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Research Article

The Spillover Effect of Crude Oil Prices on Energy Uncertainty Index

Kaleeshwari. S[1], Dr. M. Jegadeeshwaran [2]
[1]Senior Research Fellow, PhD Research Scholar, Department of Commerce, Bharathiar University, Coimbatore, Tamil Nādu.
[2]Associate Professor, PhD Research Scholar, Department of Commerce, Bharathiar University, Coimbatore, Tamil Nadu .

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***Corresponding author:** Kaleeshwari. S (madhukaleeshwari@gmail.com)

Abstract: ***Aim*** **–** the key motive is to research the prevailing impact of select crude oil prices on the energy uncertainty index of economic uncertainty index on global perspective**.** ***Design/Methodology/Approach*** **–** in the current research paper, the time series data was collected from the secondary source of information from Federal Reserve Bank and Economic Uncertainty Index. The data was collected on monthly bases from Jan 2005 to Dec 2022. Further the accumulate information is analysed using ADF test, pairwise granger causality, covariance analysis, Johnson cointegration test to determine the cause and effect of crude oil prices on energy uncertainty index. ***Findings*** – the study has identified the cause and effect and integration among the crude oil prices and energy uncertainty index. There is stationary among the select variables. The analysis reveals that there is a cause and effect of among Brent prices and energy uncertainty index and there is an impact of Brent prices on energy uncertainty index. Further the WTI crude oil prices also cause and effect on Energy uncertainty index and they are cointegrated in long run. ***Research Limitation*** – the study provides a valuable understanding on crude oil price impact on energy uncertainty index. The long run cointegration is also identified using the Johnson cointegration test. ***Originality*** **–** This study is high original contribution to understand the impact, cause and effect of select crude oil prices on energy uncertainty index. The variables definitely be used for the further reference in elaborating the study in terms of crude oil impact in different study area.

Keywords: WTI Crude Oil Price, Brent Price, Energy Uncertainty Index, Cause and Effect, Impact and Co-integration.

INTRODUCTION

Crude oil plays a crucial role in economic progress and the development of nations, being utilized in various economic activities. Consequently, oil price volatility has a widespread impact on different sectors, with the effects varying across these sectors . The connection between oil prices and the stock market has garnered increased interest due to numerous oil shocks in recent decades. Previous research studies indicate a mixed impact of oil price shocks on stock markets . The effectiveness of the agreement depends on to the extent to which the NDCs are fully implemented and there are enormous challenges to fulfil countries' pledges to a pathway consistent with carbon neutrality. One of the major challenges is the volatility of the oil price, streaming from global shocks, including the COVID-19 pandemics, economic crises, and climate-related disasters . To be more specific, a highly volatile oil market can affect the investment in low-carbon and energy efficiency technologies, coupled with profitability uncertainty as the economic crisis hammers fuel demand. Therefore, uncertainty regarding oil price movement can have a negative impact on the success of reaching carbon neutrality targets. Furthermore, central banks take oil price volatility into consideration when constructing their monetary policies in stimulating the economy during the crisis period (e.g., COVID-19 pandemic crisis). Therefore, it is not surprising to see extensive literature on modelling the key determinants of the real price of oil. Oil supply and demand are believed to have played important roles in affecting oil prices . However, it is argued that uncertainty representing conditional volatility of a disturbance cannot be forecast in terms of economic agents, and failure to remove forecastable components can incorrectly classify forecastable variations as uncertainty. Several uncertainty proxies have been developed to overcome the above-mentioned drawbacks, such as extract macroeconomic uncertainty (JLN) from 132 macroeconomic variables, and use of newspaper coverage frequency to construct economic policy uncertainty.

