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THE DOLLAR AND GOLD: WHICH IS THE SAFEST HAVEN? COVID-19 EVIDENCE

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Abstract. This paper examines the dynamic correlation between the US dollar and gold prices during the coronavirus pandemic to determine which of the two assets is a safer haven from an investor's perspective. The research utilises methods of analysis and synthesis of theoretical knowledge from published articles, literature, and official statistics websites. Data covering the period from January 1, 2020 to May 26, 2021, were primarily collected from the latest versions of these websites. The study includes a quantitative analysis of variables, including the Johansen cointegration test, the Granger causality test, and the error correction model. Our empirical analysis reveals a long-term equilibrium relationship between the US dollar and gold price. There is a one-way inverse causality relationship between the dollar and gold price. The results indicate that gold can be considered the safest haven from the investors' perspective.

Keywords: *Dollar exchange rate; economic crisis; financial crisis; gold price; hedge; safe haven.*

JEL Classification: **F**31, G01, G10, G11, G14, G15

INTRODUCTION

The recent financial crisis resulting from the COVID-19 pandemic has instilled doubt and fear in investors' minds regarding the future of their assets. The simultaneous strengthening of the US dollar and the increase in gold prices suggest their potential as havens against losses in financial markets. The question that arises is which of these assets provides the safest haven. This question warrants a comprehensive study to assess their ability to serve as havens against financial market losses and determine which one is the safest.

A safe haven, whether strong or weak, is defined as an asset that exhibits a negative correlation or is uncorrelated with other assets or portfolios during specific periods (Baur & McDermott, 2010), such as during falling stock markets or in times of market stress or turmoil. The distinguishing factor between these two types of assets lies in the duration of their effects. A hedge is expected to hold on average, whereas a safe haven is only required to hold its value during certain periods, such as financial crises (Baur & McDermott, 2010). A safe haven differs from a hedge, which refers to an asset that is uncorrelated or negatively correlated with another asset or portfolio on average (Baur & Lucey, 2010).

An economic crisis denotes a situation in which a country's economy undergoes a sudden decline in strength, typically resulting from a financial crisis. The economic crisis can manifest as stagflation, recession, or depression (Cazan & Cucos, 2013). On the other hand, a financial crisis is defined as a period characterised by a sharp decline in asset prices, the inability of companies and consumers to repay their debts, and financial institutions facing a liquidity shortage. Often, a financial crisis is associated with a bank panic or a rush to withdraw money from savings accounts due to investors' fear that the value of these assets will decline if kept within a financial institution (Kenton, 2022). Other situations that can be described as a financial crisis include the bursting of a speculative financial bubble, a stock market crash, a sovereign default, or a currency crisis. A financial crisis can be limited to banks or spread to an entire economy, a region, or even global economies (Kenton, 2022).

Our study aims to establish foundations for further discussions on safe havens, as it continues to occupy an increasing space in investors' portfolios. The goal is to provide protection against the volatility of their assets during the COVID-19 crisis and diversify their risks, which plays a crucial role in investors' decision-making. The research focused on investigating the presence of an integration relationship between the price of the dollar and gold, as well as the existence and direction of any causal relationship between them during the coronavirus crisis. The study is structured as follows:

- The first section comprehensively reviews the existing literature on the subject.
- The second section presents the empirical model used in the study, which examines the characteristics of the time series and conducts cointegration tests. This section also includes the empirical analysis and a detailed discussion of the results.
- Finally, in Section 3, the study concludes, summarising the key findings and implications drawn from the research.

