6 | 52.8% ** | 0.19 | 1.76 * | 5.75 *** | 52.6% ** | 0.63 | 1.86 * | 5.04 ** |
| 7 | 53.1% ** | 0.31 | 1.71 * | 5.84 *** | 53.5% ** | 0.59 | 1.78 * | 5.09 *** |
| 8 | 53.3% *** | 0.34 | 1.8 * | 5.95 *** | 53.7% ** | 0.53 | 1.77 * | 5.13 *** |
| 9 | 52.7% ** | 0.22 | 1.77 * | 5.94 *** | 53.7% ** | 0.51 | 1.69 * | 5.09 *** |
| Monthly (April 8, 2020 to June 1, 2021) | | | | | | |
| 0.1 | 72.7% ** | 0.61 | 0.67 | 1.33 | 72.7% * | 0.78 | 0.77 | 1.41 |
| 0.2 | 70% * | 0.36 | 0.97 | 2 | 65% * | 0.41 | 0.99 | 1.95 |
| 0.4 | 61.80% | 0.33 | 0.58 | 1.3 | 61.80% | 0.43 | 0.62 | 1.33 |
| 0.6 | 51.10% | -0.48 | 0.2 | 0.67 | 46.70% | -0.14 | 0.45 | 0.95 |
| 0.8 | 47.20% | -1.05 | -1.13 | -0.32 | 45.30% | -0.91 | -0.91 | -0.18 |
| 1 | 51.70% | -0.77 | -0.53 | 0.33 | 53.30% | -0.65 | -0.38 | 0.43 |
| 2 | 40% | -2.24 | -1.16 | 0.31 | 45% | -1.87 | -0.7 | 0.74 |
| 3 | 45.60% | -1.91 | -1.07 | 0.77 | 52.20% | -1.49 | -0.87 | 0.84 |
| 4 | 47.90% | -2.28 | -1.58 | -0.12 | 53.10% | -1.71 | -1.24 | 0.23 |
| 5 | 43% | -2.98 | -2.43 | -0.94 | 50% | -2.12 | -1.57 | -0.23 |
| 6 | 44.70% | -3.56 | -2.36 | -0.55 | 47.60% | -2.36 | -1.37 | 0.18 |
| 7 | 54.30% | -2.61 | -1.91 | 1.09 | 51.40% | -1.94 | -1.29 | 0.79 |
| 8 | 49.50% | -2.92 | -2.06 | 0.93 | 51.40% | -2.27 | -1.5 | 0.79 |
| 9 | 50.90% | -3.29 | -2.25 | 0.92 | 50.90% | -2.58 | -1.7 | 0.84 |
| In-Sample | 51.30% * | -0.34 | 1.05 | 1.97 | 50.40% | -0.35 | 0.98 | 1.85 |

Notes: Augmented refers to the augmented model. Price refers to the commodity price model. SR is the success ratio; its significance level from the directional accuracy (DA) test is marked by asterisks. DM is the Diebold–Mariano test statistic reported under the two loss functions MAE and MSE. CW is the Clark–West test statistic. *** indicates significance at 0.1%, ** at 1%, and * at 5% levels respectively. π is the ratio of out-of-sample forecasts to in-sample observations.
information and absorb the short-run disequilibrium. In turn, this procedure cuts the uncertainty in crude costs and triggers the unpredictability in crude costs at very minimal stages in the long term. Generally, the results back the proofs given by (Younes and Altug, 2021), who illustrated that the economic downturn plus financial crisis cause more significant crude costs uncertainty. Concerning the overall views, we proffer that achieved crude cost unpredictability advancements result from crude price dynamics variations of crude consumption and production beyond. Equally, we propose the relevance of investment headwinds that send information that adds significantly to variations in crude costs. This analysis follows Anh et al. (2021). They deliberate on the source and the effect of crude price unpredictability and contend that anticipations of progressive merchants, movement of crude distribution costs, and drift demand from crude are mirrored in crude costs disparities. The results confirm the results of (Camba, 2020), who reiterated the pertinence of crude distribution headwinds and global demand headwinds in attaining variations in crude costs. Contrarily, our results conform to Rahman (2021), in which speculations do not add to variations in crude cost unpredictability. We depict that speculative headwind, as shown by the global crude stockpile headwinds, causes a considerable direct reaction of the crude costs’ instability, which is comparatively greater in breadth relative to the latter’s reactions to output and cumulative consumption headwinds. For this, the total crude stockpile increasing from progressive market actors, in anticipation of growing crude costs within the future, leans to distort the market now and thus expands its uncertainty.

