Volatility Integration of World GDP and World Inflation Rate with Crude Oil Prices

S. Vijayakumar [1]
P. Karthikeyan [2]

Abstract

Purpose : The price of crude oil directly affects inflation. The cost of products and services goes up across the economy when oil prices rise. Since both factors affected crude oil price movement, the current study focused on how variations in the global gross domestic product (GDP) and global inflation affect crude oil price volatility.

Methodology : In the current study, the relationship and extended impact among a few study variables were analyzed using bivariate GARCH models (diagonal VEC GARCH and BEKK GARCH). The analysis was based on annual sample data from January 2000 to December 2022 to investigate the volatility association in the three variables, along with volatility, spillover, and the effect.

Results : The study revealed the mutual relationships among world GDP, inflation, and crude oil prices. The world GDP and crude oil prices were found to have a considerable conditional correlation when bivariate GARCH models were employed. Therefore, while they showed volatility spillover in co-variance, the global GDP and inflation rate did not show volatility spillover effects on crude oil prices. A noteworthy correlation between the pace of global inflation and the price of crude oil was also discovered by the investigation. On the other hand, it is insignificant and shows a reverse impact of world GDP on the changes in crude oil prices. Additionally, the world inflation rate volatility negatively affected oil prices in the spillover effect.

Implications : This study is significant from the investment point of view as various investors invest in financial instruments. This study revealed substantial information to policymakers and corporations for essential decisions regarding exploration and production activities. It also contributed to an academic pool of information domains for further research. The interplay between these factors could significantly influence economic outlooks and policy decisions globally.

Value/Originality : This is the first study on crude oil, world GDP, and world inflation, as far as we know.

Keywords : inflation, interest rates, gold, crude oil, volatility spillover

JEL Classification Codes : E31, E490, F1

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Crude oil is one of the essential commodities and a necessity since it has emerged as the prime source of several petroleum products. It serves as fuel in different kinds of transportation, heating, cooking, or generating electricity, and has its utility and application in various activities. Exporters of crude oil depend mostly on these funds to support infrastructure projects and public services that promote economic expansion. However, countries that import oil must manage the financial impact of fluctuating oil prices on their trade

[1] *Research Scholar (Corresponding Author),* Department of Management Studies, Center for Post-Graduate and Research Studies,Periyar University, Dharmapuri - 636 701, Tamil Nadu. (Email : vijikumar71@gmail.com)
[2] *Professor,* Department of Management Studies, Center for Post-Graduate and Research Studies, Periyar University, Dharmapuri - 636 701, Tamil Nadu.

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balances and inflation rates. Furthermore, the oil business contributes to capital investment, government revenue through taxes, and employment, supporting overall economic growth and stability. Therefore, maintaining economic momentum and guaranteeing long-term prosperity depends heavily on the stability and affordability of crude oil supply. Additionally, the issue arises when there is an inflation-related imbalance between the supply and demand for crude oil volatility (Rosnawintang et al., 2020; Sarmah & Bal, 2021).

Crude oil is also known as black gold or hydrocarbon liquids, which account for about a third of total world energy consumption. Zavadska et al. (2020) analyzed the volatility patterns in Brent crude oil spot and futures prices covering the major crises that had impacted the oil markets substantially more so during the First Gulf War (1990–1991), Asian financial crisis (1997–1998), the terrorist attack in the United States (2001), and also the global financial crisis (2008–2009). All these crises occurred due to different factors and had multi-dimensional implications in the oil market. This study observes that during financial and economic crises, higher levels of volatility were correlated with disruptions in the supply and demand for oil and that volatility persistence is a critical issue when uncertainty stems from global financial and economic instability. Thus, problems still need to be investigated to gain additional insights about how to solve occurring problems in this area.