1. LITERATURE REVIEW

Evidence of the potential for gold to act as a safe haven asset was presented by Baur and Lucey (2010). Their results show that gold tends to hold its value if stock markets experience extremely negative returns in Germany, the UK and the US (Baur & Lucey, 2010). After examining a sample spanning 30 years from 1979 to 2009, they found that gold is a hedge and a safe haven for major European and United States stock markets. However, it does not play this role for Australia, Canada, Japan and the large emerging markets such as the BRIC countries. They also differentiated between the weak and strong forms of safe haven. Looking at specific crisis periods, they find that gold was a solid safe haven for most developed markets during the height of the recent financial crisis (Baur & McDermott, 2010). Ciner, Gurdgiev, & Lucey investigated five major classes of financial assets. They examined how and under what circumstances each might act as a hedge or a safe haven for the others. They found, in line with traditional investment strategies, that gold acts as a safe haven for most assets, with the exception of oil. They also found that bonds do not appear to be a long-term hedge against stock price movements but act as a safe haven for stocks (Ciner, Gurdgiev, & Lucey, 2012).

Regarding the safe haven property and its role in financial markets, Ranaldo and Söderlind (2010) studied high-frequency exchange rates from 1993–2008. They proved evidence that the Swiss franc and the Japanese yen tend to rise against the US dollar when US stock prices fall, US bond prices increase, and foreign exchange volatility rises. This materialises at different intervals, from a few hours to several days. The latter effects were particularly evident for the yen during the 2008 crisis (Söderlind, 2010).

Based on empirical results, Hossfeld and MacDonald concluded that the Swiss franc and the US dollar can be described as safe haven currencies. Meanwhile, the yen's rally in crisis appears to be mainly due to the unwinding of carry trades. As for the euro, the results do not indicate any significant reaction to a particular crisis (Hossfeld & MacDonald, 2014).

Bouri, et al. (2019) in their study found that gold and crude oil are not strong safe-haven assets for clean energy indicators. However, crude oil shows superiority over gold during extreme market movements. On the other hand, a study by Ji, Zhang, & Zhao (2020) found that assets' safe-haven role has become less effective for most studied assets. However, future contracts for gold and soybean are still considered safe-haven assets during the COVID-19 pandemic. Additionally, a study by Cho & Han (2021) revealed that the effects of different shocks on safe-haven currencies are asymmetric, with the Japanese yen being the strongest safe-haven currency, followed by the Swiss franc and the euro. A study by Akhtaruzzaman, Boubaker, Lucey, & Sensoy (2021) explored the role of gold as a hedging asset or safe haven during different stages of the COVID-19 pandemic. The results indicate that gold was considered a safe haven for stock markets in the early stage of the pandemic but lost its role in the second stage. The costs of hedging significantly increased during the second stage. Furthermore, the results of a study by Bokhtiar, Kabir, & Mamunur (2021) showed that silver and Islamic stock indices were safe havens during the global stock crisis of 2008 and the COVID-19 pandemic. The complementary analysis also indicated that gold and Bitcoin still exhibit safe-haven behaviour during sharp market contractions, implying that safe-haven assets may vary over time.

A study by Smales (2019) concluded that Bitcoin is not a safe haven, as it is more volatile, less liquid, and more costly in transactions compared to other assets, even in normal market conditions. Additionally, an article by Wang, Wei, Zhang, & Liu (2023) indicated that gold maintains its strong safe-haven role for oil contracts over different time periods before and after the COVID-19 pandemic. However, Bitcoin has a weak impact as a safe haven in the short-term oil market.

Furthermore, an article by Nedved & Kristoufek (2023) highlighted that gold is consistently the safest and most secure safe haven for Bitcoin, while oil occasionally exhibits safe-haven characteristics, and stocks do not show any safe haven properties. The results of an article by Wen, Tong, & Ren (2022) suggested that gold is the best safe haven for both the oil and stock markets during the COVID-19 pandemic, while Bitcoin does not exhibit safe-haven characteristics.