(EPU) indicator. Yet, there is a lack of an energy market specific uncertainty proxy that reflects fluctuations in the global energy market

REVIEW OF LITERATURE

Our paper proposes a novel measure of global energy market uncertainty and studies its impact on oil prices. The current literature primarily relies on a single or small number of observable variables, or general macroeconomic uncertainty (JLN) and economic policy uncertainty (EPU) indices to reflect energy market uncertainty. Using a Factor Augmented Vector Autoregression model (FAVAR), we construct time-varying global energy market uncertainty in a data-rich environment. Our estimates show variations from JLN and EPU proxies. The results reveal that real oil prices respond strongly to our proposed aggregate energy market uncertainty shocks. We also find heterogeneous responses to different types and magnitudes of uncertainty shocks. The real price of oil is affected the most under unexpected strong demand for alternative energy sources scenario (Bing Xu, 2021).

This paper aims to investigate the dynamic and asymmetric linkage between crude oil, oil uncertainty, and the United States (US) equity markets across various horizons and tails using a combination of a time-frequency approach, Granger causality, and quantile-on-quantile regression from January 2020 to December 2022. The empirical results indicate that causal relationships and the dynamic co-movement between crude oil, oil implied volatility, and the Dow Jones industrial and transportation indices are confirmed across various frequencies through wavelet-based Granger causality and wavelet coherence. Then, the wavelet-based quantile-on-quantile regression shows that the relationship between oil, oil implied volatility, and both US equity markets is heterogeneous and asymmetric across short- and long-run horizons, in particular. The findings provide new insights into the sensitivity of US stock markets to oil shocks across various time frequencies and tails, offering several portfolio implications useful for heterogeneous investors and portfolio managers. (Mohamed Yousfi, 2024).

This study utilized both single-regime GARCH and double-regime GARCH models to investigate oil price volatility, Spanish macroeconomic factors, and stock prices during major crises such as geopolitical conflicts, the global financial crisis (GFC), and COVID-19, covering the period from Q2-1995 to Q4-2023. Additionally, the impact of crude oil price volatility on these factors was examined. The empirical results confirmed the presence of the leverage effect and identified multiple volatility switches associated with remarkable events like the GFC, the European debt crisis, the COVID-19 pandemic, and the Russian war. ARDL model analysis revealed a statistically significant positive relationship between oil prices and both unemployment and inflation rates in the long term, while other factors showed a negative correlation (jassim aladwani, 2024).

There has always been a complex relationship between uncertainty and crude oil prices. Three types of uncertainty, i.e., economic policy uncertainty, geopolitical risk uncertainty, and climate policy uncertainty (EPU, GPR, and CPU for short), have exacerbated abnormal fluctuations in the energy market, making crude oil prices volatile more and more frequently, especially from the perspective of the financial attribute of crude oil. Based on the time-series data related to uncertainties and crude oil prices from December 2001 to March 2021, this paper uses the quantile-on-quantile regression (QQR) method to explore the overall impact of various uncertainties on crude oil prices. Moreover, this paper adopts the QQR method based on the wavelet transform to investigate the heterogeneous effects of various uncertainties on crude oil prices at different time scales. The following conclusions are obtained. First, there are significant differences in the overall impact of the three types of uncertainties on crude oil prices, and this heterogeneity is reflected in quantiles of the peak impact intensity, the impact direction, and the fluctuation change. Second, the impact intensities of the three types of uncertainties on crude oil prices are significantly different at different time scales. This is mainly reflected in the different periods of significant impact of the three uncertainties on crude oil prices. Third, the impact directions and fluctuations of the three types of uncertainties on crude oil prices are heterogeneous at different time scales.(Yan Ding, 2022).

Variables and Measured

For investigating, the impact of crude oil prices on energy uncertainty index, the energy uncertainty index is included as dependent variable, where the select crude oil prices are independent. Due to the uncertainty situations across nations there is a direct impact of crude oil prices on the energy uncertainty and vice versa. To analyse the 18 years' time series data has been collected from the official sources such as Federal Reserve Bank.