Furthermore, the outbreak of the COVID-19 pandemic had a significant impact on all the economies, human life, and social unrest across the globe, making the issue even more crucial. It had a detrimental impact on the world economy and energy sectors. It led to interruptions in the crude oil supply, which heightened the volatility of crude oil prices globally (Zavadska et al., 2020). Bonney Light FOB Nigeria London crude oil prices settled at US $18.74 a barrel (bbl) on the international market as of April 30, 2020; this was a decrease of US$100.74/bbl (–84.32%) from US$ 119.48/bbl on the same day in 2012. During the epidemic, corporations engaged in exploration and production (E&P) lowered their capital expenditures. It just increased to US $116 per barrel on May 24, 2022, up US $97.26/bbl (518.99%). E&P companies increased capital expenditure plans during the post-pandemic period. The world's three major producers in E&P, viz., USA, Russia, and Saudi Arabia, dominate the oil market. They continue to grow their production, but other Middle Eastern producers will collectively gain the market share over time. Saudi Arabia, Kuwait, the United Arab Emirates, Iraq, and Iran are important Gulf producers that also contribute significantly to crude output.

The COVID-19 pandemic has profoundly impacted both crude oil markets and GDP growth, exacerbating economic challenges worldwide. The combination of weak demand and surplus supply strained oil-producing nations and energy companies, leading to layoffs, bankruptcies, and reduced investment in the sector. The emerging scenarios necessitated more investigation to gain a deeper understanding of them. Following the lead, this paper looks at the correlation between the increase in crude oil prices and the shock volatility of the global GDP.

Literature Review

A survey of the literature on factors influencing oil prices and their volatility has been conducted in order to identify and evaluate the elements that are more pertinent to specific oil price moments across various segments.

Crude oil plays a major export-import role in economies, which affects the exchange rate as well (Golub, 1983; Hartley & Medlock, 2014; Lakshmanasamy, 2022). The study by Kaufmann et al. (2008) analyzed the oil price model where oil prices are linked to refinery utilization, non-linearities between price and supply considering OPEC capacity utilization, and information and data available in futures prices for oil. The study applied several analytical tests against the predictive power of their fundamental model, a simple random walk model, and a model in which futures prices are the only predictors of spot prices. The study found a simple random walk model as a more appropriate prediction model. Hamilton (2009) and other studies on the oil market indicated that income, not price, is the main factor influencing the quantity needed in short-term market behavior

(Fattouh, 2007; Kilian, 2014). According to US studies and estimates, the short-run price elasticity of demand is usually almost non-existent.

In contrast, income elasticity estimates are observed to be 0.5 for industrially advanced countries. Kilian and Murphy (2014) observed specific contradictory results, and they analyzed that the short-run price elasticity of demand may be around –0.26 when accounted for in the inventory. Furthermore, Gately and Huntington (2002) also observed an almost proportional relationship between income and oil demand in developing countries, where they found income elasticity at 1.00. Dargay and Gately (2010) analyzed the income elasticity for China at approximately 0.74 for the period from 1980–2007. In their research, Kilian and Murphy (2014) noted comparable conclusions and suggestions. Kilian and Hicks (2013) observed similar results when examining the relationship between changes in oil prices and a weighted average of GDP forecast revisions for the group countries, which they classified as China + India and U.S. + Germany + Japan. The authors assumed that changes in GDP forecasts directly affected demand shocks. A forecast revision is measured month to month over the period from 2000–2011 to 2008–2012. The analysis concluded that during the study period, revisions to GDP forecasts—of which there were mostly those for China and India—occurred to impact changes in real oil prices.

The 2008 oil price spike was mostly caused by rising demand and falling supply, according to a report released by the Commodity Futures Trading Commission (2008). These recommendations were not adequately supported through appropriate data and documents to prove the qualitative analysis. Furthermore, industry analysts have also drawn attention to the rising marginal cost even though production costs drive oil prices. It is assumed that higher oil prices will draw more expensive supplies to the market. In an analysis of implied volatilities from options on crude oil futures that took into account OPEC meetings, Ederington et al. (2011) discovered that implied volatility increased as the meeting drew near and then decreased by about 5% over the course of the next five days. The study observed that highly visible bi-annual conferences were associated with a minimal drop in implied volatility. It was also observed that the most pronounced decline in volatility coincided with the meetings of the Ministerial Monitoring Committee, where production recommendations are announced. Kilian (2014) and others offered an alternative viewpoint, highlighting the fact that oil price volatility can be substantial due to the underlying supply and demand curves' high degree of price inelasticity and their reflection of supply or demand shocks. Furthermore, it has been noted that the correlation between volatility and inventory may have an adverse effect on the quantity of inventory.

