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The hedge or safe haven property of gold, cryptocurrency, and clean energy of China and US economies against the changes in oil prices: Evidence from ARDL approach

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Abstract

Using the ARDL technique, this article examines the hedging or safe haven property of gold to oil prices, cryptocurrency, and clean energy in the US and China monthly data from 2013-2018. The findings demonstrate that there are connections between oil, bitcoin, gold, and renewable energy that are both short- and long-term. The investors benefit from this relationship when making hedging decisions. Nonetheless, a negative connection exists between Bitcoin and gold, indicating that the latter might serve as a safe haven for investments. The contradictory findings between the Bound test and the ECM underscore the complexities of analyzing relationships among variables, which might be due to the small sample size. However, legislative support for renewable energy and the choice of technology may be influenced by the effectiveness of clean energy stock markets in the US and China, which can then affect the development of clean energy technology.

Keywords: Gold, Cryptocurrency, Clean Energy, Oil, ARDL

1. Introduction

Around the world, clean energy is acknowledged as a viable substitute for crude oil due to several causes, including climate change, technological advancements in clean energy, the scarcity of fossil fuels, and fluctuating oil prices. Many nations have switched to economies that are resilient to climate change(Rhodes, 2016). To address the increasing demand, however, massive financial expenditures for clean energy projects are needed (Maghyereh et al., 2019). The surge in interest from investors and policymakers has shifted towards a flourishing investment in clean energy companies (Shahzad et al., 2019). On the other hand, clean energy has received much attention due to climate change, resource scarcity, and energy security. Investments in sustainable energy technology have drawn attention throughout the last ten years. These expenses peaked in early 1980 and then started to fall. The business sector often makes investments in ERD&D technologies in developed nations(Gallagher et al., 2006).

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An investment of US$279.8 billion was invested in China in clean energy projects in 2017, resulting in a significant boost to the 157GW energy capacity. This amounted to 10% greater than the previous year's capacity. In a similar vein, during the past few years, renewable energy stock performance has improved(Zhang, 2018). In 2017, China invested at unprecedented levels in renewable energy (Liu, 2019). The country spent $132.6 billion on renewable energy last year, a 24 percent increase over the previous year. Solar accounted for $86.5 billion of that total(Ball, 2019). To prevent power failures, grid imbalances, and environmental problems, major nations, including China, Iran, Russia, Turkey, and Vietnam, have banned Bitcoin mining(Bao et al., 2022). The US is a big supporter of cryptocurrencies, whereas China has restricted them. Nevertheless, in both developed countries, the use of renewable energy has advanced remarkably. Put differently, these two countries take quite different approaches related to Bitcoin, which is why, for practical purposes, the US and China studied in this study.

In this paper, the researcher start by discussing clean energy for the following reasons: **First**, there has been a significant surge in the growth of clean energy throughout the past 20 years. The effectiveness of the clean energy markets affects several energy-related issues, including using energy sources, producing energy from crude oil, and the development of clean energy technology. Clean energy stock markets are said to impact energy consumption, several economic sectors, and the creation of new job possibilities. **Second**, the clean energy stock market impacts dirty energy markets, like crude oil, and it may be used as a hedge against oil stocks due to the strong association between the effectiveness of the capital market and the veracity of pricing information. **Third**, legislative support for renewable energy and the choice of technology may be influenced by the effectiveness of clean energy stock markets, which can then affect the development of clean energy technology. Furthermore, the progress of renewable energy technologies may be impacted by market inefficiencies. As a result, it influences the clean energy stocks' results. In terms of Bitcoin and renewable energy stock markets, there is still little research done. Thus, this gap is addressed. As a result, this study looks into how resilient clean energy is to changes in oil prices, gold, and cryptocurrency.