A study by Disli et al., 2021 indicated that gold, oil, and Bitcoin did not demonstrate safe-haven properties for traditional, sustainable, and Islamic investor stocks during the COVID-19 pandemic. However, in the long run, investors can diversify using gold, oil, and Bitcoin. Moreover, an article by Long, et al., 2021 used the NARDL model to analyse the performance of Bitcoin and gold under the influence of various uncertainty factors. The results indicate that Bitcoin is not a strong safe haven and cannot cope with uncertainty, while gold can hedge against uncertainty to varying degrees. Additionally, an article by Conlon, Corbet, & McGee (2020) found that Bitcoin, Ethereum, and Tether are not safe havens for most of the examined international stock markets during the COVID-19 pandemic.

Our study focuses on a unique aspect compared to other studies, exploring which of gold and the dollar is the safest haven during the COVID-19 pandemic. This finding assists policymakers and global investors choose a secure haven for their financial portfolios.

2. EMPIRICAL MODEL

2.1. Studying the nature of time series

It is necessary to investigate the characteristics of the time series used to estimate any standard model or relationship, such as the error correction model in the short term, or the simultaneous integration relationship in the long term. The investigation is accomplished through a descriptive study of the series data in addition to the study of its stability.

2.1.1. Descriptive study of time series data

The US dollar exchange rate series (USD)

We symbolise the daily series of the US dollar exchange rate with respect to the euro as usd_t. This series consists of 366 observations from January 1, 2020 until May 26, 2021. Figure 1 shows the curve of the usd_t series data.

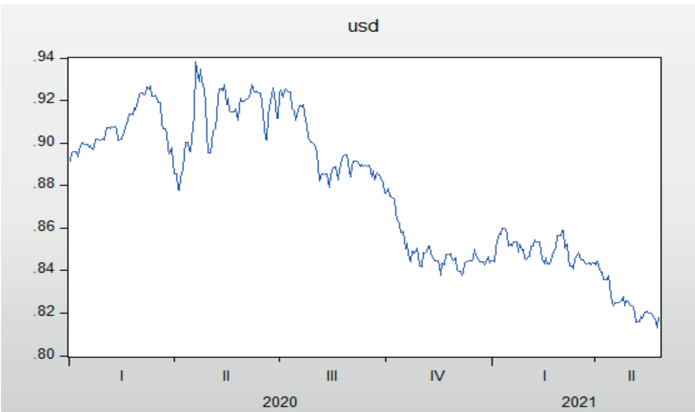


Fig. 1. Curve of the US dollar exchange rate (usd) (Exchange Rates UK, 2022).

The series has an arithmetic mean of (0.876997) and a standard deviation of (0.033891). The standard deviation gives us an idea of the dispersion of values around the mean. The series recorded a maximum value (0.938300) on April 20, 2020, and a minimum value of (0.813000) on May 25, 2021. These two values represent the highest and lowest exchange rates observed for the dollar during the study period. The usd curve exhibits significant fluctuations in the series of the US dollar exchange rate. It initially showed a positive upward trend at the beginning of the period until June 30, 2020, coinciding with the rapid spread of the new Coronavirus. This pandemic led to global quarantine measures and mandated people to stay at home. This resulted in reduced work across all sectors and created uncertainty in the financial market regarding the future of companies. As a result, investors sought safe havens to protect their wealth, and the US dollar, one such safe haven, experienced an increase in its value against the euro during this period.

The trend then changed, and from approximately July 22, 2020, the USD exchange rates started fluctuating within the range of 0.94 and 0.84 euros per dollar, showing a negative slope. From October 21, 2020, the series exhibited a fluctuating decline until the end of the study period. This can be attributed to the gradual lifting of quarantine measures and a gradual return to normalcy.

The fluctuation in the overall slope of the usd_t series implies that it contains a general trend component. Therefore, the stability of this series is closely related to the removal of this component.

The gold price series data (xau*)*

The symbol representing the daily price series of gold is denoted xau. The series consists of 366 observations, from January 1, 2020, to May 25, 2021. Figure 2 shows the curve of the xau_t series data. The series has an arithmetic mean of (1806.80) and a standard deviation of (125.7075). The standard deviation indicates the dispersion of values around the mean value of the series. The series recorded a maximum value (2115.20) on August 6, 2020, and a minimum (1494.60) on March 18, 2020. These two values represent the most significant increase and decrease in the price of gold observed during the study period.