The study undertaken by Baumeister and Peersman (2009) analyzed the changes in oil market dynamics during the period from 1960–2008 since the volatility in crude oil prices had risen significantly during this period when oil production had declined substantially. In a study, Kilian (2014) identified the essential components and features responsible for changes in the oil price. They included constant mean spot price change per period, mean reversion to a constant long-run mean price level, mean reversion to a stochastic long-run mean price level, constant spot price volatility, or a time-varying stochastic spot price volatility; price changes with constant volatility, and a variable mean leap size with constant volatility. The stochastic process describes the behavior of the instantaneous change in the "convenience yield," which can follow a mean reverting process and the constant or stochastic risk-free rate of interest. Amarfio et al. (2017) found that excessive production of crude oil could lead to oversupply and a decrease in price.

On the other hand, excess consumption may also result in a hike in oil prices. The availability and large-scale awareness about other energy resources will also reduce oil demand and, thereby, oil prices. A higher price for oil is strongly related to the geopolitical context of rivalry and instability. Political decisions in countries that produce and consume oil, fluctuations in foreign exchange rates, particularly the value of the dollar, and the futures market are further factors driving up oil prices. Therefore, global crude oil prices tend to change over time due to a host of factors, and therefore, the volatility in the oil prices cannot be attributed to a single market.

A study on global oil demand was conducted by Alekhina and Yoshino (2019), comprising and disaggregating the demand from different groups such as the Organization for Economic Co-operation and Development (OECD), the People's Republic of China (PRC), and India to evaluate the scale of their contributions to global oil price movements. The industrial output (IP) index was taken into consideration in this study as a factor influencing oil consumption. The analysis found that the PRC's and the OECD's IP had a favorable effect on the price of oil. More importantly, the study analyzed a significant negative impact on oil prices and the appreciation of the US dollar exchange rate, among other factors. This study assumes more significance since it considered the IP index as a determinant of oil demand. Vespignani and Ratti (2016) found a strong correlation between the IP and the price and demand for oil. Taking into account the phenomenon of perfect market competition, the study evaluated the effects of oil price shocks on actual economic activity.

Furthermore, Huynh (2016) analyzed the impacts of energy prices on the business cycle, while Hesary and Yoshino (2013) developed an oil demand and supply model based on monetary policy variables. The study by Alekhina and Yoshino (2019) revealed the extent of oil price fluctuations based on macroeconomic variables and monetary policy implications of the country exporting the energy. Therefore, we may conclude that understanding and analyzing the factors contributing to the volatility in oil prices is even more crucial for the good of people, the private sector, and policymakers.

A different study by Taghizadeh-Hesary et al. (2019) observed a linkage between energy and food security through price volatility. The study assumed that inflation in oil prices works against food security. Therefore, it may be necessary to diversify energy consumption in this sector, i.e., overcoming higher reliance on fossil fuels to an optimal combination of renewable and non-renewable energy resources that will add to energy security and food security. This study also analyzed the impact of biofuel prices on food prices.

The bivariate generalized autoregressive conditional heteroskedasticity (GARCH) models (diagonal VEC GARCH and BEKK GARCH) were applied to investigate the volatility association, including the volatility spillover effect on the sample data of gold price, crude oil price, and yield (interest rate), and found that there was no evidence of volatility spillover from gold and crude oil on the interest rates by Rastogi et al. (2023). DCC GARCH was applied to examine the linkage between crude oil and yield, and no association was found between crude oil and yield by Tuysuz (2013). Using DCC GARCH for crude oil, WPI inflation, and interest rates, Malhotra and Krishna (2015) found that crude oil had no discernible impact on interest rates. The study by Apergis et al. (2019) and Akram (2004) applied the MS-VECM model to investigate the cointegrating relationship between gold and interest rate, which observed significant cointegration between gold and the interest rate in G7 counties. Mohapatra et al. (2024) employed the generalized autoregressive conditional heteroscedasticity (GARCH) (1,1) model to model volatility. To estimate the leverage effect, they used the *T*-GARCH model, while the DCC-GARCH model was utilized to analyze the spillover effect of exchange rates on selected sectoral indices. They found that the leverage effect was present in all the series, as the sum of α and λ in the *T*-GARCH model was less than 1, indicating the model's acceptability. Kothadia and Nayak (2020) used a univariate approach to study the impact of the equilibrium relationship between deposit interest rates and stock market returns on inflation. They found that in nations where there was no equilibrium link between the residual and the consumer price index, a unidirectional causal relationship was established.