The volatility and huge increase in the returns of clean energy and cryptocurrencies since their debut attracted participants in the capital market. Bitcoin continues to lead the cryptocurrency in terms of capitalization even as the number of cryptocurrencies rises(Taskinsoy, 2020). Bitcoin, often known as “digital gold”; showed great resilience during the turmoil and global uncertainty of having potential hedging and safe haven characteristics(Selmi et al., 2018). Moreover, bitcoin is used as a hedge for equities and the dollar in an unstable global economy(Dyhrberg, 2016b). Nevertheless, Bitcoin is not a good hedge for developed markets and could only be useful for the restricted advantages of diversification (Bouri et al., 2017; Klein et al., 2018; Smales, 2019). Participants in the financial markets must comprehend the potential of Bitcoin to safeguard themselves against market volatility and a decline in stock returns(Magnuson, 2018).

The volume and value of a wide range of financial products have increased in recent decades. On the other hand, the financial system is now more vulnerable, and investors need more hedge funds or safe havens than before. Moreover, investors typically look for assets that may be utilized to hedge their investments against various risks(Matkovskyy & Jalan, 2019).

Various research, however, addresses the safe haven or hedging characteristics of assets (Bekiros et al., 2017; Cheema et al., 2023; Ji et al., 2020). As a result, during a financial crisis, assets like gold, bitcoin, renewable energy, and oil are employed as safe havens and hedging strategies(Baur & Lucey, 2010). Hedging is defined by Baur and Lucey (2010) as an asset that exhibits inverse relationships with other erratic market items or assets. However, only in periods of market turbulence does a safe haven asset have a negative connection with other market assets. Due to its significant characteristic of being uncorrelated with other asset classes, gold has historically been employed as a hedge against inflation(Baur & Lucey, 2010). Research on these qualities of gold during the COVID-19 pandemic has shown conflicting findings(Cheema et al., 2022; Ji et al., 2020). Investigating these variables' hedging and safe having a property is therefore worthwhile.

Global asset markets show a strong causal link between commodities and financial markets, with opportunity and risk spilling over to other areas. and to make the best investment decisions, investors in commodity assets concentrate on following changes in the prices of stocks and commodities(Choi & Hammoudeh, 2010). Long-run associations may still be tested using the ARDL method framework since there is no need to modify the data. The ARDL approach uses an error correction term to integrate the short-term effects of the given variables with a long-run while preserving long-run information. Furthermore, the optimal leg selection for every variable could be observed. Finally, the ARDL approach yields reliable and consistent findings for small sample sizes, which is advantageous for tiny samples(Alimi, 2014). The ARDL approach examined gold's hedge or safe haven properties.

The global economy is significantly influenced by crude oil, known as the "king of commodities," ever-demanding renewable energy stocks, gold as a refuge during financial crises, and cryptocurrencies like Bitcoin as a hedge and option pricing, portfolio allocation, and hedging methods are all significantly impacted by the volatility of oil prices(Antonakakis et al., 2018).

Three main limitations of the current research are as follows: first, the majority of studies focus only on the relationship between oil prices and stocks of energy; the relationship between clean energy stocks, bitcoin, and oil has not yet been investigated. Second, research has only addressed the distribution's mean and variance, ignoring the left and right tails of the return distribution (Henriques & Sadorsky, 2008; McNeil & Frey, 2000; Suresh et al., 2017). Nonetheless, logical investment choices must consider both the long- and short-term distribution in all of its components. Third, there has not been much discussion of the hedging potential of Bitcoin and renewable energy using gold and oil. As a result, this study looks into the safe haven or hedging characteristic of US and Chinese clean energy equities and the prices of gold, oil, and cryptocurrency.

Section 2 reviews the pertinent literature, Section 3 addresses methodology, Section 4 examines the empirical findings, and then the conclusion.

2- Literature Review

Table 1 below describes the work done in literature

Table 1:. Literature review of selected studies

Source	objective	Remarks
Baur and Lucey (2010)	This study investigates constant and time-varying relationships between US, UK, and German stock, bond, and gold returns to explore using gold as a hedge or safe haven.	They conclude that, on average, gold acts as a hedge against equities and provides a temporary safe haven during volatile stock market situations.
Shakil et al. (2018)	Using the ARDL technique, this study investigates the link between the price of gold in Saudi Arabia and the stock market index, oil prices, exchange rate, interest rate, and CPI.	The findings demonstrate the value of gold as an inflation and portfolio hedge. Adding a specific percentage of gold to a portfolio can lower risk during financial crises.