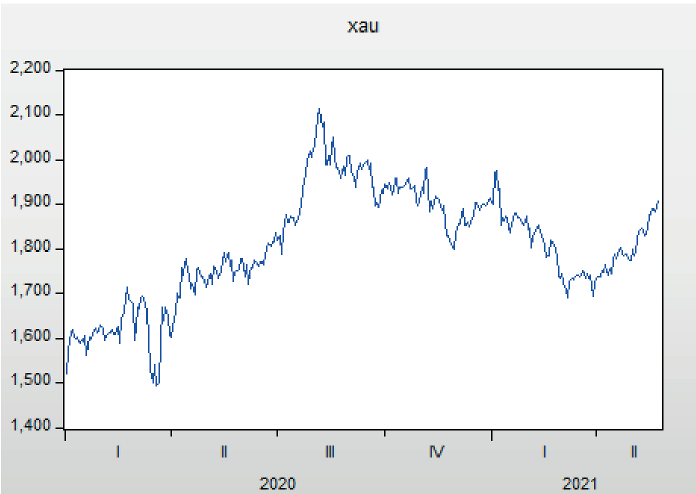


Fig. 2. Gold price curve xau_t (KITCO, 2022).

The curve of $\mathrm{xau_t}$ series shows an initial positive slope with increasing rates from the beginning of the study period until August 6, 2020. This was followed by a change to a slow negative slope, which was quickly followed by another positive slope. This behaviour suggests that there was an increasing demand from investors for gold as a safe haven during the COVID-19 pandemic. The price of gold gradually increased throughout the study period, nearly doubling its initial value.

Although there was a relative decline in the price towards the end of the period due to the lifting of quarantine measures and the gradual return to normal life, the price of gold remained significantly higher than at the beginning of the period. The fluctuation in the overall slope of the $\mathrm{xau_t}$ series indicates the presence of a general trend component. Therefore, this series's stability is associated with removing this trend component.

2.1.2. Study of stationary time series

The series is considered stable if it oscillates around a fixed mean, with variance unrelated to time (Hasan et al., 2021). In general, it is very difficult to determine the nature and stability of a time series by simply examining its graph. In the absence of stability, the apparent regression observed in the time series values can often be misleading. Therefore, it is essential to employ statistical data analysis to test the stability and uncover trends in the time series.

The instability of a time series variable is often attributed to the presence of a unit root. Therefore, it is necessary to perform unit root tests on the time series data to determine their stability and degree of integration. There are several unit root tests available, but we will use the two most common ones: the augmented Dickey–Fuller test (ADF) (Dickey & Fuller, 1979) and the Phillips–Perron test (PP) (Phillips & Perron, 1988). Table 1 presents the results of the ADF and PP tests for the "lusd"and "lxau" [*]series, with a lag order of *P*.

Table 1. Unit Root Testing for Time Series

		lxau					**lusd**				
Test type		ADF			**PP**		**ADF**			**PP**	
		P	t-Stat	prob	t-Stat	prob	*P*	t-Stat	prob	t-Stat	prob
Original series	**(1)**	8	1.00	0.91	1.08	0.92	6	1.07	0.92	0.87	0.88
	(2)	8	−1.84	0.35	−2.29	0.14	6	−0.30	0.92	−0.52	0.88
	(3)	8	−1.69	0.75	−2.24	0.46	6	−2.65	0.25	−3.03	0.12
The first difference series	**(1)**	7	−10.07	0.00	−20.45	0.00	5	−7.72	0.00	−16.26	0.00
	(2)	7	−10.13	0.00	−20.48	0.00	5	−7.82	0.00	−16.27	0.00
	(3)	7	−10.12	0.00	−20.51	0.00	5	−7.75	0.00	−16.24	0.00
The decision		lxau (I)					lusd(I)				

Note: Augmented Dickey–Fuller test: The degree of slowing was selected according to the automatic selection using the Akaike method (Akaike, 1974) Phillips–Perron test:

delay degree $l = 4\left(\frac{366}{100}\right)^{\frac{2}{9}} \approx 5$

Source: Prepared by the researchers based on EViews 10 outputs.