Conversely, no causality was found in countries where the relationship existed. Their findings indicated that trends or seasonality in the purchasing power differences generated by the two variables could influence a nation's inflation. Agarwal et al. (2019) found that inflation and fiscal deficit adversely affected China's economic growth. Goel (2024) analyzed trends in both the wholesale price index food (WPIF) inflation and the consumer price index food (CPIF) inflation in India. They quantified the persistence and volatility in both measures of food inflation and their sub-components, discovering higher persistence in CPIF than in WPIF inflation, while volatility remained similar in both. Cereals, pulses, milk, and spices were examples of disaggregated goods with strong persistence, while fruits, vegetables, and some manufactured goods showed considerable volatility. Kumar and Khanna

(2018) investigated the volatility behavior and its spillover in the stock markets of four Asian countries: India, China, Hong Kong, and Japan. Using the ARCH, GARCH (1,1), and bivariate GARCH-BEKK models, Kumar and Khanna (2018) explored the volatility behavior and spillover effects from one country to another. The study's results indicated that the Chinese market experienced the most significant fluctuations, while the Indian financial market was the most stable among the selected markets.

There is further evidence that establishes the market's volatility and volatility spillover. Lakshmanasamy (2022) claimed that the GARCH estimates show how the volatility and spillovers in one market affected the volatility and spillovers in other Indian markets. This resulted in crude oil price, exchange rate volatility, and volatility spillovers caused volatility in the BSE Sensex. Nirmala and Deepthy (2018) observed significant high volatility persistence in all commodity indices of MCX. The asymmetric models of GARCH find a presence of leverage effect only in the MCX ENERGY index, but it is not seen in any other indices of MCX. Singh and Ahmad (2011) found that while conditional volatility was seen in both of the chosen futures markets, the Indian stock futures market was the only one to exhibit the threshold and leverage effects.

Research Gap

Extensive literature exists on the interplay between crude oil, volatility, and inflation rates. Several researchers have used a wide range of methods and factors to investigate these links. Numerous research has demonstrated the strong correlation between inflation and financial crises, which is widely accepted. In the current global scenario, another financial crisis could potentially lead to a resurgence of inflation. Reviews indicate that a single factor does not drive volatility in oil prices but results from a combination of internal and external influences, with supply and demand being significant in all contexts. This study aims to explore the covariance among global GDP, world inflation, and crude oil prices. An analysis of this kind could help investors bolster their holdings to lessen the impact of inflation.

Thus, the following hypotheses are framed by considering the research gaps in the literature in the alternate form:

Hypotheses

- **H01** = World GDP has no conditional covariance with crude oil prices.
- **Ha1** ≠ World GDP has conditional covariance with crude oil prices.
- **H02** = World inflation rate has no conditional covariance with the crude oil prices.
- **Ha2** ≠ World inflation rate has conditional covariance with the crude oil prices.
- **Ha3** = World GDP has a volatility spillover effect on crude oil prices.
- **H03** ≠ World GDP has no volatility spillover effect on crude oil prices.
- **Ha4** = World inflation rate has a volatility spillover effect on crude oil prices.
- **H04** ≠ World inflation rate has no volatility spillover effect on crude oil prices.

Data and Methodology

We utilized an empirical methodology to investigate the covariance and correlation between the variables being studied. The data came from PEPS, the IMF, and IHS Markit. To investigate the theories, we used the GARCH model. The GARCH model is ideal for this research since it computes, evaluates, and forecasts volatility. The research methodology framework entails a systematic approach to achieving the study's objectives. The current research employed a judgmental non-probability sampling technique that aligns with this aim. The data utilized in this study are quantitative.