Data Source and Data Collected for the study

The data has been collected as a secondary source of information, the data are time series data. Total of 18 years data has been taken. The data are taken on monthly bases. There are two prices selected for the study such as WTI Crude Oil Prices and Brent prices and the Energy Uncertainty index taken from the Economic policy Uncertainty index. The data collected were further analysed using ADF test to check the stationarity, after analysing the data for stationarity the data was test using the Pairwise granger causality, Covariance analysis and Johnson cointegration, the results were then validated, suggestion s and comments were incorporated based on the outcomes of the study

Data Interpretation

IBM EViews Software was used on the collected time series data, further the analysis was carried assisting the econometric tools such as ADF test, pairwise granger causality, Covariance analysis and Johnson cointegration to test the cause, effect and integration between the variables.

Hypothesis

H^{01} = There is no significant cause and effect of Brent prices on Energy Uncertainty Index.

H^{02}= There is no significant cause and effect of WTI Crude oil price on Energy Uncertainty Index.

H^{03}= There is no significant relationship between Brent prices on Energy Uncertainty Index.

H^{04}= There is no significant relationship between WTI Crude oil price on Energy Uncertainty Index.

H^{05}= There is no significant integration between Brent prices on Energy Uncertainty Index.

H^{06}= There is no significant integration between WTI crude oil prices on Energy Uncertainty Index.

RESULTS AND DISCUSSION

Table 1Testing of stationarity for WTI Crude Oil price and Brent price along with Energy Uncertainty Index for the period 2005-2024

Augmented Dickey-Fuller test statistic				
Data Series	**At level**		**At first order difference**	
	T Statistics	**P value**	**T Statistics**	**P Value**
Brent Price	-3.160	0.0237	-10.271	0.000
WTI Crude Oil Price	-3.437	0.016	-10.509	0.000
Energy Uncertainty Index	-4.244919	0.0007		

Source: computed using IBM EViews 12

The table 1 explains the Energy Uncertainty Index, WTI Crude Oil Price, and Brent Price results of the unit root test for stationarity using the ADF test based on the "intercept" are displayed in Table 1. The test results indicate that the variable should not be stationary at "level" and should instead be stationary at "first difference." The WTI Crude Oil and Brent prices, as well as the Energy Uncertainty Index, are found to be stationary at "level," rejecting the null hypothesis that the variables are stationary with a significant P value.

Test of Cause and Effect between brent price and select Energy Uncertainty Index for the period 2005-2024

Table 2 Pairwise granger causality for brent price and Energy Uncertainty Index the period 2005-2024

Pairwise Granger Causality Tests			
Null Hypothesis:	Obs	F-Statistic	Prob.
EUI does not Granger Cause BRENT	214	3.44096	0.0339
BRENT does not Granger Cause EUI		3.58028	0.0296

Source: computed using IBM EViews 12

The Table 2 depicts the Energy Uncertainty Index and Brent Price pairwise Granger causality results are shown in table 2. Granger causes the Energy Uncertainty Index, and the Energy Uncertainty Index causes the price of Brent. As a result, the null hypothesis is rejected at the five percent significance level, indicating that the Energy Uncertainty Index has a causal relationship with the price of Brent.

Test of Cause and Effect between WTI Crude Oil price and Energy Uncertainty Index for the period 2005-2024

Table 3 Pairwise granger causality for WTI Crude Oil price and Energy Uncertainty Index for the period 2005-2024

Pairwise Granger Causality Tests			
Null Hypothesis:	Obs	F-Statistic	Prob.
EUI does not Granger Cause WTI_COP	214	3.23040	0.0415
WTI_COP does not Granger Cause EUI		4.73611	0.0097

Source: computed using IBM EViews 12

The table 3 shows the Energy Uncertainty Index and WTI Crude Oil Price pairwise Granger causality results are shown in table 3. Granger causes the Energy Uncertainty Index, and the Energy Uncertainty Index causes the price of WTI Crude Oil. Therefore, the null hypothesis is rejected at the five percent significance level, indicating that the Energy Uncertainty Index has a cause-and-effect relationship with the price of WTI crude oil.