[*] lusd and lxau are symbols representing the time series for the dollar and gold, respectively, where: $\mathrm{lusd} = \log(\mathrm{usd})$, $\mathrm{lxau} = \log(\mathrm{xau})$.

The results, presented in the table clearly indicate that both the “lusd” and “lxau” series are unstable and contain unit roots. This is evident from the calculated test statistics, which are significantly lower than the critical values of MacKinnon at the 5 % significance level in absolute value.

In Table 1, it is clearly seen that the p-values of three-unit root tests are less than 0.05 signalising about rejection of the null hypothesis of a unit root. Thus, the first-order differenced time series can be considered stationary while the raw time series are non-stationary (p-value > 0.05).

2.2. Cointegration Test

2.2.1. Johansen's Cointegration Test

Johansen's test is more comprehensive than the methodology applied in the Engle–Granger test. In the long run, it allows the determination of the number of equilibrium relations among several integrated variables of the same degree. Most importantly, the test reveals whether there is a unique co-integration (Bourbonnais, 2012, p. 210).

The test involves estimating the vector autoregressive model (VAR) using the maximum likelihood function, assuming the presence of *P* economic variables in the autoregressive vector of degree *K*. The number of cointegrations can be determined using the trace test or the maximum eigenvalue test. The number of cointegration vectors can be determined by comparing the likelihood ratios to the critical values. The trace is calculated using the following relationship (Bourbonnais & Terraza, 2016):

$$\lambda_{\text{trace}}(r) = -n \sum_{i=r+1}^{K} \ln(1 - \lambda_i), \quad (1)$$

where

λ_i – eigenvalues;

K – number of variables;

r – matrix order.

The Johansen test is as follows (Bourbonnais, 2012, p. 210):

- The order of the matrix π is set to zero ($r = 0$), representing the null hypothesis H_0: $r = 0$, against the alternative hypothesis H_1: $r > 0$. We reject H_0 if the value of λ_{trace} exceeds the critical value of Johansen–Juselius and then proceed to the next test.
- The matrix order is set to π equals one ($r = 1$), corresponding to the null hypothesis H_0: $r = 1$, and the alternative hypothesis H_1: $r > 1$. We reject H_0 if the value of λ_{trace} is greater than the critical value of Johansen–Juselius and proceed to the next test.

The optimal number of lag periods (P) for the VAR model must be determined to perform this test. This can be achieved by selecting the minimum value based on the Hannan–Quinn and Schwarz criteria. The following table illustrates the lag periods.

Table 2. Determining Slowdown Periods

Degree of delay	01	02	03	04	05	06	07	08
Akaike	–13.93	–13.94*	–13.92	–13.91	–13.92	–13.91	–13.92	–13.93

Source: Prepared by the researchers based on EViews 10 outputs.

From the table, we have chosen a lag period of P = 2 as the optimal number of lag periods based on the Hannan–Quinn and Schwarz criteria. With the lag period determined, we can proceed to apply the Johansen method of cointegration. We get the results presented in Table 3.

Table 3. Johansen's Cointegration Test

Unrestricted cointegration rank test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace statistic	0.05 critical value	Prob.**
None * at most 1	0.370102 0.041728	30.28924 2.557426	15.49471 3.841466	0.0002 0.1098
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level *denotes rejection of the hypothesis at the 0.05 level **MacKinnon–Haug–Michelis (1999) p-values Unrestricted cointegration rank test (maximum eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max-eigen statistic	0.05 critical value	Prob.**
None* At most 1	0.370102 0.041728	27.73181 2.557426	14.26460 3.841466	0.0002 0.1098
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level				

Source: Based on EViews 10 outputs.

