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The Effects of Geopolitical Risks on Oil Price Volatility

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ABSTRACT

This study investigates the short-term and long-term effects of geopolitical risks on the volatility of oil price. Data used in this study are the daily geopolitical risk index, oil price and USD index during the period from January 04, 2010 to December 31, 2022. Using the autoregressive distributed lag (ARDL) bounds testing approach, the empirical results confirm that the geopolitical risks has positive effects on the volatility of oil price in both the long-term and short-term, meaning that a decrease in the geopolitical risk Index is associated with an increase in the volatility of oil price. In addition, the results derived from the ARDL model indicate that USD index has a positive effect on the volatility of oil price in the short-term, but it has no impact on the volatility of oil price in the long-term. Finally, the results of the error correction model confirm that only 2.81% of the disequilibria from the previous trading day is converged and corrected back to the long-run equilibrium in the current trading day.

Keywords: Geopolitical risks, oil price volatility, ARDL
JEL Classifications: C32, F51, Q34, Q41

1. INTRODUCTION

Energy in general and oil in particular is one of most valuable commodities in the world and it has been played a significant role in safeguarding national economic, social development and global economic growth. The global oil price volatility could impact on the economy and inhibit the stability of the financial system, may even lead to systemic risks in global financial markets. Therefore, oil price volatility has been received much attention of policy makers and practitioners in many countries. One of factors that impact on global oil prices and its volatility is geopolitical risks (GPRs). Caldara and Iacoviello (2022) define the GPRs as the risks related to acts of terrorist, tensions and wars between countries. The effects of GPRs on oil price and volatility have attracted considerable attention from scholars over the last decades. However, the findings from empirical studies have not been consensus. Specifically, some studies reported a positive association between GPRs and oil price volatility (Bouoiyour et al., 2019; Li et al., 2020; Lee et al., 2021; Qian et al., 2022; Wu et al., 2023). Contrary to the first group of studies, several studies found a negative impact of GPRs on oil price volatility (Plakandaras et al., 2019; Qin et al., 2020; Cunado et al., 2020; Zhang et al., 2022). The inconsistent findings of previous studies could be due to different methods employed in these studies. It is important to note that previous studies mainly employs ordinary least squares (OLS) and vector autoregression (VAR) to measure the impact of GPRs on oil price volatility. These models have some limitations in estimating the effects of GPRs on oil price volatility (Qin et al., 2020) with time series data.

The aim of this paper is to investigate the effects of GPRs on oil price volatility. The contribution of the paper is to enrich the literature by employing the Autoregressive Distributed Lag (ARDL) model with the extensive database. The prominent advantage of ARDL model over other alternative cointegration methods is that an error correction model (ECM) can be estimated from the ARDL model, hence the short-run and the long-run effects of explanatory variables on the dependent variable can be simultaneously computed. The key hypothesis of this study is that the GPRs have positive effects on oil price volatility in both long-term and short-term. As expected, the findings derived from the ARDL model indicate that the GPRs are positively associated the volatility of oil price. The rest of the paper is organized as follows. Section 2 reviews the empirical literature while Section 3 describes the data sources and methodology used in the study. Section 4 discusses the empirical findings. Finally, conclusions are presented in Section 5.