Source	objective	Remarks
Gokmenoglu and Fazlollahi (2015)	Using the ARDL model, this study examines whether or not the price of gold, oil, gold price volatility, and oil price has a substantial effect on the stock market price index (GSPC)	The long-term link between all variables was discovered to be that the stock market price index converges to its long-term equilibrium level at a daily adjustment speed of 1.2%, with the contribution of the volatilities of the oil and gold markets.
Khelifa et al. (2021)	This study examines the two-way link between the cryptocurrency market and hedge funds in COVID-19. First, the relationship between traditional hedge fund strategies and cryptocurrency hedge funds utilizing VAR and VECM models. Second, the impact of fluctuations in cryptocurrency prices on the prices of cryptocurrency hedge funds through the use of ARDL and ARDL-ECM.	The data demonstrates COVID-19's gravely detrimental effects on hedge funds, reflected in the considerable decline in their valuations. However, throughout this time, there was no impact from the interaction between cryptocurrency and hedge funds.
Asaad (2021).	This study examines the relationships among the price of gold, exchange rates, oil, and stocks on the Iraqi stock exchange during the COVID-19 epidemic.	The results showed that natural gas, gold, and the stock market had asymmetric long-term effects on crude oil. In the short term, however, natural gas is asymmetrically impacted by crude oil. In the short and long term, gold is a significant variable for gas and oil.
Dyhrberg (2016a)	The asymmetric GARCH technique was employed to examine Bitcoin's hedging potential and determine if it qualifies as virtual gold.	The data demonstrates that bitcoin may be used as a short-term hedge against equities and the US currency. Additionally, Bitcoin may be used as a tool to protect against market-specific risk and has the same hedging capabilities as gold.
Baur and Smales (2018)	The gold and the risks of geopolitics on severe financial instability.	It concludes that there is no response to geopolitical risk. The volatility index of the stock market does not account for geopolitical risk.
Sari et al. (2010)	The effect on the price of oil and the value of gold, silver, platinum, palladium, and the US currency relative to the euro was estimated.	Metals discovered a modest long-term equilibrium relationship but a robust short-term feedback relationship. Nonetheless, by investing in precious metals, oil, and the euro, investors may diversify away at least some of the risk.
Stenslås et al. (2019)	Using the Garch Dynamic conditional correlation (DCC) model, they examined the use of Bitcoin as a hedge and diversifier for investors in established and emerging markets and commodities.	The study concludes that bitcoin is useful in developing nations as a hedge, safe haven, and diversifier.
Ewing and Malik (2013)	This study employs daily returns to investigate the volatility of gold and oil futures incorporating structural breakdowns using univariate and bivariate GARCH models.	The conclusion presents compelling evidence of a substantial volatility spillover between oil and gold futures.
Chkili (2016)	This study covers the link between gold and stock markets for the BRICS nations. An asymmetric DCC model was employed to investigate the time-varying correlations between assets.	Weekly data was used to conclude that a portfolio's risk-adjusted return might be increased by including gold.

Source	objective	Remarks
(Broadstock et al., 2012)	The dynamics of global oil prices in China are covered in this research, along with a conditional link using the asset pricing model.	It has been observed that the Chinese stock market is very susceptible to fluctuations in the global stock market. A time-varying conditional correlation model was used to account for both structural instability and the Garch residual.

3. Data and Methodology

This study's data set consists of monthly time series for oil prices, gold prices, bitcoin prices, and clean energy stocks in China and the US. The period covered by the monthly data is 2013 to 2018. The total number of observations is 72.

Data for the Gold price was collected from investing. Com. Bitcoin historical data was acquired from investing.com. China Clean Energy (CCGY) data was collected from NY investing.com. The source of US clean energy was Invesco Wilder Hill Clean Energy ETF (PBW) and crude oil data WIT spot price FOB.

The macroeconomic and stock market variables' short- and long-term relationships are evaluated using the Autoregressive Distributive Lags (ARDL) model. If the series' first difference is (Δyt), the long-term connection could end(Owusu & Odhiambo, 2014).