Ultimately, we contend that our results could be linked to current proofs in connection with the financialization of the crude market (Chatziantoniou et al., 2021). Crude costs are not solely determined by crude market production and consumption’s disequilibrium caused by growing financialization. Our results support the proof given by (Shang and Hamori, 2021). They documented those crude costs react immediately to media reports encapsulated in different asset costs in stock returns, interest rates, and exchange rates, which signifies that simple act like any different investment asset. Deducing from our analysis, the world financial investment uncertainty, global financial interbank rates, and global investment trajectories in currencies are entirely anticipated to produce international economic insecurity.

Thus, we remark on the direct relationship between crude cost unpredictability and the stress and uncertainty indicators, implying that the pandemic headwind produced extra crude cost instability, primarily due to expanded uncertainty and financiers’ stress plus concerns. Furthermore, the association between crude unpredictability and EPU increased by eight-seven percent. It concerns the bilateral relationship in the entire timeframe, mirroring the impacts of the pandemic on crude unpredictability that happened via the conduit of insecurity. This means that crude cost unpredictability was occasioned by insecurity, the global biggest crude user. We discover that the GARCH equation with t innovations represents the most sustainable modeling supply instability of the hydrocarbon and extractive sectors among the GARCH plus SV equations.

To double validate our results, we did sensitivity analysis to explicitly analyze the interface among crude prices and unpredictability alongside these headwinds. We reevaluated a VAR model applying the three parameters. The United States crude requirement, crude output, and WTI. This approximation was carried out by applying the dataset every four weeks since daily data for crude output and crude requirements were not accessible. Furthermore, whereas we termed the organization for petroleum nations, we applied the United States crude demand to be a substitute variable for crude demand (since the global crude demands were not available).

5. Conclusion and policy implication

This research paper evaluates the market-evolving nature of the fundamentals of crude cost unpredictability and its causal factors in understanding the present contagion. We utilize the VAR and the GARCH analysis to estimate the contagion’s crude costs, unpredictability, and international economic effect. The results corroborate that the current contagion has adverse effects on the crude sector, primarily in two ways. It resulted in the headwinds for demand and cut international demand for hydrocarbons, increasing uncertainty for major advanced and developing nations. Next, it resulted in output headwinds as the pandemic caused hydrocarbons conflicts among the leading crude supplying countries. The two headwinds seem to have caused the more than necessary crude unpredictability. The study’s primary focus is to evaluate the effect of uncertainty ignited by these headwinds plus investor concerns regarding crude unpredictability. Thus, our results are consistent after evaluating their sensitivity levels. So, a plausible future study might include analyzing the capability of our modeling to predict future crude unpredictability. We detect that the supply expansion of the crude and natural gas and the extractives sector show readily noticeable features of investment time series, in the form of a more prominent tail and a high-level pinnacle.

It was also found that the scale, duration, and the indicators of reactions of output unpredictability of the United States extractive sectors to global crude price variations vary greatly based on if output headwinds cause them. Particularly within the United States output disruptions, by demand headwinds or by crude leaning demand. Moreover, the United States output headwinds, total requirements headwinds, plus crude-leaning demand shocks meaningfully adversely affect the supply unpredictability of the United States hydrocarbons, natural gas, and the extractive sectors. In contrast, the reactions of the output unpredictability of the United States hydrocarbons plus natural gas and the extractive sectors to non-United States headwinds are meaningful.

(iii) The other point, to estimate the contributions of crude headwinds to the differences in the supply unpredictability of the Unites States hydrocarbons and the natural gas sectors, we apply the approach of FEVD that hinges on the structural VAR equation. Generally, the United States output headwinds, non-US supply headwinds, total demand headwinds, and crude-leaning demand shocks can elucidate 46–64 percent of the variance within the output volatilities of the United

| Table 7 Uncertainty analysis. |
|-------------------------------|-----------------|-----------------|-----------------|
| VIX                          | Uncertainty indicators | PC               |
|                              | USEPU            | GEPU            | GR              |
| 0                             | 3.3774***        | 4.1537***       | 3.4382***       |
| 1                             | 0.0175           | -0.1641         | -0.0045         |
| 2                             | 0.895            | -2.1939         | -0.7404         |
| 3                             | -0.3442          | 0.4686**        | 0.1462          |
| 4                             | 0.8669***        | 0.8702***       | 0.8672**        |
| Adjusted R²                   | 0.7575           | 0.7689          | 0.7565          |
| F-statistic                   | 50.3677***       | 53.5856***      | 49.9702***      |
| DW                            | 1.7241           | 1.7404          | 1.7481          |
| AIC                           | -0.6329          | -0.6808         | -0.6272         |