2. LITERATURE REVIEW

Oil price volatility has been widely considered as one of the main factors explaining economic crisis. Besides the relationship between oil price and macroeconomic and financial variables that has widely been investigated (Barsky and Kilian, 2002; Hamilton, 2003; Kilian, 2009), the impact of GPRs on oil price volatility has also been studied, especially when many political events occurred frequently in recent years. However, the findings from these studies have not been consensus. Some studies empirically support the hypothesis that GPRs lead to increases in oil price volatility. Specifically, Bouoiyour et al. (2019) constructed a composite GPRs indicator by accounting for sources of geopolitical risks, namely global trade tensions, US-China relation risks, US-Iran tensions, Saudi Arabia's uncertainty and Venezuela's crisis. They found that the geopolitical acts generate a positive and strong impact on oil price dynamics. Li et al. (2020) examined the dynamic correlation and causal link between geopolitical factors and crude oil prices based on data from June 1987 to February 2020. Using a time-varying copula approach, they found that the correlation between geopolitical factors and crude oil prices is strong during periods of political tensions. The geopolitical acts index drives the rise in the crude oil prices. In addition, they found unidirectional causality running from geopolitical factors to crude oil prices by using the Granger causality test. Similarly, Lee et al. (2021) employed the newly developed geopolitical threats index to examine whether threats of war, terrorism, ethnic and political violence within and between countries are powerful enough to predict global oil prices volatility. Monthly data on global geopolitical threats index and global prices of crude were drawn upon for causality during the periods from 1990 to 2020. Using various causality methodologies, the results of this study indicate that geopolitical threats has positively impact on oil prices volatility. Moreover, Salisu et al. (2021) reported that GPRs have predictive value for tail risk in the oil market. They found that threats increase tail risk in the oil market with the full monthly data sample for the period from 1916 to 2020. Furthermore, Qian et al. (2022) explored the predictability of GPRs on oil market volatility with the autoregressive Markov-regime switching model and obtained several similar findings. Specifically, the results show that the high GPRs can lead to high fluctuations in oil market. This finding implies that GPRs have a more powerful ability for forecasting oil price volatility during recessions. Recently, Wu et al. (2023) investigated the relationship between GPRs and oil prices across typical oil-importing and oil-exporting countries by applying single-factor and two-factor GARCH-MIDAS-GPR models. They found that GPRs had a significantly positive impact on oil price changes and the GPRs of oil-exporting countries had a stronger effect on the changes in oil prices than that of oil-importing ones.

Contrary to the first category, other studies assert that GPRs have negative effects on oil price volatility. Plakandaras et al. (2019) analyzed the impact of GPRs on oil returns and covariance. They applied news-based indices of global GPRs as well as a composite measure of the same for emerging economies and found that GPRs generally have a significant negative impact on oil returns. Additionally, Qin et al. (2020) investigated the asymmetric effects of GPRs on energy (crude oil, gas and heating oil) returns and volatility under different market conditions during the period from 1990 to 2018. Using a quantile regression model, the results show that GPRs have significantly negative effects on crude oil returns in the bearish market and on heating oil returns in the normal and bullish markets. Besides, Cunado et al. (2020) analyzed the dynamic impact of GPRs on real oil returns for the period February 1974 to August 2017. The results derived from a time-varying parameter structural vector autoregressive (TVP-SVAR) model show that GPRs have significantly negative impact on oil returns due to decline in oil demand. Zhang et al. (2022) detected that the uptrend of GPRs, which disrupt both economic activity and oil production, imposes stronger shocks on future oil demand than on supply, and thus results in a dramatic decrease in oil prices.

From an asymmetric analysis, Ren et al. (2023) used a quantile autoregressive distributed lag (QARDL) approach to examine the nonlinear and asymmetric effect of GPRs on different price quantiles of crude oil prices in China. At high quantiles in the short term, there is a negative direction between the GPRs and the oil price. Besides, the study pointed out that geopolitical risks still are a main factor in debilitating oil prices, but the relationship between geopolitical risks and the oil price was positive in the short term due to market sentiment and other interfering factors. In the long term, the GPRs and the oil price gain an equilibrium relationship. In transmission mechanisms of GPRs to the crude oil prices, Jiao et al. (2023) found that the indirect impact of GPRs on oil price volatility via different transmission paths by using the time-varying parametric vector autoregressive (TVPVAR) model. They pointed out that there were two clear and unique geopolitical transmission paths to enhance energy-related decisions, namely, micro media (supply, demand, inventories, speculative behaviors) and macro media (global economic activities). In particular, influencing economic fluctuations from geopolitical factors is the most influential path to indirectly impact oil prices. In the effect of GPRs spillovers, Zhang et al. (2023) noted that developed countries are net transmitters while emerging countries are relatively net receivers of geopolitical risk. Moreover, the bilateral direction between oil prices and GPRs was explored. In particular, geopolitical tensions and bad oil volatility, extreme GPRs tend to contribute substantially to good oil volatility otherwise.