The following equation defines the ARDL(q,p) model. In this model, yt and xt are dependent and independent variables respectively, and q and p are the corresponding lags. (Garratt et al., 1998; Pesaran et al., 2001).

$$\Delta y_t = \beta_0 + C_0 t + \sum_{i=1}^{q} \varsigma_i \Delta y_{t-i} + \sum_{j=0}^{p} \omega_j \Delta x_{t-j} + \gamma_1 y_{t-1} + \gamma_2 x_{t-1} + \epsilon_t$$

The coefficients β0 and C0 represent the coefficients and εt is the error. The coefficients γ and ωj for all j represent the short-run relationship while the γj, j = 1, 2, ..p represents the relationship for the long run. The final long-run coefficient for x is $-\frac{Y2}{Y1}$.

A few presumptions must be made in the second phase of the ARDL technique, the ECM-term. The F-bound test yields acceptable findings.

$$y_t = \beta_0 + \beta_1 x_t + \varepsilon_t$$

Model specification

UCCEPR=f(gpr, opr, bpr, ccepr) (1)

Where

UCCEPR=US clean energy stock price return

GPR= Gold price return

OPR= Oil price return

BPR= Bitcoin price return

CCPR= China clean energy returns

Each variable is represented by its differenced form, which is obtained by dividing its log forms (CCEPR) by LCCEP/LCCEPt-i. To have a deeper understanding, the variables' natural logarithms are employed.

The ARDL model specification is the relationship of gold, oil, bitcoin, and clean energy can be estimated in equation (2).

$$DCCEPR = \alpha_0 + \sum_{i=0}^{k} b1DUCCPR_{t-i} + \sum_{i=0}^{k} b2DGPR_{t-i} + \sum_{i=0}^{k} b3DOPR_{t-i} + \sum_{i=0}^{k} b4DBPR_{t-i} + \sum_{i=0}^{k} b5DCCEPR_{t-i} + \sigma_1 LUCCEPR_{t-1} + \sigma_2 LGPR_{t-1} + \sigma_3 LOPR_{t-1} + \sigma_4 LBPR_{t-1} + \sigma_5 LCCEPR_{t-1} + \mu_t \quad (2)$$

Where k is used for lag order ARDL–bound testing enables us to analyze both The 1(0) and 1(1) variables together. The FLUCCEPR (LUCCEPR/LGPR, LBPR, LOPR, LCCEPR) and the other variables of equation 2 are denoted as follows:

F_{LGPR}(LGPR/LUCCEPR, LOPR, LBPR, LCCEPR)

F_{LUCCEP}(LLUCCEPR/LGPR, LBPR, LOPR, LCCEPR)

F_{LOPR}(LOPR/LUCCEPR, LGPR, LBPR, LCCEPR)

F_{LBPR}(LBPR/LUCCEPR, LOPR, LGPR, LCCEPR)

F_{LCCEPR}(LCCEPR/LUCCEPR, LGPR, LBPR, LOPR)

These are testing against alternative hypothesis of existence of cointegration.

H0=δ1= δ2= δ3= δ4= δ4= 0

Against:

H1= δ1≠ δ 2≠ δ3 ≠ δ4 ≠ δ5≠ δ 6≠0

Once the presence of a long-term link has been established, the following stage is to determine the ideal lag duration using accepted metrics, such as the Akaike Information (AIC) and Schwarz Bayesian criterion (SBC). The ARDL long-run version is shown in equation 3.

$$LGLDP_t = \alpha_0 + \sum_{i=1}^{k} b1LUCCPR_{t-i} + \sum_{i=0}^{k} b2LGPR_{t-i} + \sum_{i=0}^{k} b3LOPR_{t-i} + \sum_{i=0}^{k} b4LBPR_{t-i} + \sum_{i=0}^{k} b5LCCEPR_{t-i} + \mu_t \quad (3)$$

The error correction term which was used in the ARDL, is shown in Equation 4.

$$DCCEPR = \alpha_0 + \sum_{i=1}^{k} b1DUCCPR_{t-i} + \sum_{i=0}^{k} b2DGPR_{t-i} + \sum_{i=0}^{k} b3DOPR_{t-i} + \sum_{i=0}^{k} b4DBPR_{t-i} + \sum_{i=0}^{k} b5DCCEPR_{t-i} + b6ECT_{t-1} \quad (4)$$

To obtain a stationary variance, all variables underwent a logarithmic transformation. After that, the researcher identifies which variables are stationary to start our empirical testing.