Note: DW is the Durbin-Watson statistic, AIC is the Akaike Information Criterion. *** denote significance at 10%, 5% and 1% level, respectively.
starts crude and natural gas mining sectors. The United States output headwinds have additional predictive ability for the variations within the output unpredictability over the total requirement headwinds and crude-leaning demand headwinds. The crude-leaning demand headwinds elucidate extra variations of the supply unpredictability over the total demand headwinds for crude and the mining sectors.

The effect of growing crude costs on GDP falls in the financing and increasing changes in the prices of goods and services. However, the RE-backed program can advance gross domestic product while decreasing its adverse impacts on the ecology. Concerning crude importation nations that are adversely influenced by increasing crude costs, reliance on crude costs ought to be cut. The most secure way to do this is to diversify the energy mixes of these countries. The best thing is building a national energy strategy that includes all renewable energy sources, wind and solar being at the forefront, financial incentives that encourage energy conservation programs and growing the application of energy-efficient measures.

Thus, policy formulators ought to present more significant consideration to the interfaces among these markets as even short-run headwinds can harm the economy, as records have revealed. Whereas our analysis proposes fascinating interfaces among these markets, the particular headwinds that underpin the crude markets are not evaluated, as it is a constraint on our analysis. For instance, the research implies that crude cost decreases via various structural headwinds, such as crude leaning demand and stockpile headwinds and demand headwinds due to variations in international economic system activity, affect asset markets in varied ways.

It is approximated that depreciation in the exchange rate majorly passes via changes in prices of goods and services by increasing the costs of imported goods estimated. It was approximated that exchange rates can equally pass via no costs levels in imports, production, and consumption. Hence, this research depicts that the exchange rate attains a marked effect on Purchasing power parity-according to changes in the prices of goods and services. Nevertheless, the timeframe from the middle of 1990 to the close of 2000 is closely linked with the drastic fall of crude stockpiles due to petroleum exporting countries’ supply cuts, excluding recovery times. Additionally, the time from 2000-to 2005 was associated with modifications in crude supply from the organization of petroleum exporting nations’ member nations to avoid crude stockpiles (Yousef M, Mokni K, 2019).

Similarly, preexisting research focused on bilateral rates against the United States dollar. Regarding macro data accessibility, incidences are the most researched every four weeks and three months. Our results conform to the existing literature on the Meese–Rogoff puzzle ubiquitous within these bilateral rates. Nevertheless, many novel findings are worth observing. Merchants focused on correctly predicting the directional variation in the Canadian dollar or the United States dollar, crude costs, and its volatility stays important fundamentals, particularly at everyday incidences, even excluding a beating random drift-in regarding point prediction. Secondly, the conduits perform differently in small open countries that import crude. Thirdly, currency issues applied to crude cost and unpredictability to predict exchange rates. Fourthly, the predictive analysis diminishes when we advance from daily to every four weeks occurrences.

Author statement
Lei Chang: In the process of writing the article, the first author participated in the idea of the article and the collation and analysis of data, and the; Zulfiquar Ali Baloch: carried out the design of relevant methods, project support, data collection and proofreading, Hayot Berk SAYDALIEV & Mansoor Hyder: Reviewing, Editing, Monitoring, Azer Dilanchiev: Editing, English check, reviewing and Supervision.

Data availability
The authors do not have permission to share data.

