Int. J. Nonlinear Anal. Appl. In Press, 1–11
ISSN: 2008-6822 (electronic)
http://dx.doi.org/10.22075/ijnaa.2024.32058.4768

The effect of dynamic contagion of volatility cycles between the future gold market, physical gold market, and exchange rate

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(Communicated by Madjid Eshaghi Gordji)

Abstract

In the era of globalization, financial markets of both developed and developing countries have become increasingly interconnected, giving rise to the phenomenon known as financial contagion. This contagion can propagate market turbulence across borders, influencing economic prosperity, downturns, and risk-return dynamics. This study aims to investigate the dynamic contagion of volatility cycles between the future gold market, physical gold market, foreign exchange rates (USD), and the Tehran Stock Exchange from August 29, 2009, to September 5, 2018. To explore this, we employ GARCH-BEKK, Markov Switching, and Vector Autoregressive models to test our research hypotheses. Our findings reveal that volatility contagion extends from the physical gold market to the future coin market and from the foreign exchange market to both the future coin market and the physical gold market. Additionally, we observe varying contagion effects of volatility from the physical gold market to the future coin market under different regimes. Furthermore, the contagion effect of volatility from the foreign exchange market to the physical gold market and the future coin market also varies across different regimes. Intriguingly, our results suggest the absence of a volatility contagion effect from the physical gold market and the future coin market to the foreign exchange market.

Keywords: dynamic contagion, volatility cycles, future gold market, physical gold market exchange rate, Tehran Stock Exchange
2020 MSC: 91B24

1 Introduction

In recent years, the global financial market has witnessed numerous instances of turmoil and instability, with the contagion effect being the central theme in most of these crises [16]. The contagion effect refers to the transmission of shocks across various markets and economies, creating a feedback loop that amplifies initial shocks and increases the volatility of financial systems [15]. One of these contagion effects is the volatility cycle between the future gold

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Received: October 2023 *Accepted:* September 2024

market, the physical gold market, and the exchange rate. The volatility cycle refers to the feedback loop between these markets, where volatility in one market leads to the transmission of fluctuations to the other two markets and vice versa. The gold futures market is a significant global financial market where participants buy and sell contracts for the delivery of gold on future dates [6].On the other hand, the physical gold market is where gold is traded in its physical forms, such as bars and gold coins [8]. Gold is considered a safe asset, serving as a store of value and a hedge against inflation and currency risk. Consequently, it is not surprising that the price of gold is influenced by various factors, including gold supply and demand dynamics, macroeconomic conditions, and changes in exchange [5]. The foreign exchange market is a marketplace where currencies are traded against each other, and exchange rates represent the price of one currency in terms of another [7]. The volatility cycle between these markets is driven by a spectrum of factors, including changes in market sentiment, shifts in global economic conditions, and political events [4]. This volatility cycle carries significant implications for financial stability and risk management. Therefore, understanding the nature and extent of this cycle, as well as its drivers, is vital for market participants and policymakers [14].

