International Journal of Economics and Financial Issues

ISSN: 2146-4138

available at http: www.econjournals.com

International Journal of Economics and Financial Issues, 2025, 15(1), 397-411.

Dynamic Comovement between Indian Commodity Futures, Economic Policy Uncertainty and Geopolitical Risk: Evidence from Wavelet Analysis

M. Thilaga*, K. Prabhakar Rajkumar

Department of Commerce, Periyar University, Salem, Tamil Nadu, India. *Email: mthilaga244@gmail.com

Received: 04 September 2024 **Accepted:** 23 November 2024 **DOI:** https://doi.org/10.32479/ijefi.17622

ABSTRACT

The present study examines the dynamic comovements between two global risk factors and commodity futures returns. The study considers the daily futures price of nine commodities spanning from January 4th, 2012 to September 29th, 2023. The study employs wavelet analysis and wavelet-based Granger causality tests to analyze dynamic comovement and causal relationship between global risk factors and commodity futures return at different time horizons. The study results show a strong comovement between the US economic policy uncertainty (USEPU) and commodity futures return except for silver and mentha oil. On the other hand, the geopolitical risk (GPR) exhibits a weak relationship with gold, lead, zinc, and energy commodities across all-time frequencies. Further, the Wavelet Granger causality test results provide strong evidence that commodities futures return cause the USEPU in all the time horizons. Followed by the geopolitical risk reports significant evidence that commodities futures return causes GPR in all time horizons.

Keywords: Commodity Futures Return, Economic Policy Uncertainty, Wavelet Granger Causality, Geopolitical Risk
JEL Classifications: G1, G40

1. INTRODUCTION

Since 2003, the commodity markets in India have grown rapidly, and it holds a crucial place in the global commodity market. As the fifth largest economy in terms of GDP (IMF, 2022)[1] and being the world's major importer and consumer of commodities. At present, there are five active national-level exchanges in operation. Especially, the multi-commodity exchange became the seventh-largest commodity derivatives exchange in the world in terms of the number of contracts traded[2]. Recently, commodity futures markets have gained popularity as an asset class for market players such as investors and portfolio managers. It is also used as a risk mitigation tool against any adverse price movements of the underlying assets (Andreasson et al., 2016). In the recent past, commodity markets have been a major source of global concern due to tremendous changes in commodity prices and rising investors' demand for commodities (Rajput et al., 2021).

With liberalization, privatization, and globalization (LPG), the economic and financial systems are interconnected across the globe. Any economic uncertainty that happens in one country may have direct or indirect effects on other countries. Further, the magnitude of the impact is high when it originates from leading economics (Dakhlaoui and Aloui, 2016; Ellis and Liu, 2021; Forbes and Chinn, 2004). Economic policy uncertainty plays a pivotal role in influencing financial assets. Since the global financial crisis, there has been a substantial increase in economic uncertainty (Li et al., 2020). Indeed, economic policy uncertainty has considerably affected the stock and commodity markets

1 sourced from IMF data (as of April 30, 2024)
2 FIA data, 2023 https://www.mcxindia.com/home

(Bessler et al., 2021; Batabyal and Killins, 2021; Dakhlaoui and Aloui, 2016; Das and Kumar, 2018; Zhang and Broadstock, 2020). There are a few studies that also examine the global risk factors and find a significant impact of EPU in different dimensions. Kido (2016) and Bilgili et al. (2022) investigate the connection between economic policy uncertainty, geopolitical risk, and exchange rates. Demir and Ersan (2017) and Guizani et al. (2023) study the impact of EPU, geopolitical risk, and corporate cash holdings. (Zhang et al., 2015; Jumah et al., 2023; Schwarz and Dalmacio, 2021) examine the relationship between economic policy uncertainty and corporate leverage. Farooq et al. (2022) and Liu and Zhang (2020) explore the impact of economic policy uncertainty on corporate investment. On the other hand, the geopolitical risk factor drastically affects the stock market. Bouri et al. (2019) document that Islami bonds and stocks may hedge geopolitical risks. Subsequently, Balcilar et al. (2018) study the geopolitical risk issues on the returns and volatility of BRICS stock markets.

In recent years, the newly proposed news-based uncertainties have received significant momentum due to unprecedented economic conditions like the pandemic and increasing geopolitical uncertainty such as the Ukraine invasion. According to Brogaard and Detzel (2015) document that policy decisions taken by the government are likely to cause uncertainty called EPU. However, it also increases the risk by fostering a vicinity of uncertainty about future economic policy decisions. Further, the uncertainty about economic policies, such as fiscal and monetary policies as well as regulatory policies, substantially affects the county's economic growth and investment (Baker et al., 2016). A handful of studies extensively examine the impact of EPU on commodity markets. Studies like (Kang and Ratti, 2013; Wang and Sun, 2017; Yin, 2016) document that EPU significantly affects oil prices. It is noteworthy that economic policy uncertainty could cause shocks to the commodities market. In other words, the EPU is an important factor that drives commodity price volatility (Li et al., 2023). The study also seeks to answer the following question: how do economic policy uncertainty and geopolitical risk affect commodity futures returns? Against this backdrop, the present study examines the impact of global risk factors on commodity futures returns. The study contributes to the existing literature in several ways.

First, we use daily commodity futures returns and global risk factors by employing wavelet analysis and the wavelet Granger causality test. Second, we use newly proposed news-based uncertainty, such as daily US economic policy uncertainty and geopolitical risk factors proposed by Baker et al. (2016) and Caldara and Iacoviello (2018) respectively. Further, the study results show a strong comovement between the US economic policy uncertainty (USEPU) and commodity futures return except silver and mentha oil. Next, the wavelet Granger causality test results provide strong evidence that commodities futures return cause the USEPU in all the time horizons. The study results provide some policy implications to the policymakers and market participants.

The rest of the paper is organized as follows. Section 2 deals with a brief literature review. Section 3 represents data and methodology, Section 4 presents empirical results, and Section 5 provides concluding remarks.

2. REVIEW OF LITERATURE

Prior studies have extensively studied the relationship between commodities markets and newly proposed news-based uncertainties such as economic policy uncertainty, and geopolitical risk in the developed countries. However, these studies have employed various econometric techniques to study the impact of policy uncertainty and commodity futures prices. Poncela et al. (2014) confirm that uncertainty plays an important role in identifying comovements among non-energy commodity prices. Yin and Han (2014) document that uncertainty leads to enhanced commodity prices and volatility. Andreasson et al. (2016) find some significant associations between USEPU and commodity futures returns except energy commodities. Liu et al. (2022) examine the complex connection between international commodity market and uncertainties. The study employs a wavelet approach and detrended cross-correlation analysis. The authors find a significant comovement between the international commodity market and uncertainties in the short and medium terms. Similarly, Jiang et al. (2023) study the risk spillover association between commodity markets and China's economic policy uncertainty (CNEPU). They use closing prices of 14 commodities spanning from January 2007 to November 2020. The study employs a quantile connectedness approach and finds a short-term risk spillover association between CNEPU and commodity futures.

Li et al. (2023) investigate the dynamic linkage and extreme risk spillover between uncertainties and the USA and Chinese commodity markets. The overall results document that during the initial stage, both commodity markets show higher complexity and volatility in response to uncertainty shocks. However, Lyu et al. (2021) and Zhu et al. (2020) analyze the economic policy uncertainty shock on the commodities market. The study finds that the domestic EPU shocks show an adverse effect on commodity futures. Xiao et al. (2022) study the impact of economic policy uncertainty on US commodity markets during the pandemic outbreak. The study results show that EPU significantly affects the commodity markets. Xiao et al. (2019) explore the impact of economic policy uncertainty on China's grain futures prices. The study shows that EPU has significantly affected the price of grain futures in China. In the Indian context, there are limited studies examining the global risk factors and commodity futures returns. For instance, Dehghanzadeh Shahabad and Balcilar (2022) verify the dynamic relationship between EPU and commodity prices in India. The study results show that the changes in the price of goods are not much affected by Indian EPU.

Shaikh and Vallabh (2024) investigate the impact of economic policy uncertainty on the gold price in India and the World Gold Council. They find a positive association between economic policy uncertainty and gold prices in India. After the rigorous review process, it is found that very few studies have examined the Indian commodity futures markets. Next, they also employ standard volatility spillover and causality models to examine the causality and spillover effects. To address this concern, the present study verifies the dynamic comovement between global risk factors and commodity futures returns in the Indian context by employing wavelet analysis and wavelet Granger causality tests.