References
Adejole, A., Ahmed, F.F., Adam, S.U., 2021. Examining the dynamic effect of COVID-19 pandemic on crude oil prices using structural vector autoregressive model. Energy. https://doi.org/10.1016/j.energy.2021.120813.
Aghiyosi, O.S., 2018. Oil price volatility and business cycles in Nigeria. Stud. Bus. Econ. https://doi.org/10.4274/sbe.2018.0018.
Akhtaruzzaman, M., Boubaker, S., Chiah, M., Zhong, A., 2021. COVID–19 and oil price risk exposure. Finance Res. Lett. https://doi.org/10.1016/j.frl.2021.101882.
Alam, M.S., Shahzad, S.J.H., Ferrer, R., 2019. Causal flows between oil and forex markets using high-frequency data: asymmetries from good and bad volatility. Energy Econ. https://doi.org/10.1016/j.eneco.2019.104553.
An, S., Gao, X., An, H., An, F., Sun, Q., Liu, S., 2020. Windowed volatility spillover effects among crude oil prices. Energy. https://doi.org/10.1016/j.energy.2020.117521.
Ahu, Hoang Quoc, Le, Thi Phuong Quyen, Da Le, Nhu, Lu, Xi Xi, Duytig, Thi Thuy, et al., 2021. Antibiotics in surface water of East and Southeast Asian countries: A focused review on contamination status, pollution sources, potential risks, and future perspectives. Sci. Total Environ. 764 https://doi.org/10.1016/j.scitotenv.2020.128685.
Arri, H., Kouki, S., Gallali, M. imen, 2021. The impact of COVID-19 news, panic and media coverage on the oil and gold prices: an ARDL approach. Resour. Pol. https://doi.org/10.1016/j.resourpol.2021.102661.
Awon, Tahir Muntau, Khan, Muhammad Shoail, Haq, Inzamam Ul, Kazmi, Sarват, 2021. Oil and stock markets volatility during pandemic times: a review of G7 countries. Green Finance 3 (1), 15–27. https://doi.org/10.3934/GF.2021002.
Aydin, L., Ari, L., 2020. The impact of Covid-19 on Turkey’s non-recoverable economic sectors compensating with falling crude oil prices: A computable general equilibrium analysis. Energy Explor. Exploit. https://doi.org/10.1114/598729094007.
Barraza, S., Civelli, A., 2020. Economic policy uncertainty and the supply of business loans. J. Bank. Finance. https://doi.org/10.1016/j.jbankfin.2020.105983.
Bourbeau, D., David, Jawadi, B. Rouin, P., et al., 2021. Oil price volatility in the context of Covid-19. Int. Econo. 167, 39–49. https://doi.org/10.1016/j.inteco.2021.05.001.
Bogshan, Abdullah, Bakry, Walid, Li, Yongjing, et al., 2021. Oil price volatility and firm profitability: an empirical analysis of Shariah-compliant and non-Shariah-compliant firms. Int. J. Emerg. Mark. https://doi.org/10.1108/IEM-10-2020-1285.
Camba, A.C., 2020. Capturing the short-run and long-run causal behavior of Philippine stock market volatility under vector error correction environment. J. Asian Finance Econ. Bus. https://doi.org/10.13106/JAFEB.2020.VOL7.NO8.041.
Chatziantoniou, I., Degiannakis, S., Delis, P., Filis, G., 2021a. Forecasting oil price volatility using spillover effects from uncertainty indices. Finance Res. Lett. https://doi.org/10.1016/j.frl.2021.101885.
Chatziantoniou, I., Filippidis, M., Filis, G., Gabeuer, D., 2021b. A closer look into the global determinants of oil price volatility. Energy Econ. https://doi.org/10.1016/j.eneco.2021.105092.
Chien, F.S., Sadiq, M., Kamran, H.W., Nawar, M.A., Hussain, M.S., Raza, M., 2021. Co-movement of energy prices and stock market return: environmental wavelet nexus of COVID-19 pandemic from the USA, Europe, and China. Environ. Sci. Polit. Control Ser. https://doi.org/10.11566/021-12988-2.
David-Wayes, O.M., Amuka, J.I., Ezeudike, C.F., Aji, I.M., Nwankwo, M.C., 2021. Oil price volatility and macroeconomic performance in nonoil exporting countries in sub-Saharan Africa. Int. J. Energy Econ. Pol. https://doi.org/10.32479/ijep.2021.11.002.
Diaz, E.M., Molero, J.C., Perez de Gracia, F., 2016. Oil price volatility and stock returns in the G7 economies. Energy Econ. 54, 417–430. https://doi.org/10.1016/j.eneco.2016.01.002.
Diebold, F.X., Yilmaz, K., 2012. Better to give than to receive: predictive directional measurement of volatility spillovers. Int. J. Forecast. https://doi.org/10.1016/j.ijforecast.2011.02.006.
Ewing, B.T., Malik, F., 2017. Modelling asymmetric volatility in oil prices under structural breaks. Energy Econ. https://doi.org/10.1016/j.eneco.2017.03.001.
Freilich, J.D., Bejan, V., Parkin, W.S., Chermark, S.M., Gruenewald, J., 2020. An intervention analysis of fatal far-right extremist violence within a vector-autoregressive framework. Dyn. Asymmetric Contfl.: Pathways toward Terrorism Genocide. https://doi.org/10.1080/17467586.2019.1700541.
Gharib, C., Mefteh-Wali, S., Serret, V., Ben Jabeur, S., 2021. Impact of COVID-19 pandemic on crude oil prices: evidence from Econophysics approach. Resour. Pol. https://doi.org/10.1016/j.resourpol.2021.102929.
Gill-Alana, Luis A., Monge, Manuel, 2020. Crude Oil Prices and COVID-19: Persistence of the Shock. Energy Res. Lett. 34 (4), 622–635. https://doi.org/10.1016/j.ijforecast.2018.04.007.