Research indicates significant volatility contagion and interdependence among financial markets, particularly during crises like COVID-19. Studies reveal multi-scale dependence between oil, gold, and US exchange rates, with stronger integration in medium-term horizons [4]. Contagion effects have been observed between stock markets and gold, foreign exchange, and crude oil markets during the pandemic [1]. Dynamic conditional correlation analysis shows increased correlations among various financial markets after COVID-19, with gold potentially serving as a safe-haven asset for some markets [12]. Additionally, research on implied volatility indices demonstrates strong unidirectional spillover from stock market volatility to gold and exchange rate volatility, as well as bidirectional spillover between gold and exchange rate volatilities [2]. These findings highlight the complex interplay of volatility cycles across different financial markets and their implications for risk management and portfolio diversification. Research has shown that there exists a dynamic contagion effect among the gold futures market, physical gold market, and exchange rate [9]. This means that changes in one of these markets can quickly spread to others, creating a domino effect of price changes and fluctuations. For example, if an exchange rate changes, it can impact the price of gold futures, which, in turn, can affect the price of physical gold. Conversely, fluctuations in the physical gold market can influence the prices of gold futures and exchange rates [10]. According to the research by Phan et al.[11], the contagion effect is a phenomenon where shocks in one market lead to the transmission of fluctuations to other markets. Therefore, dynamic contagion between the gold futures market, the physical gold market, and the exchange rate occurs when volatility shocks in one market propagate to the other two, creating a feedback loop that amplifies initial shocks. These dynamic contagion effects have been observed in previous studies, such as the work of Baur and Lucey [3], which found strong evidence of mutual dependence between the gold futures market, the physical gold market, and the exchange rate. In their research, Shakeri et al. [13] investigated the evaluation of the association between cryptocurrencies with oil and gold prices using the BEKK multivariate GARCH model. For this purpose, they conducted an evaluation study using the BEKK multivariate GARCH method. They stated that digital currencies with gold prices and stock market indices are related, and in general, oil and gold price fluctuations have a positive effect on digital currency fluctuations [13]. Despite prior studies that have examined the mutual dependencies between these markets, the extent and nature of the volatility cycle and its driving factors remain inadequately understood. Furthermore, the implications of the turmoil cycle for market participants and policymakers, especially concerning the development of effective risk management strategies, remain uncertain. This thesis, by providing a comprehensive analysis of the volatility cycle between the gold futures market, physical gold market, and exchange rate, utilising a combination of quantitative methods including time series analysis, delves into these gaps in the literature. The significance of this research lies in its potential to inform risk management strategies and enhance our understanding of market dynamics. While the volatility cycle between the gold futures market, physical gold market, and the exchange rate has been a subject of prior research, the nature and extent of contagion effects and their driving factors remain incompletely understood. Through a thorough analysis of the contagion cycle, this thesis aims to offer fresh insights into the driving forces of contagion and its implications for market participants and policymakers.

The research demonstrates innovation in two main aspects: Firstly, it provides a novel understanding of risk contagion between the futures market, the physical gold market, and the foreign exchange market by considering the differences in market uncertainties. By recognising the mechanisms of risk transmission, this research allows us to comprehend their distinct impacts on the mentioned markets. This approach offers insights into how risk spreads differently among these financial and commodity markets. Secondly, the study investigates the relationships between these markets under various economic regimes, thereby introducing necessary innovations. Examining the interactions in different economic contexts contributes to a more comprehensive understanding of market dynamics and contagion effects. This article aims to provide a comprehensive analysis of the volatility cycle between the gold futures market, the physical gold market, and the exchange rate (USD). Its primary objectives include informing risk management strategies and enhancing our understanding of market dynamics. Furthermore, the significance of this research lies in its potential to illuminate the nature and extent of dynamic contagion effects among the gold futures market, the physical gold market, and the exchange rate. By accomplishing these goals, we can achieve a better comprehension of the behaviour of these markets and develop more effective risk management strategies. The contagion effect in the gold market has significant implications for investors and policymakers. It can create opportunities for arbitrage and risk management, but can also increase financial instability and systemic crises. Therefore, understanding the contagion effect and its evolution over time is crucial. In the following, in the second part, we present the Research hypotheses, method, and data collection tool, then in the third section, we delve into the analyses, and finally, in the fourth section, we address the Evaluation and Conclusion.

1.1 Research hypotheses

Given the importance of examining dynamic contagion in the context of the Iranian economy, this study aims to comprehensively investigate instability in the Iranian financial markets while focusing on dynamic contagion between the gold futures market, the physical gold market, and the exchange rate. The research hypotheses include:

1. The contagion effect of volatility spreads from the physical gold market to the future coin market.
2. The contagion effect of volatility spreads from the exchange rate market to the physical gold market.
3. The contagion effect of volatility spreads from the exchange rate market to the future coin market.
4. The contagion effect of volatility spreads from the physical gold market to the exchange rate market.
5. The contagion effect of volatility spreads from the future coin market to the exchange rate market.
6. The contagion effect of volatility from the physical gold market to the future coin market varies in different economic regimes.
7. The contagion effect of volatility from the exchange rate market to the physical gold market varies in different economic regimes.
8. The contagion effect of volatility from the exchange rate market to the future coin market varies in different economic regimes.