Table 3 displays the results of the trace test. Based on these results, it is possible to accept the alternative hypothesis ($r = 0$), indicating the presence of co-integration between the US dollar exchange rate and the gold price at a significance level of 5 %. This is supported by the observation that the calculated trace value λ_{trace} exceeds the critical values, and the critical probability of 0.0002 is smaller than the specified significance level of 0.05.

The aforementioned findings indicate a long-term equilibrium relationship between the US dollar exchange rate and the price of gold. This conclusion is further reinforced by the maximum likelihood test, which suggests that the two variables do not deviate significantly from each other in the long run, indicating a strong connection between the dollar exchange rate and gold price. Typically, when the dollar exchange rate decreases, the demand for gold tends to increase, leading to an upward movement in gold prices. This behaviour signifies that investors often prefer to hold gold rather than the dollar during times of crisis.

Table 4, which displays a simple correlation matrix, further supports the inverse relationship between the US dollar exchange rate and the gold price.

Table 4. Simple Correlation Matrix

	lusd	***lxau***
lusd	1	–0.3284
lxau	–0.3284	1

Source: Prepared by the researchers based on EViews 10 outputs.

The correlation matrix provided in the table indicates an inverse relationship between the exchange rate of the US dollar and the price of gold. This implies that when the price of gold increases, the US dollar exchange rate tends to decrease. Conversely, during times of increased demand for safe investments or when there is a need for a safe haven, the demand for gold may rise, increasing its price.

The inverse relationship between the US dollar exchange rate and the price of gold aligns with common market dynamics. As the value of the US dollar weakens, it becomes relatively more expensive to purchase gold, which can result in an increase in gold prices. Conversely, during periods of economic uncertainty or when investors seek safe-haven assets, the demand for gold typically rises, leading to an upward movement in its price.

2.2.2. Causality test between the US dollar exchange rate and the gold price

The Granger test of causality is a statistical concept based on prediction. It aims to demonstrate the predictive usefulness of one variable, denoted as y_{1t}, in forecasting another variable, denoted as y_{2t}. The test determines whether y_{1t} can be considered a cause of y_{2t} $(y_{1t} \rightarrow y_{2t})$ by evaluating if including the past values of y_{1t} in addition to the past values of y_{2t} improves the prediction of y_{2t} compared to using only its own past values.

Conversely, the test also examines whether y_{2t} can be considered a cause of y_{1t} $(y_{2t} \rightarrow y_{1t})$ by evaluating if including the past values of y_{2t}, along with the past values of y_{1t}, enhances the prediction of y_{1t} compared to using only its own past values. The Granger test assesses the predictive power of one variable on another and provides insights into the existence and direction of causal relationships.

According to Granger, the absence of cointegration between two variables suggests the lack of a causal relationship between them (Seth, 2007). In other words, if the variables are not cointegrated, it implies that one variable does not influence the other in a causal manner.

To conduct the Granger causality test, a two-way VAR (Vector Autoregressive) model is estimated to describe the behaviour of the two variables. Additionally, it is important to use the variables in their stable form to ensure accurate estimation. Lack of stability may lead to misleading regression results (Bourbonnais, 2015). Table 5 displays the results obtained using EViews.

Table 5. Granger Causality Test Results

Null hypotheses	Obs	F-Statistic	Prob.
dlxau does not Granger cause dlusd	363	6.47164	0.0243
dlusd does not Granger cause dlxau		1.26204	0.2843

Source: EViews 10 outputs.

Conclusions from the above table are as follows:

✓ $dlxau$ and $dlusd$

Since the critical probability value is 0.02, which is less than 5 %, we accept the alternative hypothesis that the price of gold affects the exchange rate of the dollar, meaning that changes in the price of gold lead to changes in the exchange rate of the dollar.