3. DATA AND METHODOLOGY

The present study uses daily commodity futures prices for nine commodities, including two precious metals (gold and silver), three base metals (aluminum, lead, and zinc), two energy commodities (crude oil and natural gas), and two agricultural commodities (cotton and mentha oil). We select the commodities based on the availability of data for the whole study period. Next, we use the recently proposed news-based US economic policy uncertainty index (USEPU)[3] and geopolitical risk (GPR)[4] constructed by Baker et al. (2016) and Caldara and Iacoviello (2021). The daily commodity price data are downloaded from the official website of multi commodity exchange (MCX)[5]. In addition, the USEPU, and GPR data are obtained from (http://www.policyuncertainty.com) website. The data used for the study covers from 4th January 2012 to 29th September 2023. Further, the study uses commodity futures daily prices to calculate the daily commodities futures return using the following equation (1). The return series are expressed in terms of percentage by multiplying with 100.

$$r_t = \ln\left(P_t / P_{t-1}\right)\times 100 \tag{1}$$

Where r_t represents the daily commodity futures return, P_t indicates daily commodity futures price at the time t and $t-1$.

3.1 Wavelet approach

The wavelet technique (ψ) is employed in the study. It is a square integral element with real value and an average is equal to zero, for instance $\int_{\ldots\infty}^{\infty} \psi(t)\,dt = 0$ The element (ψ) will waggle along with the t-axis, functioning like a wave. The precise wavelet employed here, and it is belonging to the family of morlet wavelets of Goupillaud et al. (1984) which is expressed in equation (2) as follows:

$$\psi(t) = \pi^{-\frac{1}{4}} e^{-i\omega t} e^{-\frac{1}{2}t2} \tag{2}$$

In this case, a wavelet functions on the finite time series $p(t)$, $t=1,2,3\ldots.T$.

Next, the study includes time and frequency (indicated by c, and f) parameters which are related to the wavelet as well as translating $\psi_{c,f}$ could be made and it is presented in equation (3).

$$\psi_{c,f}(t) = \frac{1}{\sqrt{f}}\psi\left(\frac{t-c}{f}\right), c, f \in \mathbb{R}, f \neq 0 \tag{3}$$

Further, the continuous wavelet transformation equation by including the time series data $p(t)$ could be obtained from the wavelet.

$$W_p(c,f) = \int_{-\infty}^{\infty} p(t)\frac{1}{\sqrt{f}}\overline{\Psi\left(\frac{t-c}{f}\right)}\mathrm{d}t \tag{4}$$

Where c represents time or location, and f is scale or frequency the bar denotes complex conjugation.

By merging the original time series coefficient ψ included in the equations (5) and (6) are restored.

$$p(t) = \frac{1}{C\psi}\int_0^{\infty}\int_0^{\infty}\left|W_p(c,f)\right|^2 \mathrm{d}c\frac{\mathrm{d}f}{f^2} \tag{5}$$

Next, it is possible to construct the wavelet power spectrum (WPS) from equation (4) to obtain more information about the behavior of amplitude of the time series of variables.

$$WPS_P(c,f) = \left|w_P(c,f)\right|^2 \tag{6}$$

However, the study employs the cross-wavelet transform (CWT) technique to find the time-scale causality relationship between $p(t)$ and $q(t)$. The CWT is expressed in the equation (7).

$$W_{pq}(c,f) = W_p(c,f)\overline{W_q(c\ f)} \tag{7}$$

Where W_p (c,f) and W_q (c,f) indicate the CWT of $p(t)$ and $q(t)$ and the bar signifies the complex conjugation. CWT represents the 2-time series covariance at a specific scale. CWT could be interpreted as a covariance for a specific scale and time.

Torrence and Compo (1998) state that the squared wavelet coherence could be presented in equation (8)

$$R^2(c,f) = \frac{\left|S(_b^{-1}W_{pq}(c,f)\right|^2}{s(b^{-1}\left|w_p(c,f)\right|^2 s(b^{-1}\left|w_q(c,f)\right|^2} \tag{8}$$

Where S presents the smoothing function over time and scale with $0\leq R^2(c,f)\leq 1$. If the $R^2(c,f)$ approaches 1. The value of the squared correlations between 0 and 1, implies the strongest relationship between $p(t)$ and $q(t)$ and it denotes by red color. Further if cap R squared, open paren c, f close paren lies 0, it indicates weak comovement between p of t and q open paren t close paren, and it is indicated in blue color.

Furthermore, Torrence and Compo (1998) propose the Chi-square method to estimate the accurate level of significance of wavelet coherence and approximate the WPS of $AR(0)$ or $AR(1)$. The wavelet coherence is represented by a thick black contour.

3 USEPU news-based index is constructed based on the news related to “economic”, “policy” and “uncertainty” which is published in the United States newspapers.

4 It generates automated text search results of the electronic archives to construct GPR index using ten newspapers.

5 It is country’s first listed commodity derivatives exchange in India. Also, MCX is the leading commodity derivatives exchange with a market share of 95.64% in terms of the trading value of commodity futures contract for the current fiscal year 2023-24. https://www.mcxindia.com/market-data/historical-data.

However, the wavelet coherence coefficient is a squared value, and it could not be possible to differentiate between positive and negative comovement. Hence, Torrence and Compo (1998) document an average by which to find the wavelet coherence differences through indications of deferrals in the wavering of 2-time series. The wavelet coherence difference phase is determined as follows:

$$\$_{pq}\left(c,f\right)=tan^{-1}\left(\frac{\Im\left\{S\left(f^{-1}W_{pq}\left(C,f\right)\right)\right\}}{\Re\left\{S\left(f^{-1}W_{pq}\left(C,f\right)\right)\right\}}\right) \tag{9}$$

3.2. Wavelet Based Granger Causality

The present study employs a wavelet-based Granger causality test (Granger, 1969) between global risk factors and commodity futures returns. Next, we use both decomposed time series of variables to systematically understand the causal relationship between global risk factors and commodity futures returns. According to Diebold's (1998) document, the Granger causality tests the predictive causality of one variable to another variable. Further, Hamilton (1985) reports that it exhibits only short-term relationships between the variables. The following VAR equations (10 and 11) represent the predictive relationship between the lag value of independent variables X and Y and the lag value of dependent variables Y and X. Also, the F test explains equation (12) shows that information on any market (X_{t-1}) is statistically significant to represent the forecast values of another market (Y_t). The study employs the following equations to run the Granger causality of the variables X on variable Y as follows:

$$Y_t=\Sigma_{i=1}^{n}\alpha_i X_{t-1}+\Sigma_{j=1}^{n}\beta_j Y_{t-J}+\mu_t \tag{10}$$

$$X_t=\sum_{i=1}^{n}\omega_i X_{t-i}+\sum_{j=1}^{n}\delta_j Y_{t-j}+\varepsilon_t \tag{11}$$

$$F=\frac{(RSS_1-RSS_2)/m}{RSS_2/(n-k)} \tag{12}$$

Where RSS_1 and RSS_2 represent restricted and unrestricted residual sum of squares, *m* or *n-k* show the degree of freedom and *k* depicts the number of estimated parameters.

4. EMPIRICAL RESULTS

Table 1 presents the descriptive statistics for the return of commodities futures, USEPU, GPR, and unit root test results. The average daily futures return is positive for all commodities. Based on the unit root test results indicate that all commodities futures return, USEPU, and GPR are statistically significant at 1% level and confirm that all the return series are stationary at level (Elliott et al., 1992). Figure 1 shows a time series plot for nine commodities' future returns, as well as the trends of USEPU and GPR.

4.1. Wavelet Analysis

The study examines the dynamic comovement between daily commodity futures return, US economic policy uncertainty, and GPR employing wavelet power spectrum and wavelet coherence analysis. We use the R software (biwavelet package) developed by Gouhier et al. (2022) to undertake wavelet analysis. Figure 2 presents the wavelet power spectrum plots for the daily commodity futures return, US economic policy uncertainty, and GPR. However, the study considers the time series data of more than 2500 observations and the scale of 256 periods has been used. The vertical and horizontal axis refers to the time in days (frequencies) and study periods. However, the white curve links to the cone of influence, indicating an edge where the wavelet power is at the end, and it becomes difficult to infer. Further, the black outline marks indicate the wavelet power spectrum, which is significant at 5%. Additionally, the means of Monte Carlo simulation are employed to obtain significant test results. The power spectrum color bar shows the magnitude of the power level, and the colors indicate that red expresses a strong correlation, and blue denotes a weak correlation. Next, the study classifies the frequency range into 3 time periods: short-term frequencies, which range from 2 to 64 days; medium-term frequencies, which range from 64 to 128 days; and long-term frequencies, which range from 128 to 256 days respectively. The power spectrum results of all commodities futures return reveal a high power (see red zones) throughout the study period from January 2012 to September 2023, on a scale ranging from 16 to 64 days and 128 to 256 days. Further, all commodity futures return shows some similarities among them. In addition, all commodity futures return exhibits high power in the short term from January 2012 to July 2015 and the middle of June 2017 to June 2019, besides, low frequency (256 period) over the study period. On the contrary, the wavelet power spectrum exhibits a low scale at upper frequencies over the full sample period.