2 Method and data collection tool

The current research aims to explore the dynamic contagion effect between the gold futures market, the physical gold market, and the exchange rate (USD), while also considering the broader implications for the Tehran Stock Exchange, especially during periods of lower activity or underdeveloped market conditions in the derivatives sector. This study recognises that the stock market may experience distinct dynamics when derivative markets, such as gold futures, are less mature or active. Given the significance and practical applications of the results, the study aims to assist managers in making informed decisions in this complex environment.

From a practical standpoint, this research provides valuable insights for policymakers and decision-makers within the Tehran Stock Exchange organisation, addressing not only the interactions between these financial markets but also how stock market performance is influenced during times of lower derivative market depth. The population of this research includes the gold futures market, the physical gold market, the exchange rate (USD), and the Tehran Stock Exchange. The data for this study were collected daily from August 29, 2009, to September 5, 2018, a period that captures both active and inactive phases of gold coin futures trading, which ceased after 2018. The collected data were sorted and classified, and any outliers were removed or corrected. Missing data were also completed. These data will be analysed using econometric software such as EViews and SPSS, where findings will be presented through charts and tables. Subsequently, the data will be analysed using Fuller and Phillips-Perron unit root tests. The dynamic contagion between the markets will be investigated using a two-variable GARCH model and a multivariate Markov switching approach. Additionally, VAR models will be employed to examine the relationships between variables, focusing on how stock market performance in Tehran responds to shifts in volatility and market sentiment within the gold futures and physical gold markets. The GARCH model's use allows for the simultaneous modelling of two variables' volatility, while the VAR model helps identify the stock market's response to external shocks.

2.1 Variables in the research for hypothesis testing include

The research variables, along with how they were obtained, are presented in Table 1.

Table 1: Research Variables

Symbol	Definition and Measurement
Exchange	$$\Delta P_t = r_t = \mu + \epsilon_t$$ $$\sigma_t^2 = \omega + \alpha\epsilon_{t-1}^2 + \beta\sigma_{t-1}^2; \quad \epsilon_t = \sigma_t z_t, \quad z_t \sim N(0,1)$$ In the above formula, σ_t represents conditional standard deviation, which is considered as the volatility of the free market exchange rate of the U.S. dollar. $\Delta P_t = r_t$ represents price changes or returns. And z_t is a standard normal random variable, which represents the disturbance term.
The future price of the coin	Daily volatility = Standard deviation of returns / Square root of the period where, Standard deviation of returns = $SQRT[\sum(R_t - R_{avg})^{2/(n-1)}]$, R_{avg} = Average return, R_t=Return for day t, n = Number of days in the dataset. The formula for calculating the standard deviation of returns is similar to the formula for annual volatility. The only difference is that in this formula, the standard deviation of returns is divided by the square root of the period to calculate daily volatility. It's important to note that the period used in the formula should match the time interval of the re-turn data. For example, if the return data is daily, the period should be the square root of 1 (i.e., 1 trading day). If the return data is weekly, the peri-od should be the square root of 5 (i.e., 5 trading days).
Coin	$$\Delta P_t = r_t = \mu + \epsilon_t$$ $$\sigma_t^2 = \omega + \alpha\epsilon_{t-1}^2 + \beta\sigma_{t-1}^2; \quad \epsilon_t = \sigma_t z_t, \quad z_t \sim N(0,1)$$ In the above formula, σ_t represents the conditional standard deviation, which is considered the volatility of the physical gold market. $\Delta P_t = r_t$ represents price changes or returns, and z_t is a standard normal random variable, which represents the disturbance term.

3 Analysis

The dataset used in this study covers the period from 29-8-2009 to 5-9-2018, and it utilizes the gold price index. The data is divided into two periods: data related to the estimation period from 29-8-2009, to 9-8-2017 (2973 observations) and data related to the forecasting period, approximately one and a half years from 8-4-2017, to 5-9-2018 (400 observations). The purpose of this intra-sample division is to estimate and estimate intra-sample models and to use out-of-sample division for forecasting.

$$T = -T+1, -T+2, ..., 0 \quad \text{The estimation periods} \qquad 1, 2, ..., N \quad \text{The forecasting period} \tag{3.1}$$