In summary, the effects of GPRs on oil price and volatility have been found in previous studies. However, empirical findings of the effects of geopolitical risks on oil volatility have been mixed. Some studies reported that the GPRs are positively associated with oil price volatility while other studies confirmed that GPRs have negative effects on oil price volatility. This study enriches the literature by using the ARDL approach to investigate the effects of GPRs on oil prices volatility in the current global context.

3. DATA AND METHODOLOGY

3.1. Data Sources

The data employed in this study are the daily GPRs index, oil price (crude oil WTI) and USD index for the period from January 04, 2010 to December 31, 2022. It is important to note that this study utilizes the geopolitical risks index that was developed by Caldara and Iacoviello (2022). The index is calculated based on selected words regarding to geopolitical risks, which are usually used by journalists when reporting on geopolitical events and threats (Micallef et al., 2023). The GPRs index was normalized to 100 from the points on the base year 2000. Specifically, the data sources are presented in Table 1.

3.2. Methodology

To investigate the effects of GPRs on oil price volatility, the following regression model is employed in this study:

$$VOL_t = \beta_0 + \beta_1 LNGPR_t + LNUSD_t + u_t \quad (1)$$

where:

- VOL: Volatility of oil price that is generated from the GARCH(1,1) model with the following form:

$$OP_t = \alpha_0 + \alpha_1 OP_{t-1} + \varepsilon_t$$

$$h_t = \omega + \delta h_{t-1} + \gamma \varepsilon_{t-1}^2 \quad (2)$$

- OP: Oil price (USD)
- LNGPR: Natural logarithm of the GPR Index
- LNUSD: Natural logarithm of USD Index

To investigate the short-run and long-run effects of GPRs on the volatility of oil price, this study employs the Autoregressive Distributed Lag (ARDL) model which was developed by Pesaran et al. (2001). The ARDL model has some advantages compared to other co-integration methods (Truong et al., 2022). The prominent advantage of this model over other alternative cointegration methods is that an error correction model (ECM) can be estimated from the ARDL model, hence the short-run and the long-run effects of explanatory variables on the dependent variable can be simultaneously computed. In addition, this approach does not require all variables in the model having the same integration order. Instead, it only requires all variables to be integrated of purely order zero, purely order one or a combination of both.

3.3. Unit Root Test

As mentioned above, the ARDL bound test requires that all variables are I(0) or I(1). Therefore, before performing the bounds test, the order of integration of all variables should be examined by using unit root tests. In this study, the widely used ADF (augmented Dickey–Fuller) test is employed to examine whether the studied variables are stationary or not. However, the ADF test may generate biased results if structural breaks exist in time series data (Faisal et al., 2021; Wada, 2022). Therefore, in addition to the ADF test, the Zivot and Andrews (2002) test unit root test with a structural break is applied for the studied variables. The selection of the lag length for these tests are based on the Akaike Information Criterion (AIC).

Table 1: Data sources

Data	Data source
GPR Index	Caldara and Iacoviello's website https://www.matteoiacoviello.com)
Oil price	Investing.com (https://www.investing.com)
USD Index	Investing.com (https://www.investing.com)

3.4. ARDL bound test for cointegration

Before estimating the short-run and long-run effects of GPRs on the volatility of oil price, cointegration tests shoud be performed as a required condition. In order to examine the co-integration between variables, this study employs the bound test. The bound test of co-integration is estimated by the following equation:

$$\Delta VOL_t = \beta_0 + \sum_{i=1}^{q_1} \beta_{1i} \Delta VOL_{t-i} + \sum_{i=0}^{q_2} \beta_{2i} \Delta LNGPR_{t-i} + \sum_{i=0}^{q_3} \beta_{3i} \Delta LNUSD_{t-i} + \delta_1 VOL_{t-1} + \delta_2 LNGPR_{t-1} + \delta_3 LNUSD + \varepsilon_t \quad (3)$$