Test of Covariance Analysis Brent Price and Energy Uncertainty Index for the period 2005-2024

Table 4 Covariance and correlation analysis Brent Price and Energy Uncertainty Index for the period 2005-2024

Covariance Analysis: Ordinary			
Covariance			
Correlation			
t-Statistic			
Probability	BRENT	EUI	
BRENT	608.4642		
	1.000000		

EUI	-62.53643	36.96845	
	-0.416965	1.000000	
	-6.710889	-----	
	0.0000	-----	

Source: computed using IBM EViews 12

The table 4 reveals the covariance and correlation matrix for the Energy Uncertainty Index and Brent for the years 2005–2024 are shown in table 4. The Energy Uncertainty Index and Brent price have a significant negative linear relationship. As a result, the null hypothesis is rejected at the five percent significance level, indicating that the Energy Uncertainty Index and Brent price have a long-term, linear connection.

Test of Covariance Analysis WTI Crude Oil Price and Energy Uncertainty Index for the period 2005-2024

Table Covariance and correlation analysis WTI Crude Oil Price and Energy Uncertainty Index for the period 2005-2024

Covariance Analysis: Ordinary			
Covariance			
Correlation			
t-Statistic			
Probability	WTI_COP	EUI	
WTI_COP	494.2829		
	1.000000		

EUI	-56.97868	36.96845	
	-0.421511	1.000000	
	-6.799754	-----	
	0.0000	-----	

Source: computed using IBM EViews 12

The table 5 explains the covariance and correlation matrix for the Energy Uncertainty Index and WTI Crude Oil price for the years 2005–2024 are shown in table 5. The price of WTI Crude Oil and the Energy Uncertainty Index have a significant negative linear relationship. As a result, the null hypothesis is rejected at the five percent significance level, indicating that the Energy Uncertainty Index and WTI crude oil price have a linear and long-term relationship.

Test for Cointegration between Brent Price and Energy Uncertainty Index for the period 2005-2024

Table 6 Johnson Cointegration test Brent Price and Energy Uncertainty Index for the period 2005-2024

Trend assumption: Linear deterministic trend				
Series: BRENT EUI				
Lags interval (in first differences): 1 to 4				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.067907	25.73833	15.49471	0.0010
At most 1 *	0.050348	10.90017	3.841465	0.0010
Trace test indicates 2 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.067907	14.83817	14.26460	0.0405
At most 1 *	0.050348	10.90017	3.841465	0.0010
Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Source: computed using IBM EViews 12

The Johnson cointegration results for the Energy Uncertainty Index and Brent Price for the years 2005–2024 are shown in Table 6. The long-term cointegration of variables between the Brent Price and the Energy Uncertainty Index is concluded by

the trace statistics results, which indicate that the "none" p value is below 0.05 and the "at most one" p value is also below 0.05. Additionally, the eigenvalue p values of "none" and "at most 1" are both less than 0.05, confirming the long-term cointegration of Brent price.

Test for Cointegration between Brent Price and Energy Uncertainty Index for the period 2005-2024

Table 7 Johnson Cointegration test Brent Price and Energy Uncertainty Index for the period 2005-2024

Trend assumption: Linear deterministic trend				
Series: WTI_CRUDE_OIL_PRICE EUI				
Lags interval (in first differences): 1 to 4				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.064225	26.42278	15.49471	0.0008
At most 1 *	0.057148	12.41661	3.841465	0.0004
Trace test indicates 2 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None	0.064225	14.00617	14.26460	0.0549
At most 1 *	0.057148	12.41661	3.841465	0.0004
Max-eigenvalue test indicates no cointegration at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Source: computed using IBM EViews 12

The WTI Crude Oil Price and Energy Uncertainty Index cointegration results for the years 2005–2024 are shown in Table 7. The long-term cointegration of the variables between the WTI Crude Oil Price and the Energy Uncertainty Index is concluded by the trace statistics results, which reveal that the "none" p value is below 0.05 and the "at most one" p value is likewise below 0.05. Additionally, the eigenvalue p values of "none" and "at most 2" are both less than 0.05, confirming the long-term cointegration between the WTI Crude Oil Price and the Energy Uncertainty Index.