4.2. Wavelet Coherence Analysis

Wavelet coherence analysis is used to find out pairwise comovements between the commodity futures return, US economic policy uncertainty, and geopolitical risk. The vertical and horizontal axis refer to the time in days (frequency) and study period, respectively. However, the white curve links to the cone of influence, indicating an edge where the wavelet power is at the end, and it becomes difficult to infer. The main advantage of wavelet coherence analysis is to identify the regions in the time-frequency domain. The red colors denote that the commodity futures return shows strong comovement with USEPU and GPR, whereas the blue color indicates that the commodity futures return exhibits weak comovement with USEPU and GPR. Moreover, the wavelet coherence is indicated by the black outline marks, which are significant at 5%. Additionally, the means of Monte Carlo simulation is employed to obtain significant test results. Next, the arrow marks in the wavelet coherence show the lead-lag relationship between the commodity futures return, USEPU, and GPR. Certainly, the arrow marks indicate the phase difference directions of the 2-time series. In particular, the 2-time series variables will move together in the same direction,

Table 1: Descriptive statistics

Commodities	Mean	Standard deviation	Min	Max	ADF	PP
Precious metal						
Gold	0.02	0.88	−8.56	5.61	−54.44***	−54.42***
Silver	0.00	1.49	−11.90	8.86	−54.90***	−54.86***
Base metals						
Aluminum	0.02	1.21	−9.41	10.25	−53.23***	−53.23***
Lead	0.02	1.33	−5.93	17.22	−54.14***	−54.27***
Zinc	0.03	1.44	−6.72	9.36	−53.97***	−53.96***
Energy commodities						
Crude oil	0.00	2.58	−34.57	23.38	−20.95***	−51.14***
Natural gas	0.01	3.21	−17.62	17.97	−53.94***	−54.03***
Agricultural commodities						
Cotton	0.02	1.30	−24.09	14.29	−50.48***	−50.55***
Mentha oil	0.00	2.03	−18.61	15.28	−50.84***	−51.26***
Recently proposed news-based index						
USEPU	−0.02	53.19	−239.94	322.46	−23.58***	−406.73***
GPR	0.01	44.36	−299.59	234.49	−25.92***	−580.08***

Source: Author's calculations

treated as zero phase difference, while the arrow marks travel towards the right direction. It is called time series are in phase (positive comovement). The arrow marks traveling towards the left direction are considered anti-phase (opposite direction and negative comovement), and when the arrow marks move left up or right down, it denotes that the 1st time series variable leads the second variable. The arrow marks move left down and right up, indicating that the second variable leads to the first variable. However, the present study considers commodity futures return as the first variable, and the second variables are USEPU and GPR.

(Figure 3a) shows the coherence between gold futures return and US economic policy uncertainty as well as geopolitical risk. The study finds a strong interrelationship between gold futures return and USEPU from August 2013 to November 2013 and is statistically significant at close to 264 days scale. Further, the arrow shows the right and down direction, confirming that both variables are in phase and implying that the gold futures return leads the USEPU. Similarly, it shows a strong correlation from the middle of May 2017 to June 2017. On the other hand, the return on gold futures and geopolitical risk pair exhibits a little red zone with 64-day scale in 2014.

The coherence between the silver futures returns and USEPU, along with geopolitical risk, is represented in (Figure 3b). The silver futures return shows weak comovement with USEPU. Besides, the study finds that from November 2013 to December 2013 and the middle of August 2023 to September 2023, silver futures return shows a strong correlation with geopolitical risk and is statistically significant at close to 64 scale. The rightward arrows point out that both the variables are in phase.

(Figure 3c) represents the comovement between aluminium futures return and USEPU as well as geopolitical risk. Thus, the study shows a strong correlation from August 2023 to September 2023 and is statistically significant at 64 scale. The arrows move towards a right and upward direction. It implies that aluminium futures return leads to US economic policy uncertainty. However, the aluminium futures return reveals a strong correlation with geopolitical risk from July 2023 to September 2023 and is statistically significant at close to 256 scales. The arrow marks move towards the right and upward direction. It indicates that the aluminium futures return leads to geopolitical risk.

The coherence between the lead futures returns and USEPU, along with geopolitical risk, is represented in (Figure 3d). The lead futures return shows weak comovement with USEPU and GPR.

Concerning (Figure 3e), we show the wavelet coherence between the zinc futures return and USEPU and geopolitical risk. The zinc futures return reveals a strong correlation between US economic policy uncertainty, especially from July 2015 to December 2016 and in the middle of June 2017-June 2019, and statistically significant at a 64-day scale and 182-day scale. The arrow marks travel towards the right and upward direction. It shows that the zinc futures return is in the phase and zinc futures return leads to US economic policy uncertainty. Although, the zinc futures return exhibits a weak correlation with geopolitical risk.

With reference to (Figure 3f), we represent the wavelet coherence among crude oil futures return and US economic policy uncertainty and geopolitical risk. Further, the crude oil futures return is strongly correlated with US economic policy uncertainty, especially from June 2017 to December 2020, and statistically significant at a 256-day scale.

Next, the arrow marks move toward the right and downward direction. It implies that the US economic policy uncertainty leads to crude oil futures return. On the other hand, the crude oil futures return shows a weak correlation with geopolitical risk from June 2017 to September 2017 and is statistically significant at 256-day frequency. The arrow marks also move towards the right and downward direction. It reveals that the geopolitical risk leads to crude oil futures return.

Figure 1: Commodities futures return, US economic policy uncertainty, and Geopolitical risk time series plots