Δ represents the first difference of the variables. The null hypothesis (H_0) of the bound test is $\delta_1 = \delta_2 = \delta_3 = 0$ (no co-integration in the long-run between variables). If the F-statistic calculated from the bounds test is greater than the critical value of the selected significance level, the null hypothesis is rejected. It means that there is a long-term relationship (co-integration) between the variables in the model. If the long-run equilibrium relationship is confirmed, the short-run and long-run effects of the GPRs on the volatility of oil price are estimated by equation (6) and (7), respectively.

$$\Delta VOL_t = \alpha_0 + \sum_{i=1}^{q_1} \beta_{1i} \Delta VOL_{t-i} + \sum_{i=0}^{q_2} \beta_{2i} \Delta LNGPR_{t-i} + \sum_{i=0}^{q_3} \beta_{3i} \Delta LNUSD_{t-i} + \delta ECM_{t-1} + \varepsilon_t \quad (4)$$

$$VOL_t = \alpha_0 + \sum_{i=1}^{q_1} \beta_{1i} VOL_{t-i} + \sum_{i=0}^{q_2} \beta_{2i} LNGPR_{t-i} + \sum_{i=0}^{q_3} \beta_{3i} LNUSD_{t-i} + \varepsilon_t \quad (5)$$

4. EMPIRICAL RESULTS

4.1. Oil Prices and the GPR Index for the Period from January 2010 to December 2022

On the basis of the collected data, the descriptive statistics of the oil prices and GPR Index for the period from January 04, 2010 to December 31, 2022 are calculated and summarized in Table 2.

Figure 1 illustrates that the trend of the oil price (crude oil WTI) could be divided by three cycles, namely January 01, 2010-January

Table 2: Summary statistics of the oil price and GPR Index (2010-2022)

Variables	Observations	Minimum	Mean	Maximum	Standard deviation
Oil prices	3,357	19.33	77.96	127.98	25.80
GPR Index	3,357	9.49	106.71	542.66	48.04

Figure 1: Oil prices from January 04, 2010 to December 31, 2022

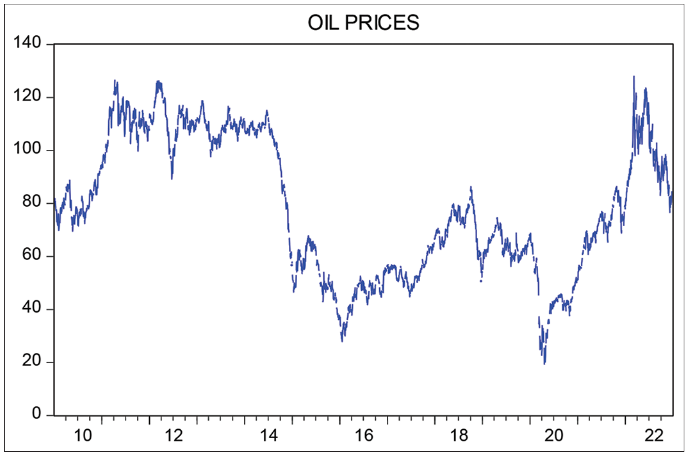
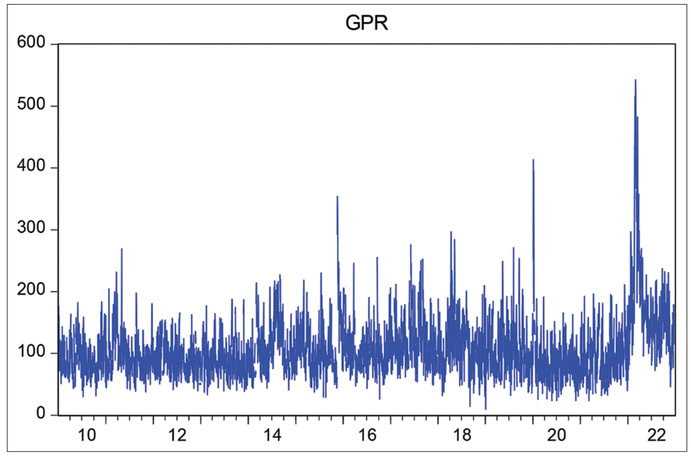