Herrera, F, Ballester, J, Weisz, E, Ogle, E, Zaki, J, 2018. Building long-term empathy: a large-scale comparison of traditional and virtual reality perspective-taking. PLoS One 13 (10), e0204494. https://doi.org/10.1371/journal.pone.0204494.

IMF, 2020. World Economic Outlook Update June 2020. International Monetary Fund.

Ince, H, Cebeci, A.F., Imamoglu, S.Z., 2019. An artificial neural network based approach to the monetary model of exchange rate. Comput. Econ. https://doi.org/10.1007/s10614-017-9705-6.

International Monetary Fund, 2021. World Economic Outlook Update, January 2021: Policy Support and Vaccines Expected to Lift Activity. International Monetary Fund.

Jarrett, F., Gonzalez, M. de la O., Lopez, R., Ramos, A.R., 2021. Cryptocurrencies and oil price shocks: a NARDL analysis in the COVID-19 pandemic. Resour. Pol. https://doi.org/10.1016/j.resourpol.2021.102281.

Jarrett, U., Mohaddes, K., Mohrtdi, H., 2019. Oil price volatility, financial institutions and economic growth. Energy Pol. https://doi.org/10.1016/j.enpol.2018.10.068.

Jawadi, F., Sellami, M., 2021. On the effect of oil price in the context of Covid-19. Int. J. Finance Econ. https://doi.org/10.1002/ijfe.2195.

Klein, T., Walther, T., 2016. Oil price volatility forecast with mixture memory GARCH. Appl. Econ. https://doi.org/10.1080/00036846.2017.1321838.

Krobouk, L., Chang et al., 2021. The historic oil price fluctuation during the Covid-19 pandemic: what are the causes? Res. Int. Bus. Finance. https://doi.org/10.1016/j.ribaf.2021.101489.

Le, T.H., Le, A.T., Le, H.C., 2021. The historic oil price fluctuation during the Covid-19 pandemic: what are the causes? Res. Int. Bus. Finance. https://doi.org/10.1016/j.ribaf.2021.101489.

Liu, D., 2021. International energy agency (IEA). Palgrave Encycl. Global Secur. Stud. https://doi.org/10.1007/978-3-319-74336-3_587-1.

Mensi, W., Al Rababa, A.R., Vo, X.V., Kang, S.H., 2021. Asymmetric spillover and network connectedness between crude oil, gold, and Chinese sector stock markets. Energy Econ. https://doi.org/10.1016/j.eneco.2021.105262.

Nonejad, N., 2020. A detailed look at crude oil price volatility prediction using large-scale comparison of traditional and virtual reality perspective-taking. PLoS One 13 (10), e0204494. https://doi.org/10.1371/journal.pone.0204494.

IMF, 2020. World Economic Outlook Update June 2020. International Monetary Fund.

Ince, H., Cebeci, A.F., Imamoglu, S.Z., 2019. An artificial neural network-based approach to the monetary model of exchange rate. Comput. Econ. https://doi.org/10.1007/s10614-017-9705-6.

International Monetary Fund, 2021. World Economic Outlook Update, January 2021: Policy Support and Vaccines Expected to Lift Activity. International Monetary Fund.

Jarrett, F., Gonzalez, M. de la O., Lopez, R., Ramos, A.R., 2021. Cryptocurrencies and oil price shocks: a NARDL analysis in the COVID-19 pandemic. Resour. Pol. https://doi.org/10.1016/j.resourpol.2021.102281.

Jarrett, U., Mohaddes, K., Mohrtdi, H., 2019. Oil price volatility, financial institutions and economic growth. Energy Pol. https://doi.org/10.1016/j.enpol.2018.10.068.

Jawadi, F., Sellami, M., 2021. On the effect of oil price in the context of Covid-19. Int. J. Finance Econ. https://doi.org/10.1002/ijfe.2195.