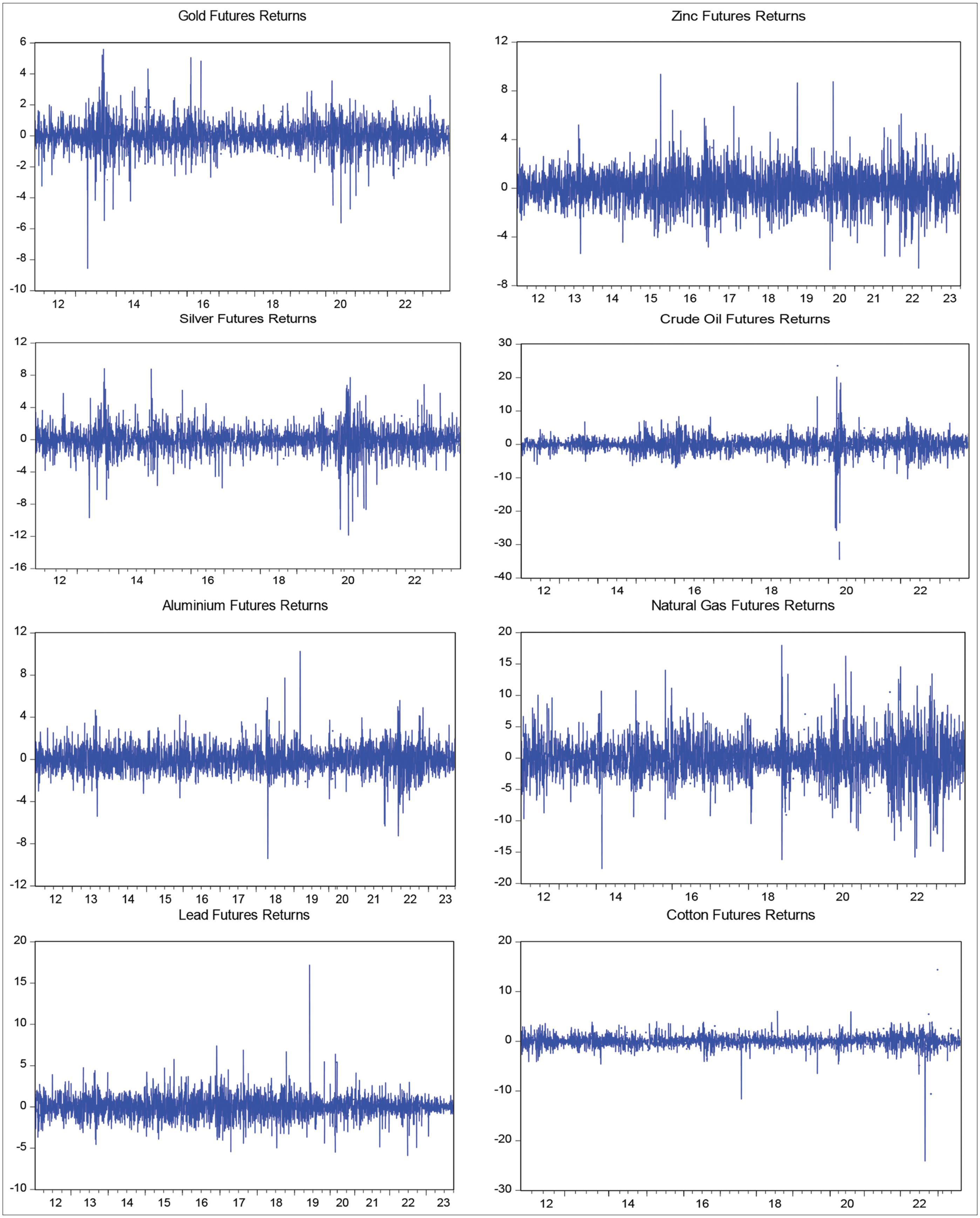
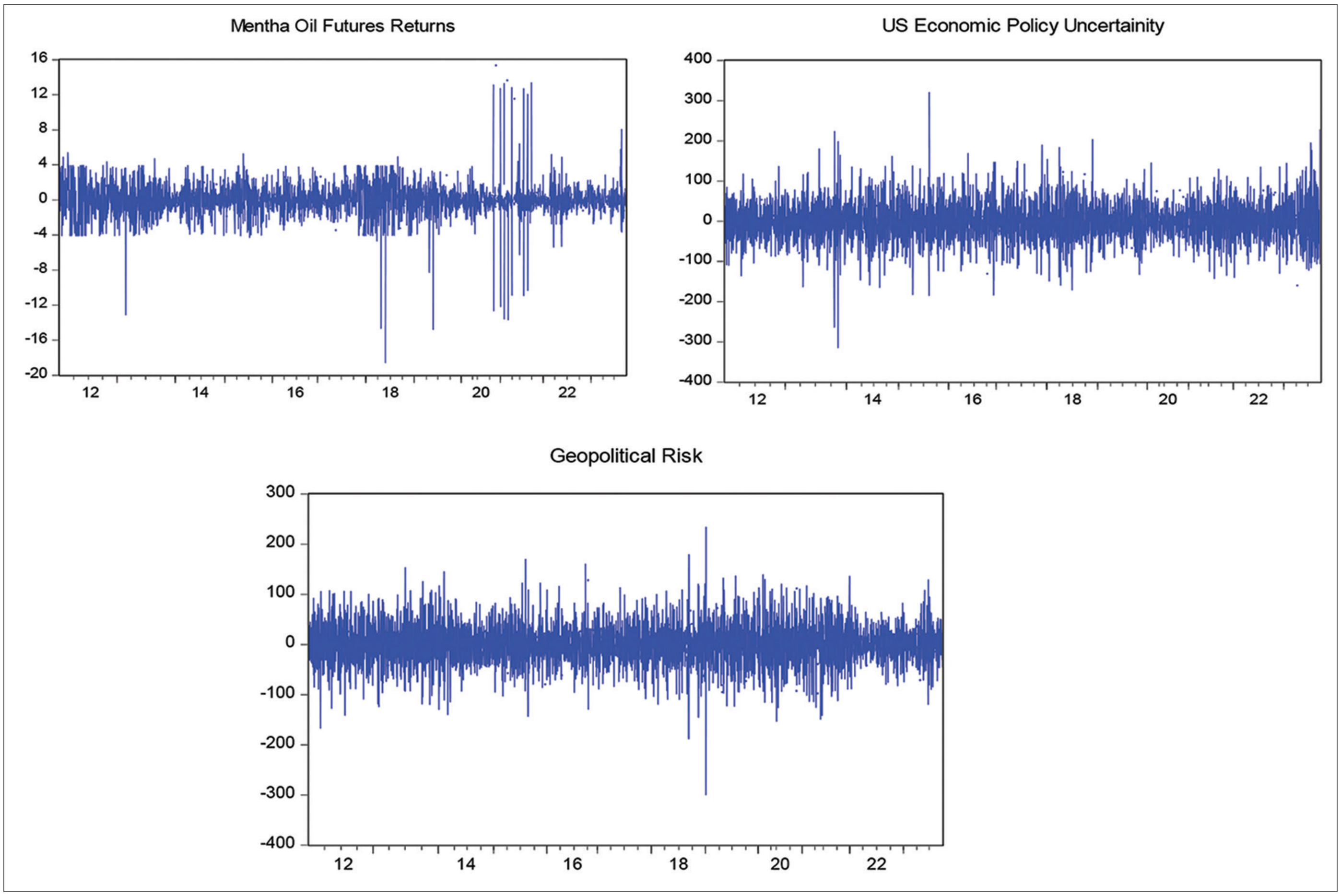


Figure 1: *(Continued)*



(Figure 3g) shows the wavelet coherence of natural gas futures return with USEPU and GPR. The study finds that natural gas futures return is substantially correlated with USEPU during June 2016-July 2016 and statistically significant at 64-day scale frequency. The arrow marks a turn towards the right and upward direction, and it indicates that the natural gas futures return is in phase. Further, it exhibits that natural gas futures return leads USEPU. Whereas the natural gas futures return shows a weak correlation with geopolitical risk.

Concerning (Figure 3h) we present our wavelet coherence among cotton futures return and USEPU and GPR. However, the study results reveal a strong correlation between cotton futures returns and USEPU, especially from January 2014 to March 2914 and in the middle of June 2017-September 2017. It is statistically significant at 64-day scale to 256-day scale frequencies. Further, the arrow marks move toward the left and downward direction. It infers that the USEPU leads cotton futures return. Similarly, the cotton futures return exhibits a correlation with geopolitical risk from March 2020 to June 2020 and is statistically significant at a 256-day scale. The arrow marks move towards the right and upward direction. It indicates that the cotton futures return leads to geopolitical risk.

Lastly, (Figure 3i) shows coherence results between mentha oil futures return and USEPU along with GPR. The study results reveal a weak correlation between return on mentha oil futures and USEPU. On the other hand, it shows a strong correlation with GPR from June 2017 to August 2017 and is statistically significant on a 256-day scale. The arrow marks a move toward the left and an upward trend. It implies that the GPR leads mentha oil futures return.

To examine the causal relationship between commodity futures returns and USEP as well as GPR across different time scales, we employ a wavelet-based Granger causality test by using the different time scales. The study employs the maximal overlap discrete wavelet approach (MODWT) to decompose the original time series data into various time scales (Hung, 2020). Although the scales D_1, D_2, D_3, D_4, D_5, $D_{6,}$ and S_6 are classified into four different time horizons, we consider (D_1-D_2) as short term, (D_3-D_4) as the medium term, (D_5-D_6) as the long term, and (S_6) as the very long term (Athari and Hung, 2022; Hung, 2020). The scales resemble the time horizon of 2-4, 4-8, 8-16, 16-32, 32-64-, and 64-128-day horizons. Whereas scale (S_6) represents more than 128 days' time horizon. Table 2 shows the empirical results between return on commodity futures and USEPU, which are based on the wavelet Granger causality test for different scales. The study results indicate that the aluminium and zinc futures return significantly causes USEPU at a 5% all-time horizon, that is short, medium, long, and very long terms. It implies that an increase in the commodity market uncertainty could impact its

Figure 2: Wavelet power spectrum plots for the commodity futures return, USEPU, and GPR