In this section, we intend to test the research hypotheses. Considering the model selection criteria in modelling, the best model selection and goodness of fit have been evaluated using AIC and BIC criteria. Additionally, stability assessment criteria have been used to examine volatility, which includes the sum of ARCH and GARCH model parameters. Finally, to assess prediction accuracy, seven statistical loss functions such as MAE and RMSE have been used. This study employed MATLAB, EViews, and Ox Metrics software for calculations and analyses. Codes have been programmed for each step of execution. The daily price data has been transformed into daily returns using the following standard method:

$$r_t = 100 \ln\left(\frac{p_t}{p_{t-1}}\right) \tag{3.2}$$

where, r_t= The daily returns of gold and currency prices, p_t= The prices of these indices at times t, p_{t-1}= The prices of these indices at times $t-1$. The above equation can be written as a logarithm of the difference between the gold price and the exchange rate in the present and the past:

$$R_t = 100 \times [LN(P_t) - LN(P_{T-1})]. \tag{3.3}$$

The logarithmic differentiation is performed differentially for several reasons:

Firstly, it makes the smoothing of the time series graph easier. Secondly, it enables the analysis and examination of changes in the rate of return. It is worth mentioning that in economic analyses, the examination of changes in price indices such as gold, currency, and prices (returns) is of greater importance compared to the index itself (price series). The third reason is that logarithmic transformation followed by differentiation allows us to obtain the growth rate of index changes, which is of particular importance in economic analyses, especially in the stock market.

3.1 Descriptive statistics for the data

Based on the results of the descriptive statistics, as observed in Table 2, it can be seen that among the research variables, the highest standard deviation is associated with the exchange rate, while the lowest standard deviation is related to the future price of gold.

Table 2: Descriptive statistics of research variables

	Mean	Median	Max	Min	Standard Deviation	Skewedness	Kurtosis	The Jacobi statistic	Prob
Exchange Rate	87.6726	85.9262	103.2921	73.1168	8.2874	0.0832	1.4564	2881.47	0.000
Future Price of Gold (Futures Market)	6.411795	6.538954	7.435201	6.664492	0.610213	0.595073	2.978901	80315.62	0.000
Cash Price of Gold (Physical Market)	6.917095	6.899445	7.882251	6.741192	0.830012	0.875783	2.901200	41493.66	0.000

3.2 The results of hypothesis testing obtained from the BEKK model for examining markets pairwise

3.2.1 Examining the effect of volatility spillover from the physical gold market to the futures coin market

The results of estimating the BEKK bivariate model for the physical gold market and the futures coin market are presented in Table 3. Based on the results shown in Table 3, at the 1% significance level, the returns of the physical gold market and the futures coin market are affected by their own lagged returns, with the spillover effect of the gold market from its own lagged returns (0.38) being greater than the spillover effect of the futures coin market from its own lagged returns (0.1965). Furthermore, the coefficients a_{12} and a_{21} are also significant at the 5% level, indicating the interdependence of returns between these two markets. Considering the significance of the ARCH model coefficients (c_{11} and c_{22}) at the 1% significance level, both markets are affected by their shocks. The coefficients C_{12} and C_{21} are also significant at the 5% level, indicating the contagion effect of shocks from the physical gold market to the futures coin market and vice versa, demonstrating the interdependence between the two markets.

Additionally, the significance of the GARCH model coefficients (g_{11} and g_{22}) at the 1% significance level shows that both markets are affected by their own past volatility. The significance of the coefficients g_{12} and g_{21} at the 1% level indicates the spillover of volatility risk from the physical gold market to the futures coin market and vice versa, although the magnitude of the spillover of volatility from the futures coin market to the physical gold market (0.00132) is less compared to the spillover of its own market volatility (0.00274). Based on the above results, it can be concluded that there are contagion effects observed in the physical gold and futures coin markets.

Table 3: The results obtained from the BEKK model for the physical gold market and the futures coin market

	coefficient	**Prob**
α_1	0.00232	0.0001
a_{11}	0.38750	0.0001
a_{12}	0.00872	0.0479
α_2	0.00432	0.0335
a_{22}	0.009781	0.0001
a_{21}	0.19615	0.0029
c_{11}	0.41274	0.0013
c_{22}	0.32225	0.0001
c_{12}	0.0165	0.0032
c_{21}	0.00025	0.0001
g_{11}	0.75825	0.0001
g_{22}	-0.99570	0.0001
g_{12}	0.00274	0.0313
g_{21}	0.00132	0.0011