Figure 2: GPR Index from January 04, 2010 to December 31, 2022



20, 2015; January 21, 2016 - March 21, 2020; March 22nd, and 2020 - December 31, 2022. Particularly, the oil price in the first cycle was a dramatic fluctuation from January 01, 2010 to April 01, 2010, reaching a peak of USD 125.89 on April 29, 2011. Then, it rounded a stable level with an average oil price of USD 110 between 2011 and 2004 and dwindled dramatically from USD 114.46 (June 24, 2014) to USD 27.88 (January 20, 2016). In 2015, oil prices declined dramatically due to the decline in the global economy. Moreover, the average oil price in the second cycle was significantly lower than that in the first one. It considerably increased, reaching a peak of USD 85 (October 09, 2018), and then dropping significantly to hit its lowest point of USD 19.32 (April 21, 2020), where this price was the lowest point from 2010 to 2020. In the last cycle, the oil price had a striking rise, reaching a peak of USD 127.89 (March 08, 2022) with the highest price between 2010 to 2022, and the last pattern was a decrease of USD 76.59 (December 08, 2022). The improvement in oil prices from 2020 to 2022 could be due to the global outbreak of COVID-19 in 2020 and the Russia - Ukraine war. Additionally, the trade war between China and the US in recent years has led to global trade instability, extending to the oil market, which remains volatile due to low demand and GPRs.

Additionally, Figure 2 shows that the trend of GPR Index from 2010 to 2022. There was a similar pattern with the oil price fluctuations. In 2013, the Russia-Ukraine war, tension in North Korea, and the Paris terrorist attacks generated a powerful rise in geopolitical risks. Geopolitical risks did not dramatically fluctuate during 2010-2016. In 2017, GPRs increased significantly because of South Korean THAAD (Terminal High Altitude Area Defence) Event. In the period of 2020 to 2022, the pandemic was also accompanied by a sharp rise in global geopolitical risks. In particular, a rapid increase in the GPRs were observed in 2022 due to the Russian invasion of Ukraine.

4.2. Unit Root Tests

As mentioned above, this study employs the ADF test and the Zivot and Andrews (2002) to check whether the variables used in the model have unit roots as a required condition of the ARDL bound test. These tests are conducted for both cases of constant only and constant with time trend. The results of the tests are summarized in Table 3. The results derived from the ADF test reveals that the null hypothesis of a unit root is significantly rejected at 1% level for VOL and LNGPR at the level. In other word, VOL and LNGPR variables are integrated to the order zero denoted as I(0). Besides, the results of the ADF test confirm that LNUSD is non-stationary at the conventional significant level of 5%. However, when the first differences are applied, the null hypothesis of a unit root is significantly rejected for the series, indicating that it is stationary. It means that LNUSD series is integrated of order 1 or I(1). In addition, the results of the Zivot and Andrews (2002) test consistently confirm that all variables in the model are I(0) at the significant level of 5%. With the evidences, it is concluded that all the variables in the model satisfy the requirements of the ARDL bound test.

4.3. ARDL Bound Test for Cointegration

As mentioned above, this study employs the bounds test proposed by Pesaran et al. (2001) to determine the long-run relationship among variables in the model. Based on the Akaike Information Criterion, the best model used for the bounds test is ARDL (4,4,1). The results of the bounds presented in Table 4 indicate that the null hypothesis of no co-integration among variables is rejected at the significant level of 1%. It means that there is a long-run equilibrium relationship between oil price volatility and the regressors. Therefore, it is concluded that the ARDL model can be used to estimate the short-term and long-term effects of GPRs on oil price volatility.