4. Empirical findings

Descriptive statistics summarize the characteristics of a data set in Table 2. The clean energy stocks of the US and oil prices are negatively skewed, while clean energy China, bitcoin, and gold prices are positively skewed. The standard deviation of bitcoin shows high volatility as compared to gold. Gold has the least volatility among all five variables. The leptokurtic tails are found in gold. The Jarque Bera test statistic shows that all price sets in this study follow a non-normal distribution.

Table 3 displays the Pearson Correlation coefficient among the variables discussed. All variables are positively correlated with all other variables except gold. Gold has a negative correlation with Bitcoin; findings are the same as earlier research (Baur & Hoang, 2021; Kyriazis, 2020).

Table 3 displays the association between these five factors. According to the correlation table, there is a negative link between changes in the price of Bitcoin and changes in the price of gold.

Table 2: Descriptive statistics of variables

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Probability
UCCEPR	0.0003	0.0042	0.1567	-0.1533	0.0570	-0.3779	3.6690	3.0141 ***	0.2216
GPR	-0.0040	-0.0079	0.0888	-0.0817	0.0335	0.0382	2.9408	0.0277 ***	0.9862
BPR	0.0765	0.0408	1.2439	-0.6546	0.2872	1.1654	6.4744	51.7828 ***	0.0000
OPR	-0.0093	0.0096	0.1646	-0.2676	0.0880	-0.6992	3.4844	6.4797 ***	0.0392
CCEPR	-0.0266	-0.0642	0.6827	-0.5206	0.2410	0.6500	3.6917	6.4144 ***	0.0405

Note: *** represent level of significance at 1%

Table 3:Correlation Matrix

	UCCEPR	GPR	OPR	BPR	CCEPR
UCCEPR	1				
GPR	0.0123	1			
OPR	0.3974	0.0303	1		
BPR	0.1366	-0.2817	0.0362	1	
CCEPR	0.2298	0.0430	0.0209	0.0825	1

Before estimating the ARDL model, a unit root test was performed to determine how the time series data were integrated. Table 3 presents the results of the traditional Augmented Dickey (ADF) test and the Phillips Perron (PP) test. The unit root tests show that all variables are integrated at 1 (0). Furthermore, the stationarity of the variables increases the suitability of using the ARDL model.

The PP, SPKK, and Augmented Dickey-Fuller (ADF) tests were run. According to the results, all of the variables are stationary at I(0) and I(0). As a result, it is chosen to examine the long-term association between variables using the ARDL approach. The order must be established before moving on to the co-integration test. Still, the method itself determines the unique lag order for every variable. Similarly, we have 72 observation data points and monthly data. This may be seen as a feature of the study's time-series data.

Table 4: F-statistics for testing the existing long-run relationship(Bound Test)

Dependent VARIBLE	F- statistics	Decision
UCCEPR	17.13***	Cointegration
CCEPR	19.51***	Cointegration
GPR	8.47***	Cointegration
OPR	7.62***	Cointegration
BPR	7.61***	Cointegration
Significance	1(O) Bound	1(1) Bound
10%	2.2	3.09
5%	2.56	3.49
2.5%	2.88	3.87
1%	3.29	4.37

Note: The maximum lag length was added to be 4, indicating statistical significance at 1%,5%, and 10%, respectively.