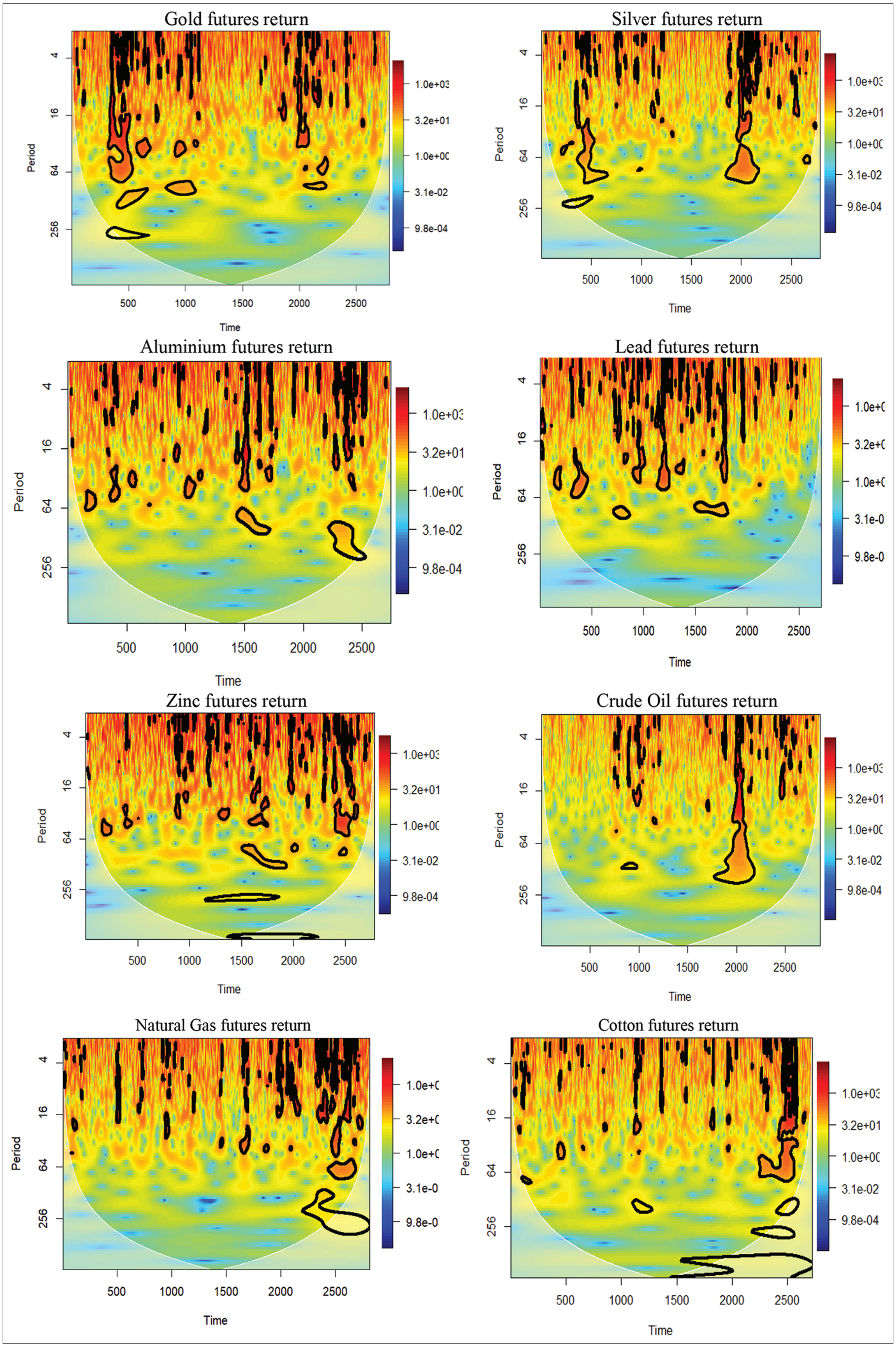
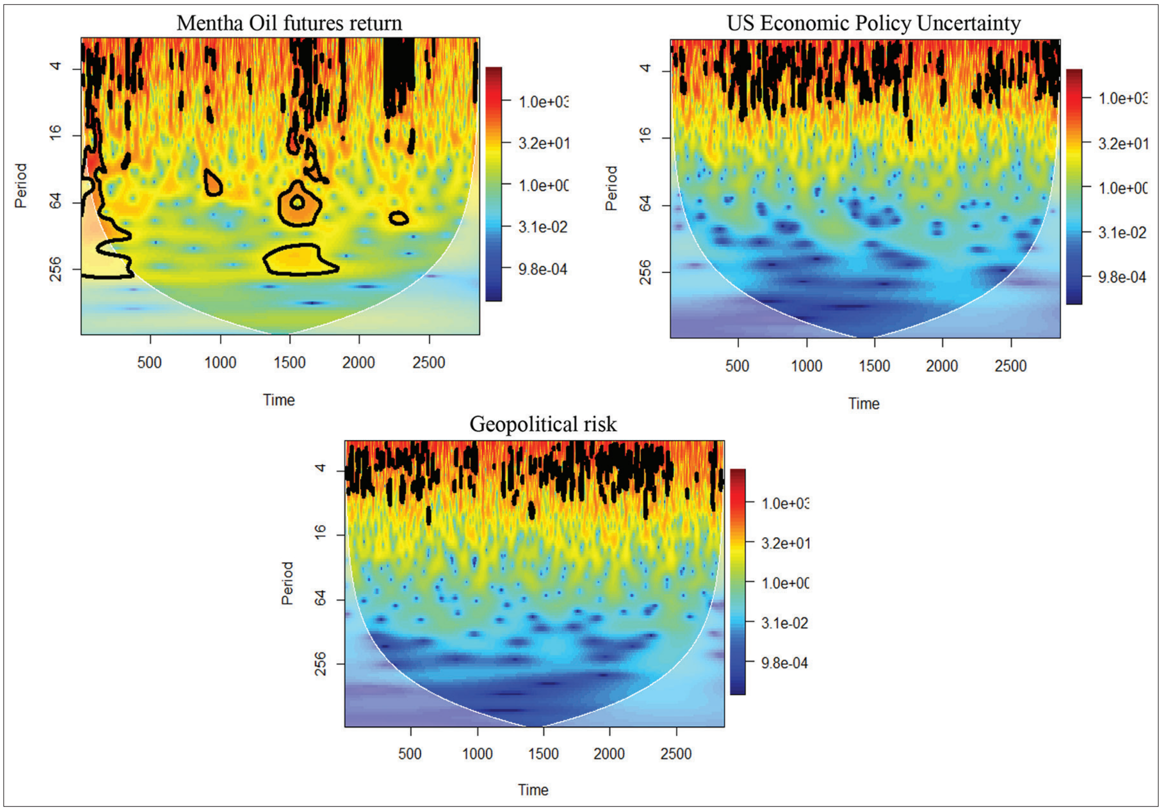


Figure 2: *(Continued)*



economic policy at all-time horizons. However, the study infers that both base metals are essential commodities, and it may increase the stability of the commodities market. Hence, any volatility in these two commodities has significantly affected the commodities market in India.

Further, a few unidirectional causality relationships exist at a 5% significant level. In particular, gold shows unidirectional relations with USEPU in the short and very long-term time horizon. On the other hand, cotton futures return exhibits unidirectional causality with USEPU. Followed by natural gas shows a similar direction in the medium and very long-term time horizon. Lastly, the mentha oil shows unidirectional causality with USEPU in the long term.

Next, the findings show some bidirectional relationship with commodity futures return and USEPU. Particularly, silver and natural gas register bidirectional causality with USEPU in the long and very long term, respectively. However, the lead exhibits a similar relationship with USEPU in the short and long term. Finally, crude oil shows bidirectional causality in the long term and very long term. It implies that commodities futures return being influenced by US economic policy uncertainty indicates that tend to invest in commodities to hedge against uncertainties.

Table 3 presents the empirical results between return on commodity futures and GPR, which are based on the wavelet Granger causality test for different scales. The study results indicate that the natural gas futures return significantly causes GPR at 5% in all time horizons, that is, short, medium, long, and very long terms. However, the study reports a few unidirectional causality relationships exist at a 5% significant level. Especially, gold, lead, and zinc show unidirectional relations with GPR in the medium, long-term, and very long-term time horizons. However, silver futures return exhibits unidirectional causality with GPR. This is followed by aluminium, which shows a similar direction in the long and very long-term time horizons. Cotton futures return shows unidirectional causality with GPR in the short, long, and very long-term horizons.

The study results show some bidirectional relationship with commodity futures return and GPR. Aluminium and crude oil register bidirectional causality with GPR in the long term. On the other hand, silver exhibits a similar relationship with GPR in the long and very long terms respectively. Followed by natural gas shows bidirectional causality in the short and long term. Finally, the lead and mentha oil exhibit bidirectional causality in the medium and short terms.

The overall findings of the study provide evidence that the time frequencies in which the causal relationship between the global risk factors and commodity futures returns manifests itself. The wavelet-based Granger causality test helps us to examine the influence of global risk factors and commodity futures returns in the short, medium, and long term. Finally, the results show that causality between the variables strongly exists. The study findings are in line with previous study (Soni et al., 2023).