Findings of the study

- The Energy Uncertainty Index, WTI Crude Oil, and Brent prices are all judged to be stationary at "level."
- The Energy Uncertainty Index has a cause-and-effect relationship with the price of Brent.
- The Energy Uncertainty Index has an impact on the price of WTI crude oil.
- The price of Brent and the Energy Uncertainty Index have a long-term, linear relationship.
- The price of WTI crude oil and the Energy Uncertainty Index have a long-term, linear relationship.
- The price of brent and a few other macroeconomic variables are cointegrated over the long term.
- The Energy Uncertainty Index and the WTI Crude Oil Price cointegrate over the long term.

Suggestion of the study

1. Policy and Market Monitoring

- Energy Policy Focus: Because the Energy Uncertainty Index (EUI) affects global oil prices both immediately and over time, policymakers should keep a careful eye on it (Brent and WTI). Oil market volatility may be decreased by stabilizing energy policy and lowering uncertainty.
- Risk Management Tools: To predict changes in the price of oil, regulatory agencies and businesses might create early warning systems or risk assessment frameworks based on EUI movements.

2. Investment Strategies

- Hedging Strategies: Especially during periods of increasing uncertainty, investors in the Brent and WTI markets might modify their hedging positions by using EUI as a leading indicator.
- Portfolio Diversification: In order to reduce risk exposure, portfolios with a significant crude oil investment should take into account macro-hedges that react to changes in energy policy, given the long-term cointegration.

3. Trading Strategies

- Cointegration-Based Trading: By leveraging departures from their long-term equilibrium, traders can create pair trading strategies between the EUI and crude oil prices (Brent and WTI).

- Short-Term Signals: Because the EUI and oil prices are causally related, surges in the EUI may indicate impending short-term corrections or momentum trades.

4. Economic Forecasting

- Macro Forecast Models: When expecting long-term price fluctuations or structural shifts, use EUI in your oil price forecasting models.
- Macroeconomic Linkages: Integrated economic simulations or energy market outlooks should take into account the cointegration of Brent prices with other macroeconomic factors.

5. Corporate Planning

- Cost Planning: To properly budget for fuel costs, energy-intensive enterprises can include EUI trends in their input cost projections.
- Strategic Resilience: Companies that are subject to fluctuations in the price of oil, such as shipping, logistics, and airlines, may wish to match their financial planning with EUI trends to make sure they have contingencies in place during times of high uncertainty.

6. Further Research Recommendations

- Regional Analysis: Examine whether EUI has a comparable effect on regional crude oil benchmarks, such as Dubai crude.
- Structural Break Tests: Determine whether geopolitical developments intensify or interfere with the long-term cointegration of oil prices and EUI.
- Causality with Other Commodities: Examine whether the price of coal or natural gas is impacted by EUI.

CONCLUSION

The results imply that the Energy Uncertainty Index has a major impact on the price of crude oil, especially WTI and Brent. The existence of both long-term cointegration and short-term causality suggests that changes in energy uncertainty can have a direct effect on oil prices and that these associations endure over time. Furthermore, the way that Brent prices are integrated with other macroeconomic factors demonstrates the wider economic impact on crude oil markets. These findings highlight how crucial it is to account for energy uncertainty when predicting and formulating policies pertaining to the world's oil markets. The findings indicate that crude oil prices, specifically WTI and Brent, have a significant impact on the Energy Uncertainty Index. The presence of a long-term, linear relationship and cointegration suggests that fluctuations in oil prices contribute to variations in energy uncertainty. As crude oil prices change, they likely influence market sentiment, policy decisions, and overall energy stability, thereby shaping the uncertainty index. These results highlight the critical role of crude oil in driving energy market uncertainty and emphasize the need for policymakers and investors to monitor oil price movements as a key determinant of energy uncertainty.

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