Table 5:The criterion for lag length selection

* Indicates lag order selected by the criterion

ECM(-1)	Coefficient	Standard Error	T-Ratio
DUCCEPR	-1.053601	0.095728	-11.00621*
DCCEPR	-1.236797	0.110030	-11.24058*
DGPR	-0.840214	0.113473	-7.404527*
DOPR	-0.675952	0.096216	-7.025335*
DBPR	-0.687097	0.100848	-6.813207*

There is evidence of co-integration between the clean energy US and gold, as demonstrated by the calculated F-statistic UCCEPR/LGPR, OPR, BPR, and CCEPR = 17.13, which is greater than the upper bound of the critical value found in (Pesaran et al., 2001). The clean energy US (UCCEPR) is the dependent variable. However, the notion of any fictitious association between the variables is ruled out by the presence of the long-term association. Stated otherwise, these factors have a theoretical relationship. The procedure has been replicated for additional variables, and the outcome demonstrates a long-term co-integration between the price of oil, bitcoin, gold, and renewable energy in China.

The results of AIC, SC, and HQ are shown in the table. Different lags can be used for the independent and dependent variables in the ARDL model. As a result, for all kinds of variables in time series, the lag length criteria were AIC, SC, and HQ. A lag length of two is chosen.

A variety of diagnostic statistics tests were run, including the Jarque-Bera, ARCH, Ramsey RESET, Breush-Godfrey LM, and Breusch-Pagan Godfrey tests. Each of these tests was used to evaluate the model's dependability. The results of the Breusch-Godfrey LM test and the Breusch-Pagan-Godfrey test demonstrate that there is no heteroscedasticity in the data and that serial correlations are not an issue. The Ramsey RESET test indicates that the model is appropriately defined, whilst the ARCH test indicates that there is no heteroscedasticity issue.

Table 6:Error- Correction representation for the ARDL approach based on SBC

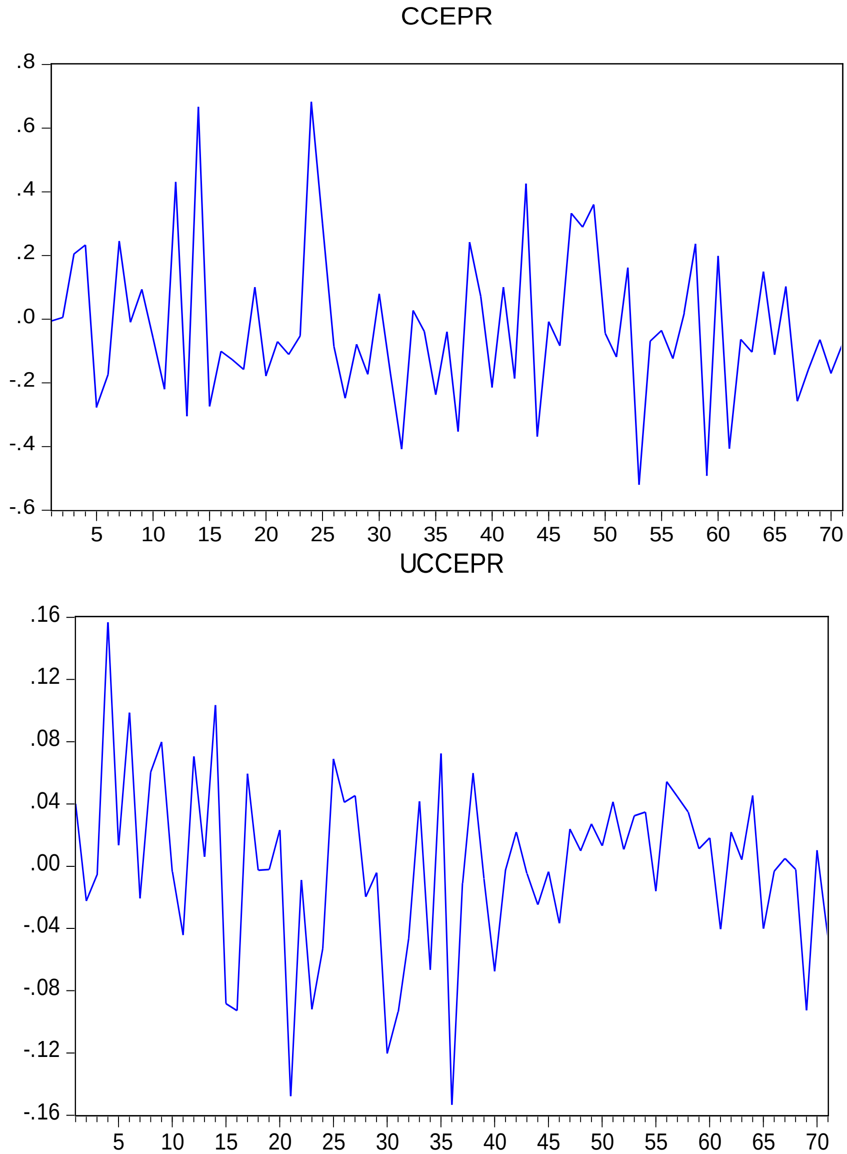
Note: *Denotes significance at the 5% level