Accordingly, whenever the demand for gold increases, it is followed by a decrease in the dollar exchange rate. This observation can be explained by the fact that investors exchange their wealth from dollars to gold in the market during crises.

Therefore, we conclude that investors consider gold a safer haven for their wealth instead of keeping the US dollars.

✓ $dlusd$ and $dlxau$

Since the value of the critical probability is 0.28, greater than 5 %, we accept the null hypothesis that changes in the dollar exchange rate do not cause changes in the price of gold.

Consequently, the change in the dollar exchange rate does not affect the price of gold. The fluctuations in the dollar exchange rate are not linked to the selling of gold during crises.

Other factors actually cause them. Therefore, during market crises, there is no evidence that investors sell gold to acquire US dollars, which indicates that investors do not consider dollars as a safer haven than gold.

Based on the discussion above, we can assert the following:

1. A change in the price of gold causes a change in the dollar exchange rate, indicating a one-way causal relationship between the two variables. However, a change in the dollar exchange rate does not cause a change in the price of gold.
2. The relationship between the dollar exchange rate and the gold price is long-term, as evidenced by the period from January 1, 2020, to May 26, 2021. This finding supports the results obtained through the joint integration method of Johansen.
3. Generally, evidence suggests that investors consider possessing gold as a safer haven during times of crisis compared to holding the US dollar.

2.3. Error correction model

2.3.1. Estimating error correction model

After confirming the existence of a long-term co-integration relationship between the dollar exchange rate and the gold price and ascertaining the presence of a causal relationship from the gold price to the dollar exchange rate through the

Granger causality test and the results of the Johansen test, we can proceed with formulating the error correction model (ECM) (Golic, 2005), (Greene, 2000). Table 6 shows the results estimated by the ECM model.

Table 6. VECM Estimation Results

Cointegrating Eq:	**CointEq1**	
DLUSD(–1)	1.000000	
DLXAU(–1)	0.806139 (0.07645) [10.5442]	
c	–0.000126	
Error Correction:	D(DLUSD)	D(DLXAU)
CointEq1	–0.121561 (0.03851) [–3.15677]	–1.119382 (0.11029) [–10.1491]
D(DLUSD(–1))	–0.499409 (0.05717) [–8.73621]	0.565132 (0.16373) [3.45157]
D(DLUSD(–2))	–0.240301 (0.05229) [–4.59587]	0.377823 (0.14976) [2.52289]
D(DLXAU(–1))	0.089090 (0.02584) [3.44739]	–0.119901 (0.07402) [–1.61988]
D(DLXAU(–2))	0.059118 (0.01817) [3.25349]	–0.040836 (0.05204) [–0.78463]
c	1.45E-05 (0.00024) [0.05976]	–1.54E-05 (0.00070) [–0.02217]
R-squared	0.300262	0.513732
Adj. R-squared	0.290435	0.506902
Sum sq. resids	0.007620	0.062509
S.E. equation	0.004626	0.013251
F-statistic	30.55241	75.22130
Log likelihood	1435.470	1054.543
Akaike AIC	–7.897625	–5.793057
Schwarz SC	–7.833123	–5.728555
Mean dependent	1.90E-05	–2.42E-05
S.D. dependent	0.005492	0.018870

Source: EViews 10 outputs.