Table 2: Wavelet Granger causality test between Commodities futures return and USEPU

Time domain	Result	H0: Commodity futures return does not cause USEPU		H0: USEPU does not cause Commodity futures return	
		F stat	P-value	F stat	P-value
Gold-USEPU					
D_1	GOLD→USEPU	2.646	0.047**	2.142	0.093*
D_2	No causality	0.733	0.533	1.429	0.232
D_3	No causality	0.639	0.590	0.787	0.501
D_4	No causality	2.108	0.097*	0.765	0.514
D_5	Gold←USEPU	0.748	0.523	3.303	0.019**
D_6	No causality	2.280	0.077*	0.188	0.905
S_6	GOLD→USEPU	4.532	0.003***	1.489	0.216
Silver-USEPU					
D_1	No causality	0.740	0.527	0.612	0.606
D_2	No causality	0.240	0.868	1.825	0.140
D_3	No causality	0.341	0.795	0.757	0.517
D_4	Silver→USEPU	4.338	0.004***	1.872	0.132
D_5	No causality	0.091	0.964	0.415	0.742
D_6	No causality	0.598	0.615	0.234	0.872
S_6	Silver↔USEPU	4.846	0.002***	5.797	0.000***
Aluminium-USEPU					
D_1	Aluminium→USEPU	3.099	0.025**	1.651	0.175
D_2	No causality	0.997	0.393	0.684	0.561
D_3	Aluminium↔USEPU	3.374	0.017**	3.450	0.015**
D_4	USEPU→aluminium	2.390	0.066*	2.716	0.043**
D_5	No causality	0.418	0.739	2.196	0.086*
D_6	Aluminium↔USEPU	3.086	0.026**	3.027	0.028**
S_6	Aluminium→USEPU	4.857	0.002***	0.664	0.573
Lead-USEPU					
D_1	Lead↔USEPU	3.144	0.024**	3.622	0.012**
D_2	Lead↔USEPU	6.440	0.000***	8.628	0.000***
D_3	No causality	1.353	0.255	1.358	0.253
D_4	No causality	2.025	0.108	4.008	0.007***
D_5	Lead→USEPU	3.639	0.012**	2.015	0.109
D_6	Lead↔USEPU	2.978	0.030**	3.996	0.007***
S_6	No causality	1.749	0.154	1.307	0.270
Zinc-USEPU					
D_1	No causality	1.593	0.188	1.156	0.324
D_2	Zinc←USEPU	1.803	0.144	2.773	0.040**
D_3	No causality	1.834	0.138	2.287	0.076*
D_4	Zinc←USEPU	0.987	0.397	3.104	0.025**
D_5	Zinc←USEPU	2.037	0.106	3.018	0.028**
D_6	Zinc←USEPU	2.596	0.050*	3.967	0.007***
S_6	Zinc→USEPU	6.031	0.000***	2.463	0.060*
Crude oil-USEPU					
D_1	No causality	0.395	0.756	0.216	0.884
D_2	No causality	1.643	0.177	1.755	0.153
D_3	No causality	1.398	0.241	0.925	0.427
D_4	No causality	0.875	0.452	2.171	0.089*
D_5	Crude oil←USEPU	0.939	0.420	4.622	0.003***
D_6	Crude oil↔USEPU	5.108	0.001***	9.189	0.000***
S_6	Crude oil↔USEPU	3.237	0.021**	17.211	0.000***
Natural gas-USEPU					
D_1	No causality	0.712	0.544	0.031	0.992
D_2	No causality	1.181	0.315	0.983	0.399
D_3	No causality	2.307	0.074*	0.361	0.780
D_4	Natural gas→USEPU	4.424	0.004***	0.896	0.442
D_5	No causality	1.847	0.136	2.081	0.100
D_6	Natural gas↔USEPU	2.836	0.036**	3.082	0.026**
S_6	Natural gas→USEPU	3.298	0.019**	0.805	0.490
Cotton-USEPU					
D_1	Cotton→USEPU	3.337	0.018**	0.641	0.588
D_2	Cotton→USEPU	3.093	0.025**	1.732	0.158
D_3	No causality	1.930	0.122	0.490	0.688
D_4	Cotton→USEPU	2.681	0.045**	1.769	0.150
D_5	Cotton→USEPU	10.267	0.000***	1.280	0.279

(Contd...)

Table 2: ***(Continued)***

Time domain	Result	H0: Commodity futures return does not cause USEPU		H0: USEPU does not cause Commodity futures return	
		F stat	P-value	F stat	P-value
D_6	No causality	0.793	0.497	0.663	0.574
S_6	No causality	0.201	0.895	0.392	0.758
Mentha oil-USEPU					
D_1	No causality	1.589	0.189	2.193	0.086*
D_2	No causality	0.694	0.555	1.357	0.254
D_3	No causality	1.844	0.136	0.059	0.980
D_4	No causality	0.752	0.521	1.536	0.202
D_5	Mentha oil→USEPU	2.713	0.043**	1.362	0.252
D_6	Mentha oil←USEPU	1.783	0.148	2.636	0.048**
S_6	No causality	2.392	0.066*	1.521	0.206

Source: Author's calculations. "↔", "←" and "→" indicate a bidirectional relationship between commodity futures return and USEPU, a unidirectional relationship between USEPU and commodity futures return and a unidirectional relationship between commodity futures return and USEPU at 5% significant level. ***, **, and * significant at 1%, 5%, and 10%, respectively

Table 3: Wavelet granger causality test between commodities futures return and GPR

Time domain	Result	H0: Commodity futures return does not cause GPR		H0: GPR does not cause commodity futures return	
		F stat	P value	F stat	P-value
Zinc-GPR					
D_1	No causality	0.174	0.913	0.404	0.750
D_2	No causality	1.904	0.126	1.032	0.377
D_3	No causality	0.290	0.832	0.309	0.818
D_4	Zinc←GPR	1.400	0.240	2.837	0.036**
D_5	No causality	0.597	0.616	1.820	0.141
D_6	Zinc←GPR	0.212	0.887	6.798	0.000***
S_6	Zinc→GPR	4.008	0.007***	1.129	0.335
Crude oil-GPR					
D_1	No causality	0.461	0.708	1.451	0.226
D_2	No causality	1.481	0.217	1.534	0.203
D_3	No causality	0.350	0.789	0.842	0.470
D_4	No causality	1.551	0.199	2.457	0.061*
D_5	Crude oil↔GPR	2.625	0.048**	3.728	0.010**
D_6	No causality	2.454	0.061*	1.991	0.113
S_6	No causality	0.886	0.447	0.506	0.677
Natural gas-GPR					
D_1	No causality	0.694	0.555	1.460	0.223
D_2	Natural gas↔GPR	3.938	0.008***	2.776	0.039**
D_3	Natural gas←GPR	1.687	0.167	3.884	0.008***
D_4	Natural gas→GPR	3.436	0.016**	1.924	0.123
D_5	Natural gas→GPR	5.528	0.000***	2.381	0.067*
D_6	Natural gas↔GPR	6.033	0.000***	3.466	0.015**
S_6	Natural gas←GPR	0.033	0.991	22.680	0.000***
Cotton-GPR					
D_1	Cotton→GPR	3.483	0.015**	0.663	0.574
D_2	No causality	0.585	0.624	0.887	0.447
D_3	No causality	1.572	0.194	1.145	0.329
D_4	No causality	0.114	0.951	1.854	0.135
D_5	No causality	1.864	0.133	1.865	0.133
D_6	Cotton←GPR	1.369	0.250	3.565	0.013**
S_6	Cotton←GPR	1.483	0.217	5.806	0.000***
Mentha oil-GPR					
D_1	No causality	1.597	0.187	0.167	0.918
D_2	Mentha oil↔GPR	4.322	0.004***	3.709	0.011**
D_3	No causality	2.603	0.050*	0.937	0.421
D_4	No causality	2.540	0.054*	1.712	0.162
D_5	No causality	1.439	0.229	1.577	0.192
D_6	Mentha oil←GPR	2.441	0.062*	4.262	0.005***
S_6	No causality	1.111	0.343	1.942	0.120

"↔", "←" and "→" indicate a bidirectional relationship between commodity futures return and GPR, a unidirectional relationship between GPR and commodity futures return and a unidirectional relationship between commodity futures return and GPR at a 5% significant level. ***, **, and * significant at 1%, 5%, and 10%, level respectively

Figure 3: Wavelet Coherence in pairs of commodity futures returns, US economic policy uncertainty (USEPU), and Geopolitical risk (GPR)