Klein, T., Walther, T., 2016. Oil price volatility forecast with mixture memory GARCH. Appl. Econ. https://doi.org/10.1080/00036846.2017.1321838.

Krobouk, L., Chang et al., 2021. The historic oil price fluctuation during the Covid-19 pandemic: what are the causes? Res. Int. Bus. Finance. https://doi.org/10.1016/j.ribaf.2021.101489.

Le, T.H., Le, A.T., Le, H.C., 2021. The historic oil price fluctuation during the Covid-19 pandemic: what are the causes? Res. Int. Bus. Finance. https://doi.org/10.1016/j.ribaf.2021.101489.

Liu, D., 2021. International energy agency (IEA). Palgrave Encycl. Global Secur. Stud. https://doi.org/10.1007/978-3-319-74336-3_587-1.

Mensi, W., Al Rababa, A.R., Vo, X.V., Kang, S.H., 2021. Asymmetric spillover and network connectedness between crude oil, gold, and Chinese sector stock markets. Energy Econ. https://doi.org/10.1016/j.eneco.2021.105262.

Nonejad, N., 2020. A detailed look at crude oil price volatility prediction using macroeconomic variables. J. Forecast. https://doi.org/10.1002/for.2679.

Nwosa, P.I., 2021. Oil price volatility and the US stock market. Empir. Econ. https://doi.org/10.1007/s00181-020-01906-3.

Rosnawintang, Tajuddin, Adam, P., Paarun, Y.P., Saidi, L.O., 2021. Effects of crude oil prices volatility, the internet and inflation on economic growth in asean-5 countries: a panel autoregressive distributed lag approach. Int. J. Energy Econ. Pol. https://doi.org/10.32477/ijep.10395.

Rossi, Barbara, 2013. Exchange Rate Predictability. J. Econ. Lit. 51 (4), 1063–1119. https://doi.org/10.1257/jel.51.4.1063.

Shang, J., Hamori, S., 2021. Do crude oil prices and the sentiment index influence foreign exchange rates differently in oil-importing and oil-exporting countries? A dynamic connectedness analysis. Resour. Pol. https://doi.org/10.1016/j.resourpol.2021.102400.

Shehzad, K., Zaman, U., Liu, X., Göreki, J., Pugnetti, C., 2021. Examining the asymmetric impact of COVID-19 pandemic and global financial crisis on dow jones and oil price shock. Sustainability. https://doi.org/10.3390/su13094688.

Smiech, S., Papiez, M., Fijorek, K., Dąbrowski, M.A., 2019. What drives food price volatility? Evidence based on a generalized var approach applied to the food, financial and energy markets. Economics. https://doi.org/10.5018/economics-ejournals.ja.2019-14.

Tanveer, Z., 2021. Event analysis of the COVID-19: evidence from the stock markets of twenty highly infected countries. J. Econ. Malays. https://doi.org/10.17576/JEM-2021-5501-1.

Thiem, C., 2018. Oil price uncertainty and the business cycle: accounting for the influences of global supply and demand within a VAR GARCH-in-mean framework. Appl. Econ. https://doi.org/10.1080/00036846.2018.1436142.

Wen, F., Xiao, J., Huang, C., Xia, X., 2018. Interaction between oil and US dollar exchange rate: nonlinear causality, time-varying influence and structural breaks in volatility. Appl. Econ. https://doi.org/10.1080/00036846.2017.1321838.

World Economic Outlook Update, 2020. June 2020: A Crisis like No Other, an Uncertain Recovery. IMF. https://www.imf.org/en/Publications/WEO/Issues/2020/06/24/\nWEOUpdateJune2020.

Yaya, O.O.S., Vo, X.V., Ogbonna, A.E., Adewuyi, A.O., 2020. Modelling cryptocurrency high-low prices using fractional cointegrating VAR. Int. J. Finance Econ. https://doi. org/10.1002/ijfe.2184.

Younes, O.A., Altug, S., 2021. The COVID-19 shock: a bayesian approach. J. Risk Financ. Manag. https://doi.org/10.3390/jrfm14100495.

Youssef, M., Mokni, K., 2020. Modeling the relationship between oil and USD exchange rates volatility, the internet and inflation on economic growth in asean-5 countries: a dynamic connectedness analysis. Resour. Pol. https://doi.org/10.1016/j.resourpol.2021.102400.

Zhang, W., Hamori, S., 2021. Oil price volatility and the US stock market. Empir. Econ. https://doi.org/10.1007/s00181-020-01906-3.