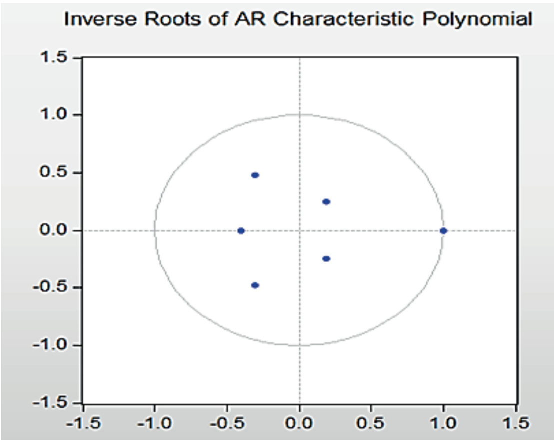
The Table 6 shows that the coefficient of error correction (cointEq1) is negative and statistically significant at a 5 % level, with a value of 0.121561. This low value indicates that the actual deviation from the equilibrium between the variables is corrected by 12.1561 % every day. This implies that short-term errors are gradually corrected over time, leading to the achievement of long-term equilibrium.

2.3.2. Form Validity Test

Unit root test

In general, the ECM model can be considered stable if all the unit root coefficients are less than or equal to one, or if all the reciprocals of the unit roots of the polynomial are within the unit circle. This indicates that the model does not suffer from the issue of correlated errors or instability of the variance.

Figure 3 and the accompanying table represent the results of the stability test obtained using the ECM model.



Root	Modulus
1.000000	1.000000
–0.303706 – 0.482837i	0.570411
–0.303706 + 0.482837i	0.570411
–0.405956	0.405956
0.185060 – 0.246099i	0.307916
0.185060 + 0.246099i	0.307916
VEC specification imposes 1 unit root(s)	

Source: EViews 10 outputs.

Fig. 3. Model stability test.

Test the significant parameters in the short term

To enhance the model's reliability and address potential standard problems, we can test the significance of the parameters in the short term using the Wald test.

Table 7. Wald Test Results

Test statistic	**Value**	**df**	**Probability**
Chi-square	146.1530	2	0.0000

Source: EViews 10 outputs.

Table 7 presents the results of the Wald test, and these results lead to the following observations:

1. The probability value of the chi-square statistic is less than 0.05, This indicates that the parameters of the independent variables cannot be absent in the dependent variable equation in the short term. In other words, the

independent variables significantly impact the dependent variable in the short term.

2. The coefficients for gold prices and the dollar exchange rate are proven significant through the Wald test. This suggests a short-term relationship between the change in gold prices and the change in the dollar exchange rate. The coefficients' significance indicates that changes in gold prices and the dollar exchange rate impact each other in the short term.
3. By conducting the Wald test, we have obtained evidence supporting the inclusion of these variables in the short-term equation and their significant influence on the dependent variable.

CONCLUSIONS

Based on the research conducted, several key results have been obtained:

1. There is evidence of cointegration between the US dollar and the price of gold at the 5 % significance level. This suggests a long-term equilibrium relationship between the two variables.
2. The research confirms a strong and long-term equilibrium relationship between the exchange rate of the US dollar and the price of gold. The maximum likelihood test supports that these variables do not diverge from each other in the long term.
3. A one-way causal relationship has been identified between the dollar exchange rate and the price of gold. This indicates that changes in the dollar exchange rate affect the price of gold, supporting a long-term relationship between these variables during the specified period.
4. The significance of transactions related to gold prices and the dollar exchange rate has been confirmed through Wald's test. This implies the presence of a short-term relationship between these variables.
5. During times of crisis, when the dollar exchange rate declines, there is an increase in the demand for gold, leading to a rise in gold prices. This behaviour suggests that investors prefer holding gold as a safe haven instead of the US dollar.
6. The correlation matrix reveals a reverse relationship between the US dollar exchange rate and the price of gold.
7. Changes in the price of gold lead to a change in the dollar's exchange rate. In other words, higher demand for gold leads to a lower exchange rate for the dollar. This indicates that investors substitute dollars for gold in the markets during crises, considering gold a safer asset.
8. Limited impact of dollar exchange rate on gold: conversely, the change in the dollar exchange rate does not cause a change in the price of gold. Fluctuations in the dollar exchange rate are attributed to other variables rather than investors selling gold to obtain US dollars during crises. This suggests that investors do not consider the US dollar a safer haven than gold.

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