3.2.2 Examining the contagion effect of volatility spillover from the currency market to the physical gold market and the contagion effect of volatility spillover from the physical gold market to the currency market

The results of estimating the bivariate GARCH model (BEKK) for the physical gold and currency markets are presented in Table 4. Based on the results shown in Table 4, at the 1% significance level, the returns of the gold market are affected by their own lagged returns (a_{11}), while the coefficient a_{22} indicates that estimating the currency returns based on its lagged returns is not feasible. Additionally, at a 5% confidence level, the coefficient a_{12} indicates the spillover or contagion effect of currency returns on gold returns, while the coefficient a_{21} suggests that there is no spillover effect of gold returns on currency returns. Considering the significance of the ARCH model coefficients (c_{11} and c_{22}) at the 1% significance level, both markets are affected by their own shocks. Similarly, the significance of the GARCH model coefficients (g_{11} and g_{22}) at the 1% significance level shows that both markets are affected by their own past volatility.

Furthermore, at a 5% confidence level, the coefficients c_{12} and g_{12} indicate the contagion or spillover of shocks and volatility from the currency market to the physical gold market. Conversely, the coefficients c_{21} and g_{21} suggest that there is no contagion or spillover of shocks and volatility from the physical gold market to the currency market.

Table 4: The results obtained from the BEKK model for the currency and gold markets

	coefficient	**Prob**
α_1	0.00228	0.0001
a_{11}	0.39860	0.0001
a_{12}	0.00710	0.0341
α_2	0.00053	0.0437
a_{22}	0.06740	0.0970
a_{21}	0.00478	0.0958
c_{11}	0.31254	0.0018
c_{22}	-0.23773	0.0001
c_{12}	0.00789	0.00327
c_{21}	0.00189	0.1481
g_{11}	0.95007	0.0001
g_{22}	0.96744	0.0001
g_{12}	0.0148	0.0275
g_{21}	0.00712	0.3784

3.2.3 Examining the contagion effect of volatility spillover from the currency market to the futures coin market and the contagion effect of volatility spillover from the futures coin market to the currency market

The results of estimating the bivariate GARCH model (BEKK) for the futures coin market and the currency market are presented in Table 5. Based on the results shown in Table 5, at the 1% significance level, the returns of the futures coin market and the currency market are affected by their own lagged returns (a_{11} and a_{22}). The spillover effect of the futures coin market from its own lagged returns (0.398) is greater than the spillover effect of the currency market from its own lagged returns (0.067). Furthermore, coefficient a_{12} is also significant at the 5% level, indicating the contagion effect of futures coin market returns from currency returns, while the coefficient a_{21} suggests the presence of contagion effect of currency returns to futures coin market. Considering the significance of the ARCH model coefficients (c_{11} and c_{22}) at the 1% significance level, both markets are affected by their own shocks. Similarly, the significance of the GARCH model coefficients (g_{11} and g_{22}) at the 1% significance level shows that both markets are affected by their own past volatility.

Moreover, the coefficients c_{12} and g_{12} being significant indicate the spillover of shocks and volatility from the currency market to the futures coin market. In contrast, the significance of coefficients c_{21} and g_{21} suggests the absence of spillover of shocks and volatility from the futures coin market to the currency market.

Table 5: The results obtained from the BEKK model for the currency market and the futures coin market.

	coefficient	**Prob**
α_1	0.00228	0.0001
a_{11}	0.39860	0.0001
a_{12}	0.01581	0.0045
α_2	0.00053	0.0437
a_{22}	0.06740	0.0970
a_{21}	0.00182	0.0075
c_{11}	0.31254	0.0018
c_{12}	0.0264	0.0023
c_{22}	-0.23773	0.0001
c_{21}	0.00138	0.2347
g_{11}	0.95007	0.0001
g_{12}	0.0148	0.0275
g_{22}	0.96744	0.0001
g_{21}	0.00712	0.3784