Data Collection and Source

In the present study, annual data of crude oil prices, namely Brent (USD per barrel), world GDP current price (trillions of U.S. dollars), and world inflation rate (change in percentage) were retrieved. The time duration was covered from January 2000 to December 2022. Complete data were retrieved from IHSmarkit – Crude oil production data: March 2022 PEPS data and IMF world data (Rastogi et al., 2023). The annual logarithmic returns data of all three variables have been considered for the analysis (Tuysuz, 2013). Table 1 reflects the description of all three variables.

Table 2 displays the results of correlation coefficients, and Table 3 shows the results of descriptive statistics and the pre-diagnostic tests completed before applying the GARCH models.

Table 1. ***Variable Description***

Name	Description
Crude Oil Prices	Logarithmic value of crude oil price Brent (USD per Barrel).
World GDP	Logarithmic value of world GDP current price (trillions of US dollars).
World Inflation Rate	Logarithmic value of world inflation rate (annual percent change).

Table 2. ***Correlation Analysis***

January 2000 to December 2022			
	Crude Oil Prices	**World GDP**	**World Inflation Rate**
Crude Oil Prices	1.000		
World GDP	0.023	1.000	
World Inflation rate	–0.065	0.077	1.000

Note. Correlation coefficients among crude oil prices, world GDP, and world inflation rate.

Table 3. ***Descriptive Analysis***

	Crude Oil Prices	**World GDP**	**World Inflation Rate**
Mean	0.003	0.332	0.123
Maximum	32.118	12.324	4.567
Minimum	–32.098	–4.318	–5.456
Standard Deviation	4.807	2.098	1.700
Skewness	–0.676	0.450	0.300
Kurtosis	12.565	6.012	6.410
Jarque–Bera	772.654***	103.400***	132.917***
Observations	340	340	340
ARCH	11.678***	12.098	24.411***
Unit Root test			

Augmented Dicky Fuller	–8.034***	–13.765***	–8.314***
Phillips–Perron	–12.345***	–15.876***	–14.123***

Notes. ***1%, **2%, and *10% denote the level of significance, respectively. Unit root test has been used for considering constant and the trends ; the ARCH test signifies serial correlation of the heteroskedasticity among the data at lag 1.

Methodology

The main objective of the present study is to determine the volatility effect of the world GDP and the world inflation rate on crude oil prices. The analysis starts with the descriptive study of all the variables and analysis of the correlation coefficients. The Jarque–Bera test has been applied to analyze the normality of the time series data. For converting time series data into stationary series, the study applied the Augmented Dicky Fuller (ADF) and Phillips - Perron (PP) tests. In addition, the autoregressive conditional heteroskedasticity (ARCH) model is applied to check the volatility effects. The multivariate GARCH model has been used to analyze the Akaike info criterion (AIC) and examine the accuracy and complexity of the estimated model. Fat tails, volatility, and asymmetry are the three main features evident from the time series data used for research. Malhotra and Krishna (2015) have extensively documented the use of the family model's GARCH to estimate the degree of volatility in time series data.

The BEKK GARCH model is based on three variables, i.e., T, U, and S, to specify the model. The equation is given below:

$$Ht = \mathrm{S0S} \text{þ} T0\varepsilon t{-}1\varepsilon 0\, t{-}1T \text{þ} U0Ht{-}1U \text{ ----- (1)}$$

$$S = [\mathrm{S11, S12, S22,0}],\ T = [t11, t12, t21, t22],\ U = [u11, u12, u21, u22]$$

In the above equation, Ht represents a 2×2 matrix of conditional covariance. Matrices U and T are the squared coefficients, where S represents the triangular coefficient matrix. In the first equation, $t11$ and $t12$ denote the ARCH effect within their values.