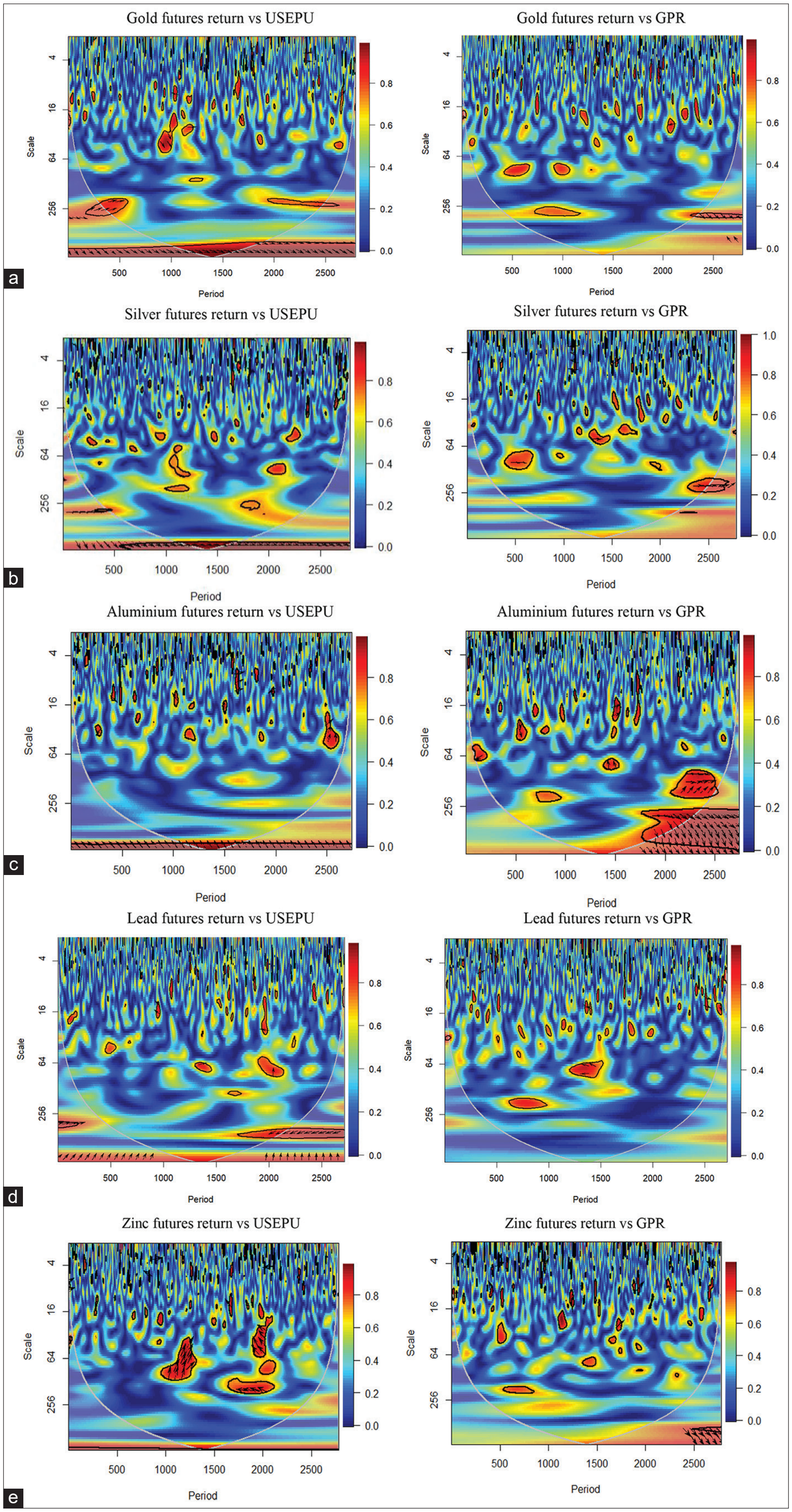
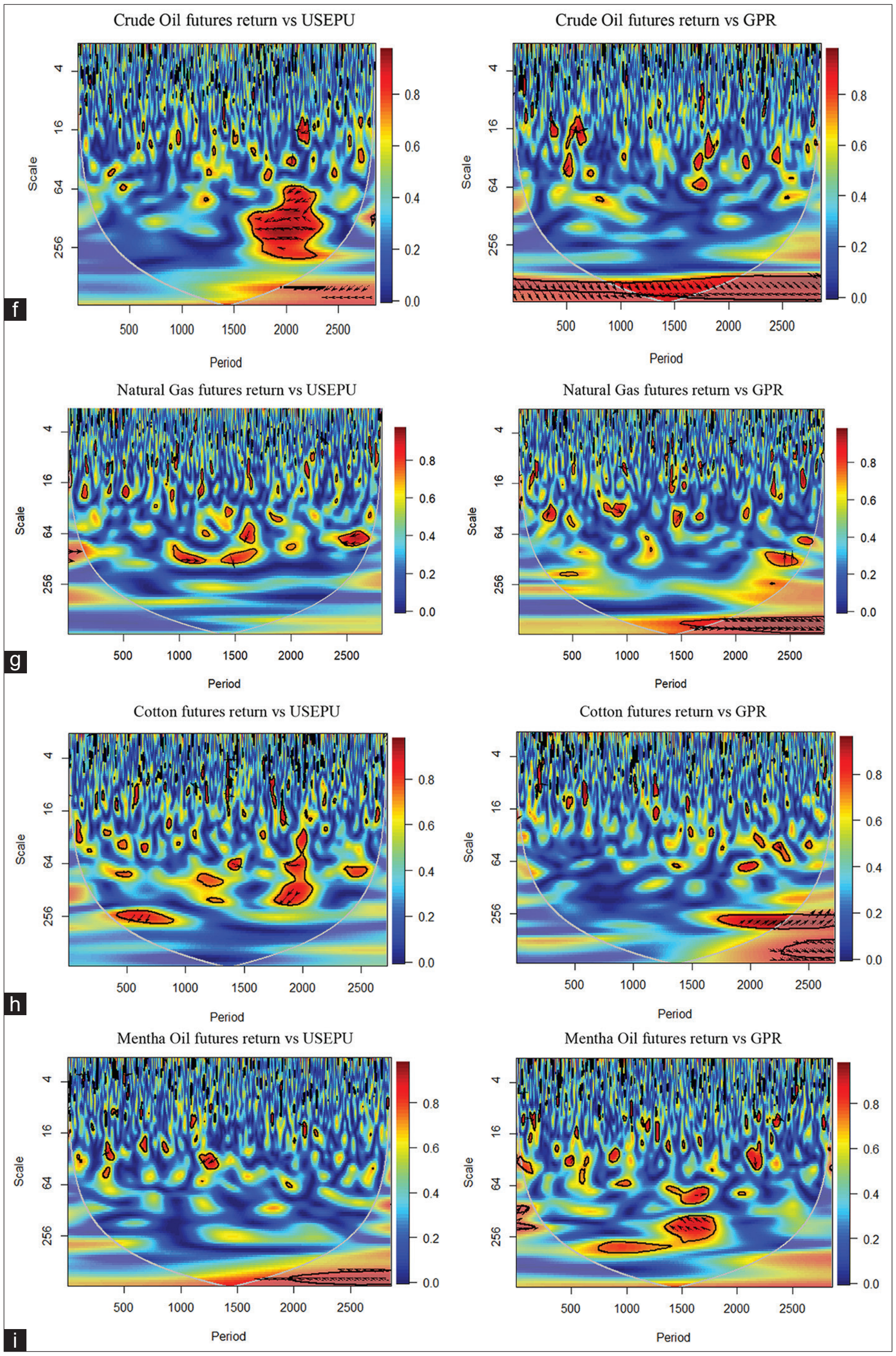


Figure 3: *(Continued)*



5. CONCLUSION

The present study examines the dynamic comovement between Indian commodity futures return and global risk factors such as economic policy uncertainty and geopolitical risk. We consider the daily futures price of nine commodities spanning from 4th January 2012 to 29th September 2023. We employ Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) tests to check the stationarity of the variables used in the study. Next, the study employs wavelet analysis and the Granger causality test to examine the dynamic comovement and causality effects between commodity futures return and global risk factors.

The wavelet power spectrum results show that commodities futures return reveal a high power (see red zones) throughout the study period on a scale ranging from 16 to 64 days and 128 to 256 days. Further, all commodity futures return shows some similarities among them. In addition, all commodity futures return exhibits high power in the short term from January 2012 to July 2015 and the middle of June 2017 to June 2019, besides, low frequency (256 period) over the study period. On the contrary, the wavelet power spectrum exhibits a low scale at upper frequencies over the full sample period. However, the wavelet coherence results show a strong comovement between the US economic policy uncertainty (USEPU) and commodity futures return except for silver and mentha oil. On the contrary, the geopolitical risk (GPR) exhibits a weak relationship with gold, lead, zinc, and energy commodities across all-time frequencies. Further, the wavelet Granger causality test results provide strong evidence that commodities futures return cause the USEPU in all the time horizons. Followed by the geopolitical risk reports substantial evidence that commodities futures return causes GPR in all time horizons.

The study results provide some significant implications for investors, market practitioners, policymakers, fund managers, and other stakeholders who are dealing with the commodities market. The present study considered only the Indian commodity derivatives market, particularly MCX. This study gives the scope for upcoming researchers in several ways for better understanding, a study can be conducted to include other indices. Further, comparative analysis can be undertaken by incorporating other stock exchanges of India as well as of foreign countries.

REFERENCES

Andreasson, P., Bekiros, S., Nguyen, D.K., Uddin, G.S. (2016), Impact of speculation and economic uncertainty on commodity markets. International Review of Financial Analysis, 43, 115-127.

Athari, S.A., Hung, N.T. (2022), Time-frequency return co-movement among asset classes around the COVID-19 outbreak: Portfolio implications. Journal of Economics and Finance, 46(4), 736-756.