4.4. Short-term and Long-term Effects of GPR on Oil Price Volatility

The short-term and long-term effects of GPR index and USD Index on the volatility of oil price derived from the ARDL model are summarized in Table 5 and Table 6 respectively. In the short-term, the GPRs Index has a contemporaneously positive effect on the volatility of oil price at the significant level of 5%. This finding

Table 3: Results of unit root tests

Variables	ADF test		Zivot and Andrews test	
	Constant	Constant and linear trend	Constant	Constant and linear trend
VOL				
Level	−6.22*** (3)	−6.34*** (3)	−6.95** (3)	−8.38*** (3)
LNGPR				
Level	−11.96*** (5)	−12.33*** (5)	−13.97*** (4)	−15.33*** (4)
LNUSD				
Level	−1.37 (0)	−2.32 (0)	−3.88*** (0)	−3.87*** (0)
First difference	−57.45*** (0)	−57.44*** (5)		

*** and ** represent significance at 1% and 5% levels respectively. The numbers in the parentheses indicate the lag section based on AIC criteria

Table 4: Results of the bounds test

Model	k	F-statistic	Significance level	Critical value	
				Lower bounds I (0)	Upper bounds I (1)
ARDL (4,4,1)	2	19.29***	5%	3.79	4.85
			1%	5.15	6.36

k indicates the number of regressors. *** represents statistically significance at 1% level

Table 5: The estimated short-run coefficients

Variables	Coefficients	t-statistic
$\Delta VOL(-1)$	−0.0539	−3.13***
$\Delta VOL(-2)$	0.0569	3.30***
$\Delta VOL(-3)$	0.0617	3.58***
$\Delta LNGPR$	0.1438	2.16**
$\Delta LNGPR(-1)$	0.0310	0.45
$\Delta LNGPR(-2)$	−0.1107	−1.62
$\Delta LNGPR(-3)$	−0.1055	−1.58
$\Delta LNUSD$	14.9732	2.94***
ECM(−1)	−0.0281	−7.37***

*** and ** indicate significance at 1% and 5% levels respectively

Table 6: The estimated long-run coefficients

Variables	Coefficients	t-statistics
Constant	−15.1036	−0.93
LNGPR	12.9467	4.36***
LNUSD	−4.1835	−0.48

*** indicates significance at 1%

implies that in the short-term an increase in the GPRs Index leads to a contemporaneous increase in the volatility of oil price. In addition, the results reported in Table 5 indicate that USD index has a contemporaneously positive effect on the volatility of oil price at the significant level of 1%. Moreover, the coefficient of error correction for the model is only -0.0281 and significant at the 1% level statistically, implying that only 2.81% of the disequilibria from the previous trading day is converged and corrected back to the long-run equilibrium in the current trading day. This adjustment speed is rather slow meaning that it takes more time to get back the long-run equilibrium after a short-run shock.

In addition to estimating the short-term effect, the ARDL approach also allows for the estimation of the long-term of GPRs on the volatility of oil price. The results of the long-term of GPRs on the volatility of oil price are summarized in Table 5. It is observed that in the long-term, the GPRs have a significantly positive effect on the volatility of oil price at the 1% level. The finding implies that in the long-term the GPRs make the oil price unstabilized. This evidence is consistent with

Table 7: Results of diagnostic tests

Diagnostic test	Statistics	P-value	Conclusions
Autocorrelation (Breusch-Godfrey test) H0: No serial correlation	2.09	0.148	Fail to reject H0
Heteroskedasticity (ARCH test) H0: No ARCH effects	0.07	0.793	Fail to reject H0

the previous findings of (Bouoiyour et al., 2019; Li et al., 2020; Lee et al., 2021; Qian et al., 2022; Wu et al., 2023), but it is contrary to findings of (Plakandaras et al., 2019; Qin et al., 2020; Cunado et al., 2020; Zhang et al., 2022). Moreover, it is found that in the long-run, the value of USD has no effects on the volatility of oil price.