The following is the equation of the bivariate VEC GARCH model of the study:

$$\mathrm{GARCH\ 1} = S11 + T11 \times \mathrm{RESID1}(-1)\,2 + U11 \times \mathrm{GARCH1}(-1) \text{ .... (2)}$$

$$\mathrm{GARCH\ 2} = S22 + T11 \times \mathrm{RESID2}(-1)\,2 + U11 \times \mathrm{GARCH1}(-1) \text{ .... (3)}$$

$$\mathrm{COV1\_2} = S12 + A12 \times \mathrm{RESID1}(-1) \times \mathrm{RESID2}(-1) + U12 \times \mathrm{COV1\_2}(-1) \text{ .... (4)}$$

In the second equation, GARCH1 estimation is for the first variable, $S11$ is the constant for the own effects of the first variable. $T11$ is denoted as the conditional residual for the own effect of variable 1, c is the lagged residual, $U11$ is conditional covariance for its external market effect, and GARCH (–1) is lagged GARCH estimations. In the third equation, GARCH2 estimation is for the second variable, $S12$ is the constant for the own effects of the first variable. $T22$ is denoted as the conditional residual for the own effect of variable 1, c is the lagged residual, $U22$ is conditional covariance for its external market effect, and GARCH (–1) is lagged GARCH estimations for the second variable. In the fourth equation, COV1_2 is the conditional covariance for the variables 1 to 2, and $S12$ is the constant for the effects of the first variable on the second variable. $A12$ denotes the ARCH effect from variables 1 to 2. RESID1(–1) and RESID2(–1) are lagged residuals for 1 and 2. COV1_2 is the lagged conditional covariance.

Analysis and Results

This research study is divided into three levels. In Table 3, the descriptive statistics of the variables constitute the mean values 0.003, 0.332, and 0.123, respectively. In Table 2, correlation coefficients are not significant. The value of the Jarque–Bera test is also reflected in Table 3; the values are significant. Therefore, the null hypothesis is rejected. The value of ARCH effects is also significant for confirming the volatility clustering. The value of the ADF and PP unit root test ensures the stationary of the time series data. Therefore, the null hypothesis has been rejected. Table 4 shows the results of the bivariate VEC GARCH model.

The coefficient of conditional covariance of volatility (U12) is significant and positive for world GDP and world inflation; it indicates that both variables are effectively positive to the volatility in the crude oil prices. The AIC and log-likelihood values of the models validate the VEC GARCH model's validity and good fit. Table 5 shows the results of bivariate BEKK GARCH, and the model has estimated that the values of U11 and U22 are significant and positive for the volatility of the crude oil prices. The results show the volatility spillover effect. The coefficients show a mixed result between the world inflation rate and the crude oil prices. The values are insignificant at the 10% level. Hence, the values indicate a reverse impact of world GDP on the changes in crude oil prices. Thus, the null hypothesis (H01) is accepted that world GDP has no conditional covariance with crude oil prices. Therefore, the volatility of the global inflation rate also has a negative impact on the price of crude oil. Consistent outcomes from both models guarantee that the findings are solid and supportive of (H02). The price of crude oil has no conditional correlation with the global inflation rate.

The data in Table 6 clearly demonstrates Granger causality between one variable and another. The findings of testing the hypotheses across a sample of 22 observations are insignificant because the *p*-value is more significant than 0.05 in every case. The GDP's current price volatility cannot be predicted by the world inflation rate (*p*-value = 0.69), crude oil benchmark (*p*-value = 0.28), or the world inflation rate. This illustrates that a particular series cannot anticipate a different time series. Furthermore, a *p*-value of 0.21 for the global GDP and a *p*-value of

Table 4. ***Bivariate Diagonal VEC GARCH (1,1) Calculations***

	Crude Oil Prices	World GDP	World Inflation Rate
Variance Equation			
S11	1.5643***	0.2376*	0.0876
S12	0.2203	0.0577	1.2705***
S22	0.5678***	0.2098***	0.0000
T11	0.3440***	0.0347**	0.2346***
T12	–0.1485	0.0067	–0.0345**
T22	0.2845***	0.3218***	0.0501***
U11	0.4657***	0.7896***	0.6054***
U12	–0.0123	0.6789***	1.3456***
U22	0.3345***	0.6785***	0.9876***
Shape (*t*-degrees)	7.7843**	7.1234***	8.7654***
Model Diagnostics			
AIC	–9.605	7.7654	10.43
Log-likelihood	–1122.134	–14.8765	3.5678

Notes. AIC = Akaike Infor Criterion, ***1%, **5%, and *10% denote the level of significance, respectively.