Lag	LogL	LR	FPE	AIC	SC	HQ
0	97.61967	NA*	0.003415*	-2.841755*	-2.809115*	-2.828822*
1	97.62498	0.010307	0.003516	-2.812500	-2.747220	-2.786634
2	98.16572	1.033759	0.003564	-2.798992	-2.701072	-2.760193
3	98.19319	0.051713	0.003668	-2.770388	-2.639829	-2.718656

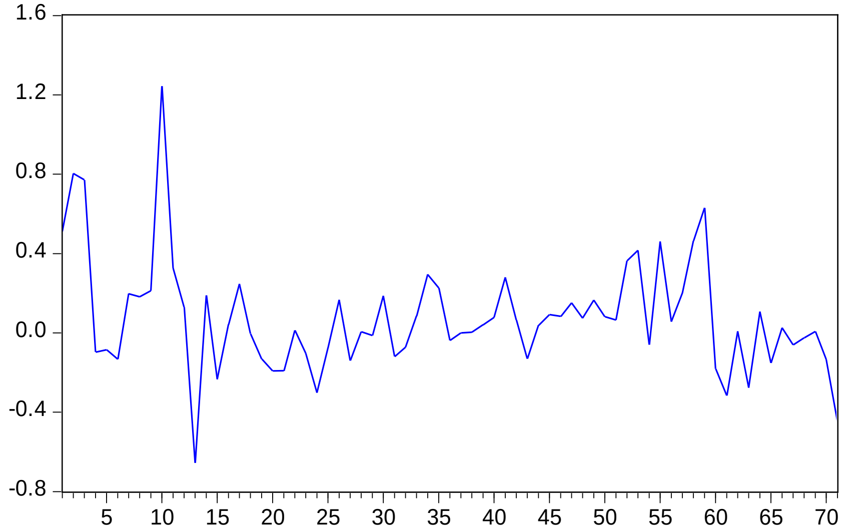
Each variable is extremely significant, has the right sign, and suggests that there has been a medium—to long-term adjustment for equilibrium. The short-term significance of these factors' influence on the dependent variables is shown by the value of the coefficient of variation. VECM displays a clear image of the short—and long-term relationships between the variables. VECM describes the connection but not the variable's relative endogeneity or homogeneity.

Additionally, graphs are included to display the outcomes of each goal. All variables in Fig. 1 have log returns: UCCEPR, CCEPR, GPR, OPR, and BPR. These results demonstrate continuity in log returns, especially Gold, which shows more stability. However, Fig. 2 displays the cosum test graphs. Since there are no structural breaks for any of the variables in this research, the test helps identify structural breaks. A structural break is an unanticipated shift in the parameters of regression models over time that can result in large forecasting mistakes and overall model unreliability(Phiri & Wang, 2022). The red lines show the trend.