Baker, S.R., Bloom, N., Davis, S.J. (2016), Measuring economic policy uncertainty. The Quarterly Journal of Economics, 131(4), 1593-1636.

Balcilar, M., Bonato, M., Demirer, R., Gupta, R. (2018), Geopolitical risks and stock market dynamics of the BRICS. Economic Systems, 42(2), 295-306.

Batabyal, S., Killins, R. (2021), Economic policy uncertainty and stock market returns: Evidence from Canada. The Journal of Economic Asymmetries, 24, e00215.

Bessler, W., Beyenbach, J., Rapp, M.S., Vendrasco, M. (2021), The global financial crisis and stock market migrations: An analysis of family and non-family firms in Germany. International Review of Financial Analysis, 74, 101692.

Bilgili, F., Ünlü, F., Gençoğlu, P., Kuşkaya, S. (2022), Modeling the exchange rate pass-through in Turkey with uncertainty and geopolitical risk: A Markov regime-switching approach. Applied Economic Analysis, 30(88), 52-70.

Bouri, E., Hammoud, R., Abou Kassm, C. (2023), The effect of oil implied volatility and geopolitical risk on GCC stock sectors under various market conditions. Energy Economics, 120, 106617.

Brogaard, J., Detzel, A. (2015), The asset-pricing implications of government economic policy uncertainty. Management Science, 61(1), 3-18.

Caldara, D., Iacoviello, M. (2022), Measuring geopolitical risk. American Economic Review, 112(4), 1194-1225.

Dakhlaoui, I., Aloui, C. (2016), The interactive relationship between the US economic policy uncertainty and BRIC stock markets. International Economics, 146, 141-157.

Das, D., Kumar, S.B. (2018), International economic policy uncertainty and stock prices revisited: Multiple and Partial wavelet approach. Economics Letters, 164, 100-108.

Dehghanzadeh Shahabad, R., Balcilar, M. (2022), Modelling the dynamic interaction between economic policy uncertainty and commodity prices in India: The dynamic autoregressive distributed lag approach. Mathematics, 10(10), 1638.

Demir, E., Ersan, O. (2017), Economic policy uncertainty and cash holdings: Evidence from BRIC countries. Emerging Markets Review, 33, 189-200.

Elliott, G., Rothenberg, T.J., Stock, J.H. (1992), Efficient tests for an autoregressive unit root. Econometrica, 64, 813-836.

Ellis, M.A., Liu, D. (2021), FOMC policy preferences and economic policy uncertainty. Economics Letters, 205, 109937.

Farooq, U., Tabash, M. I., Anagreh, S., Saleh Al-Faryan, M.A. (2022), Economic policy uncertainty and corporate investment: Does quality of governance matter? Cogent Economics and Finance, 10(1), 2157118.

Forbes, K.J., Chinn, M.D. (2004), A decomposition of global linkages in financial markets over time. Review of Economics and Statistics, 86(3), 705-722.

Goupillaud, P., Grossman, A., Morlet, J. (1984), Cycle-octave and related transforms in seismic signal analysis. Geoexploration, 23, 85-102.

Granger, C.W. (1969), Investigating causal relations by econometric models and cross-spectral methods. Econometrica: Journal of the Econometric Society, 37(3), 424-438.

Guizani, M., Talbi, D., Abdalkrim, G. (2023), Economic policy uncertainty, geopolitical risk and cash holdings: Evidence from Saudi Arabia. Arab Gulf Journal of Scientific Research, 41(2), 183-201.

Hamilton, J.D. (1985), Historical causes of postwar oil shocks and recessions. The Energy Journal, 6(1), 97, 116.

Hung, N.T. (2020), Identifying the dynamic connectedness between propane and oil prices: Evidence from wavelet analysis. International Journal of Energy Economics and Policy, 10(5), 315-326.

Hung, N.T. (2022), Time-frequency nexus between globalization, financial development, natural resources and carbon emissions in Vietnam. Economic Change and Restructuring, 55(4), 2293-2315.

IMF DataMapper/Datasets/World Economic Outlook, GDP Per Capita, Current Prices/List. (2022), Analytical Group: European Union, World. International Monetary Fund. https://www.imf.org [Last accessed on 2022 Nov 17].

Jiang, Y., Ao, Z., Mo, B. (2023), The risk spillover between China's economic policy uncertainty and commodity markets: Evidence from frequency spillover and quantile connectedness approaches. The North American Journal of Economics and Finance, 66, 101905.

Jumah, Z., Irshad Younas, Z., Safdar, N., Al-Faryan, M.A.S. (2023), Economic policy uncertainty and corporate leverage-does cash holdings matter? Evidence from the US. Cogent Economics and Finance, 11(1), 2223809.

Kang, W., Ratti, R.A. (2013), Structural oil price shocks and policy uncertainty. Economic Modelling, 35, 314-319.

Kido, Y. (2016), On the link between the US economic policy uncertainty and exchange rates. Economics Letters, 144, 49-52.

Li, H., Li, Y., Guo, L. (2023), Extreme risk spillover effect and dynamic linkages between uncertainty and commodity markets: A comparison between China and America. Resources Policy, 85, 103839.

Li, R., Li, S., Yuan, D., Yu, K. (2020), Does economic policy uncertainty in the US influence stock markets in China and India? Time-frequency evidence. Applied Economics, 52(39), 4300-4316.

Liu, G., Zhang, C. (2020), Economic policy uncertainty and firms' investment and financing decisions in China. China Economic Review, 63, 101279.

Liu, C., Zhang, W., Xie, Q., Wang, C. (2024), Multiscale analysis of the complex interaction between uncertainty and the international commodity market. International Journal of Emerging Markets, 19(9), 2499-2525.

Lyu, Y., Yi, H., Hu, Y., Yang, M. (2021), Economic uncertainty shocks and China's commodity futures returns: A time-varying perspective. Resources Policy, 70, 101979.

Poncela, P., Senra, E., Sierra, L.P. (2014), Common dynamics of nonenergy commodity prices and their relation to uncertainty. Applied Economics, 46(30), 3724-3735.

Rajput, H., Changotra, R., Rajput, P., Gautam, S., Gollakota, A.R., Arora, A.S. (2021), A shock like no other: Coronavirus rattles commodity markets. Environment, Development and Sustainability, 23, 6564-6575.

Schwarz, L.A.D., Dalmácio, F.Z. (2021), The relationship between economic policy uncertainty and corporate leverage: Evidence from Brazil. Finance Research Letters, 40, 101676.

Shaikh, I., Vallabh, P. (2024), Impact of policy uncertainty on gold price in India: Evidence from multi commodity exchange (MCX) India and World Gold Council prices. Applied Economics, 56(32), 3837-3855.

Soni, R.K., Nandan, T., Chatnani, N.N. (2023), Dynamic association of economic policy uncertainty with oil, stock and gold: A wavelet-based approach. Journal of Economic Studies, 50(7), 1501-1525.

Tarik C. Gouhier., Grinsted, A., Simko, V. (2018), R package biwavelet: Conduct Univariate and Bivariate Wavelet Analyses (Version 0.20.17). Available from: https://github.com/tgouhier/biwavelet

Torrence, C., Compo, G.P. (1998), A practical guide to wavelet analysis. Bulletin of the American Meteorological Society, 79(1), 61-78.

Wang, Q., Sun, X. (2017), Crude oil price: Demand, supply, economic activity, economic policy uncertainty and wars-From the perspective of structural equation modelling (SEM). Energy, 133, 483-490.

Xiao, D., Su, J., Ayub, B. (2022), Economic policy uncertainty and commodity market volatility: Implications for economic recovery. Environmental Science and Pollution Research, 29(40), 60662-60673.

Xiao, X., Tian, Q., Hou, S., Li, C. (2019), Economic policy uncertainty and grain futures price volatility: Evidence from China. China Agricultural Economic Review, 11(4), 642-654.

Yin, L. (2016), Does oil price respond to macroeconomic uncertainty? New evidence. Empirical Economics, 51, 921-938.

Yin, L., Han, L. (2014), Macroeconomic uncertainty: Does it matter for commodity prices? Applied Economics Letters, 21(10), 711-716.

Zhang, D., Broadstock, D.C. (2020), Global financial crisis and rising connectedness in the international commodity markets. International Review of Financial Analysis, 68, 101239.

Zhang, G., Han, J., Pan, Z., Huang, H. (2015), Economic policy uncertainty and capital structure choice: Evidence from China. Economic Systems, 39(3), 439-457.

Zhu, H., Huang, R., Wang, N., Hau, L. (2020), Does economic policy uncertainty matter for commodity market in China? Evidence from quantile regression. Applied Economics, 52(21), 2292-2308.