Table 5. ***Bivariate BEKK GARCH (1,1) Calculations***

	Crude Oil Prices	World GDP	World Inflation Rate
Variance Equation			
S11	0.0000**	0.0000	0.0000**
S12	0.0000	0.0000	0.0000
S22	0.0000	0.0000	0.0000
T11	0.3440***	0.0347**	0.2346***
T12	–0.1485	0.0067	–0.0345**
T22	0.2845***	0.3218***	0.0501***
U11	0.4657***	0.7896***	0.6054***
U12	–0.0123	0.6789***	1.3456***
U22	0.3345***	0.6785***	0.9876***
Shape (*t*-degrees)	7.7843**	7.1234***	8.7654***
Model Diagnostics			
AIC	–11.6054	3.7654	–12.43
Log-likelihood	2.1345	–14.8765	3.5678

Notes. AIC = Akaike Infor Criterion, ***1%, **5%, and *10% denote the level of significance, respectively.

Table 6. ***Granger Causality Test Output***

Null Hypothesis	Obs.	*F*-Statistic	Prob.
World GDP current prices do not Granger cause world inflation rate.	22	0.37414	0.6934
World inflation rate does not Granger cause world GDP current prices.	22	1.34943	0.2858
Dated Brent calculated annual average does not Granger cause world inflation rate.	22	1.47984	0.2556
World inflation rate does not Granger cause Dated Brent calculated annual average.	22	1.61407	0.2281
World GDP does not Granger cause Dated Brent.	22	1.35205	0.2852
Dated Brent does not Granger cause World GDP.	22	1.68853	0.2143

0.25 for the inflation rate does not accurately forecast the volatility of crude oil. Additionally, the inflation rate was not anticipated from a different GDP and crude oil series, with *p*-values of 0.22 and 0.28, respectively. Crude oil and GDP current prices cannot be used to anticipate crude oil volatility. In order to evaluate volatility and make predictions based on other series, all variables are cross-verified using Granger causality. Consequently, one may conclude that the factors included in the study do not permit the prediction range of another variable.

The fluctuations in the production of crude oil by exploration and production businesses across different nations determine the shifts in global benchmark pricing. The volatility of crude oil prices mainly depends on crude production/supplies, policy changes made by various national oil companies with the permission of their concerned government authorities of the country, and changes in the world's crude oil markets. When the benchmark price of Dated Brent was determined on a monthly average in June 2014, the impact of the coronavirus pandemic, an expected dramatic reduction in oil consumption, and an economic downturn caused crude oil prices to drop to $18.55/bbl in April 2020. In addition, major oil producers disagreed on production cuts, exacerbating the problem. US crude oil varied at $19 per barrel by mid-March 2020. In an attempt to stabilize prices, the Organization of Petroleum Exporting Countries (OPEC) and its allies agreed to record production cuts, but the prices fell to 20-year lows. In September 2023, world benchmark prices, such as Brent crude oil price, again increased to \$93.37/bbl.

Crude-producing companies come under the upstream industry and are involved in E&P activity, mainly producing crude oil, natural gas, and other value-added petroleum products. They mainly depend on the revenue realization of their products, which comes from the market rate of crude oil prices, particularly world benchmark prices. The companies' revenue depends upon the changes in international crude oil prices; therefore, they closely watch the crude oil market and make decisions on cost/investment in a long-term manner by way of optimum maintenance of capital expenditures in E&P activity. The company's financial performance is mainly based on world benchmark crude oil prices. The cost management strategy is adopted by the E&P companies with the support of government policies on the upstream industry. It is pertinent to watch the trend of world GDP and the inflation rate. Crude oil production has a major impact on the world's GDP. World inflation will have a significant impact on volatility in crude oil prices.

Volatility in crude oil prices matters, significantly impacting world GDP and world inflation rate and vice versa. This study proves the significant relationship between volatility in oil prices and world GDP and inflation rate. The future trend of crude oil prices can be estimated based on the world's GDP and inflation rate trends. This provides crucial information for exploration and production companies to plan their capital expenditure and make various strategic decisions. Based on the VEC GARCH model and the BEKK GARCH model, there is a significant relationship between the world inflation rate and crude oil prices at the 10% level. Hence, the values indicate a reverse impact of world GDP on the changes in crude oil prices.