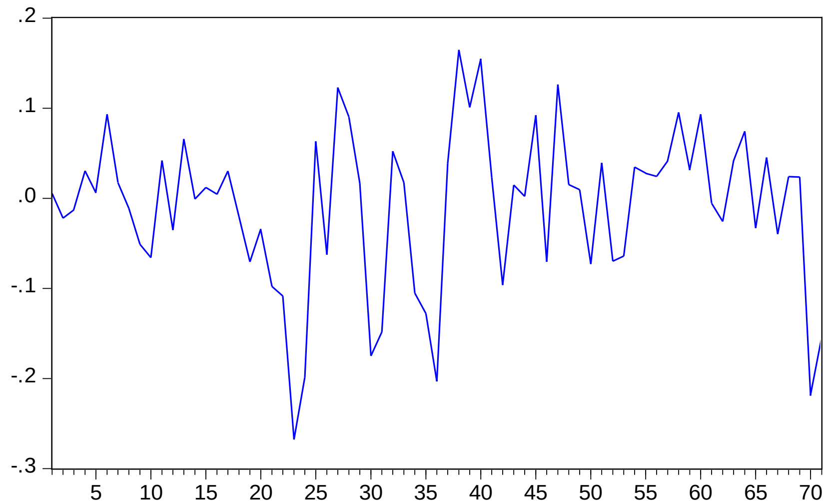
Fig 1
Graph for log returns of variables



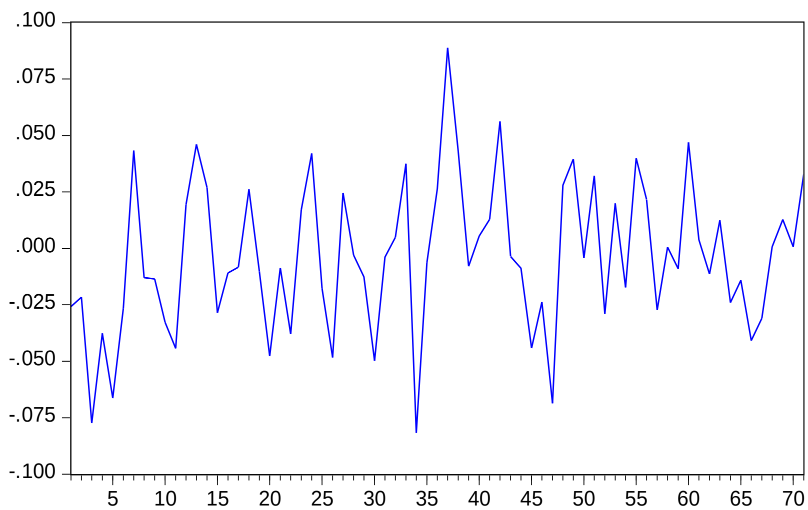
BPR


1.6
1.2
0.8
0.4
0.0
-0.4
-0.8
5 10 15 20 25 30 35 40 45 50 55 60 65 70

OPR


.2
.1
.0
-.1
-.2
-.3
5 10 15 20 25 30 35 40 45 50 55 60 65 70

GPR


.100
.075
.050
.025
.000
-.025
-.050
-.075
-.100
5 10 15 20 25 30 35 40 45 50 55 60 65 70

Fig#2 cusum test

UCCEPR CCEPR

GPR

OPR

5. Conclusion

Using the ARDL technique, this article examines the safe haven or hedging potential between US and Chinese renewable energy sources in the face of volatile oil, gold, and cryptocurrency prices. To verify the stationarity of variables, the unit root test was employed. The results show that gold prices are inversely correlated with bitcoin suggesting that gold might be utilized as a hedge(Selmi et al., 2018). Investors may turn to gold if they believe there is more danger or uncertainty in the bitcoin market as a result of macroeconomic, technical, or regulatory concerns. In contrast, investors may shift more money to Bitcoin and other digital assets during times of optimism or optimistic mood in the cryptocurrency market, which would lower demand for gold. Even while the use of cryptocurrencies is prohibited on China's mainland and cross-border financial flows are strictly regulated, users may use gold as safe haven or hedging(Bao et al., 2022). The Bound test revealed the long-run co-integration of the association between gold, clean energy, and oil. The ECM displays the short-term relationships between each variable as well. These findings contradict each other, as demonstrated by the findings of Eangle-Granger (1987)(Fitri, 2022). It demonstrates that these methods have several drawbacks that call into doubt the methods' resilience (Shakil et al., 2018). The Standard ARDL approach can be used to address the constraints. According to this research, microdata on individual investment decisions may be used to test behavioral finance models and examine their impact on gold prices(Lu et al., 2021). There are several paths that future research in this field might take.

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