4.5. Diagnostic Tests

To check the validity and reliability of the estimated results, Breach-Godfrey test for serial correlation and ARCH test for heteroscedasticity are used in this study. The results derived from these tests are presented in Table 7. Specifically, the results of Breusch-Godfrey test confirm that that the null hypothesis of no serial correlation in the model can not be rejected at the significance level of 5%. Therefore, it is concluded that serial correlation does not exist among the residuals. In addition, the results derived from the ARCH test reveal that the residuals are homoscedasticity. These diagnostic tests ensure the reliability and validity of the estimated results.

4.6. Structural Stability Tests

It is important to stress that the ARDL model is sensitive to structural breaks and the variables used in this study are also sensitive to global events. To examine the long-term stability of the coefficients in the model, this study employs cumulative sum of the recursive residuals (CUSUM) and the cumulative sum of squared recursive residuals (CUSUMSQ) tests proposed by Brown et al. (1975). It is observed in Figure 3 that the plots of CUSUM lie inside the critical bounds at the 5% level of significance. In addition, Figures 4 shows that the plots of CUSUMSQ are almost within the critical bounds at the significance level of 5%. Therefore, it can be concluded that the model used in the study is stable over the sample period.

Figure 3: Plots of cumulative sum of recursive residuals

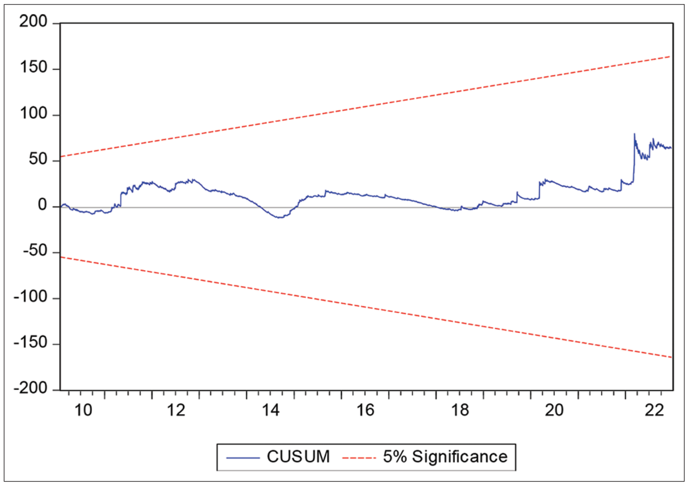
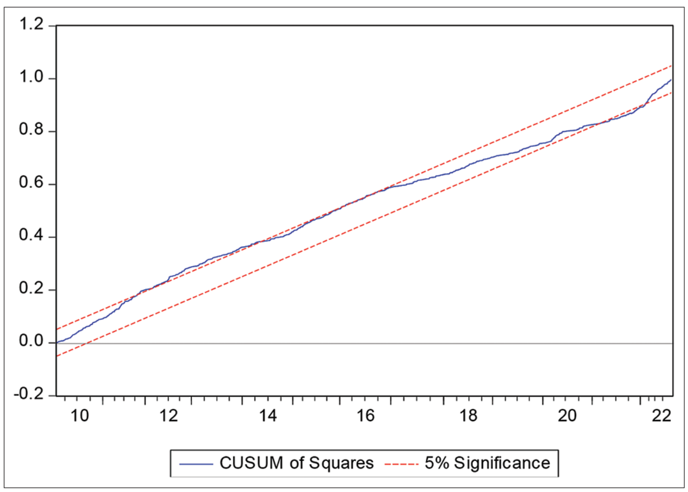


Figure 4: Plots of cumulative sum squares of recursive residuals



5. CONCLUSION

This study empirically determines the short-term and long-term effects of GPRs on the volatility of oil price during the period from January 4, 2010 to December 31, 2022. The empirical findings derived from the ARDL approach confirm that the GPRs have significantly positive effects on the volatility of oil price in both the long-term and short-term. The implication of this evidence is that the oil price are more unstabilized when geopolitics is more risky. Besides, the results reveal that the value of USD (USD index) has a positive effect on the volatility of oil price in the short-term, but it has no impact in the long-term. Finally, the results of the error correction model indicate that only 2.81% of the disequilibria from the previous trading day is converged and corrected back to the long-run equilibrium in the current trading day.

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