Additionally, the world inflation rate volatility negatively affects crude oil prices. Therefore, we agree with Ha3, which states that there is a volatility spillover effect between the world GDP and crude oil prices. In order to assist firms and governments in making critical decisions about exploration and production activities, this study offers substantial information. The results of the causality test in this study, however, show that evaluating the causality check from one variable to another is inconsequential (Table 6). We, therefore, agree with the H04 that there is no volatility spillover effect between the global inflation rate and the prices of crude oil.

Conclusion

A mutual relationship has been found among variables such as world GDP, world inflation rate, and crude oil prices by using bivariate GARCH models. The world GDP and the crude oil prices have shown a significant conditional covariance. World inflation rates do not show a significant correlation with crude oil prices. The absence of volatility spillovers on the price of crude oil for any independent variable indicates that covariance is the manner in which volatility spillovers occur. In terms of conditional variance, crude oil prices are strongly influenced by the rate of global inflation. The research findings may have policy implications regarding the association between the changes in crude oil prices due to changes in the world GDP and the world inflation rate. It may affect international long- and short-term investing plans, which are mostly based on these variables. The models used in this study, such as the BEKK GARCH model and the VEC GARCH model, reveal a significant correlation between the global inflation rate and crude oil prices. Crude oil prices are adversely affected by the volatility of the global inflation rate. As a result, this study offers firms and governments useful information to consider when making crucial decisions about petroleum products.

Policy Implications

The global GDP and inflation rate fluctuations have a significant influence on the economic growth of many different nations. Managers, corporations, policymakers, practitioners, consumers, and investors are very concerned about fluctuations in world inflation, world GDP, and crude oil prices in the international market. The fluctuation in oil prices can affect the policies of crude oil-producing companies and countries. The current study also has significant implications for investors concerning their investment decisions on oil companies, with the relevance of the impact on crude prices due to the changes in world GDP and world inflation rate. They may create a long-lasting and stable economic environment by putting smart, well-thought-out policies into action. Crude oil prices are thought to be the world's most important commodity.

Limitations of the Study and Scope for Further Research

The study tries to determine the relationship between global GDP, global inflation rate, and crude oil prices. Although only two macroeconomic parameters were examined in the study, it may be expanded to include other significant macroeconomic variables. However, other variables from micro and macroeconomic points of view, such as productivity, global economic condition, investment level, unemployment rate, and exchange rate, are untouched. Thus, there are a number of limitations to the research. Future studies focusing on the aforementioned macro and micro variables may be carried out on a country-by-country basis. Other econometrical models, such as DCC GARCH, can be used to estimate the level of volatility in order to obtain more precise results.

Authors' Contribution

S. Vijayakumar conceived the idea and developed a quantitative design to undertake the empirical study. He extracted research papers with high reputation, filtered them based on keywords, and generated concepts and codes relevant to the study design. Dr. P. Karthikeyan verified the analytical methods and supervised the study. S. Vijayakumar conducted the data collection. Dr. P. Karthikeyan did the numerical computations using Eviews software. S. Vijayakumar wrote the manuscript in consultation with both authors.

Conflict of Interest

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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About the Authors

S. Vijayakumar is a Research Scholar at the Department of Management Studies, Center for Post-Graduate and Research Studies, Periyar University, Dharmapuri, Tamil Nadu. He has worked for the Oil and Natural Gas Corporation Limited (ONGC) for 25 years. He has also taught marketing and finance in academic settings at Deen Dayal Urja Bhawan Nelson Mandela Marg, Vasant Kunj, Delhi. He has delivered guest lectures at several universities and management schools, attended national and international conferences, and worked on multiple research articles. At an international gathering in Greater Noida, he presented a poster on Petro Tech. He is currently working as General Manager (Finance and Accounting) in the corporate Office of Oil and Natural Gas Corporation Limited in Delhi.

Dr. P. Karthikeyan is a Professor at the Department of Management Studies, Center for Post-Graduate and Research Studies, Periyar University, Dharmapuri, Tamil Nadu. He has published several research papers and attended national and international conferences.