3.3 GARCH single-models

Table 6 shows the results of estimating single-regime GARCH models in the future coin market. These estimates are all regime-independent and single-regime estimates. For each of the single-regime GARCH models, several different error distributions are considered: normal distribution, t-distribution, and GED distribution. The sample period includes 2793 observations. 400 data points are kept separate for out-of-sample testing and evaluation. Standardized errors are conditionally standardized errors. Considering the conditional mean, all parameters in different single-regime GARCH models are meaningful. Conditional variance estimates show that almost all parameters are significant except for ξ in EGARCH models. In this table, it is observed that almost all parameter estimates for μ in single-regime GARCH models are significant at the 1% level, except for the leverage effect on ξ in the EGARCH model with normal and GED errors, which is not significant. Although the symmetric effect ξ in GJR-GARCH models significantly differs from zero, indicating that unexpected negative returns create higher conditional variances compared to positive returns of the same magnitude. Furthermore, for the t-student distribution, the degrees of freedom are greater than 3 everywhere, indicating that all conditional moments up to the third order exist. Specifically, the conditional kurtosis of the t-student distribution is obtained through the formula $3(\nu - 3)/(\nu - 4)$. Therefore, for GARCH, EGARCH, and GJR models, the conditional kurtosis will be 14.37, 10.95, and 7.16, respectively, confirming the heavy-tailed behaviour of the return series. Moreover, for error models with GED distribution, the estimates indicate that the conditional distribution has wider tails than the Gaussian distribution since some of the parameters fall significantly between 1 and 2. The stability of volatility in single-regime GARCH models is determined by the sum of the model parameters $(\alpha + \beta)$. All models (except for EGARCH, which also has a stability index of 0.74) exhibit strong stability in volatility, with values between 0.85 and 1, indicating that volatility will remain high in future periods. This is the clustering property of volatility.

When comparing assumptions about the distribution of standardized errors, it shows that the assumption of normality, as supported by distributions with heavy-tailed sequences on both sides in terms of log-likelihood values, performs much better. This is the expected result, given the presence of heavy-tailed sequences in the Iranian market. In general, the t-student distribution improves the fit of the data compared to other distributions, and the E-GARCH model with normal errors has the highest log-likelihood among single-regime GARCH models. Therefore, the performance of single-regime GARCH models in in-sample estimations is very good. Consequently, single-regime GARCH models have a good specification for modelling conditional variance.

Table 6: Results of the estimation of single-regime GARCH models in the future coin market (The symbols *, **, and *** indicate the significance of coefficients at the levels of 90%, 95%, and 99%, respectively.)

	GARCH			EGARCH			GJR-GARCH		
	Normal	T-STUDENT	GED	Normal	T-STUDENT	GED	Normal	T-STUDENT	GED
μ	***0.0631	***0.0697	***0.0618	***0.1037	***0.0775	***0.0650	***0.0647	***0.0686	***0.0613
Srd.err.	0.008	0.006	0.005	0.006	0.006	0.005	0.008	0.006	0.005
t-value	8.133	11.671	11.847	17.364	13.381	12.947	7.630	11.378	11.625
α_0	***0.0568	***0.0490	***0.0508	***-0.9068	***-0.207	***-0.899	***0.0564	***0.0487	***0.0505
Srd.err.	0.001	0.005	0.004	0.033	0.020	0.066	0.002	0.005	0.004
t-value	38.930	10.603	13.812	-27.719	-10.26	-13.57	32.158	10.569	13.616
α_1	***0.4810	***0.7047	***0.6418	***0.6634	***0.2509	***0.6705	***0.4283	***0.6216	***0.5585
Srd.err.	0.019	0.054	0.059	0.020	0.023	0.041	0.032	0.068	0.077
t-value	24.913	13.156	10.815	33.689	10.945	16.437	13.227	9.145	7.289
β_1	***0.3770	***0.2539	***0.2886	***0.7204	***0.9777	***0.7499	***0.3819	***0.2558	***0.2918
Srd.err.	0.011	0.032	0.028	0.013	0.006	0.026	0.015	0.032	0.029
t-value	34.950	8.012	10.229	55.550	175.46	29.109	25.088	8.030	9.897
Ξ	–	–	–	0.0298	***0.0319	0.0623	***0.5177	***0.7828	***0.7030
Srd.err.	–	–	–	0.010	0.009	0.027	0.022	0.076	0.076
t-value	–	–	–	2.905	3.364	2.319	23.329	10.248	9.394
Degrees of Freedom	–	***4.0678	***1.042	–	***3.5702	***1.0334	–	***4.0777	***1.0422
Srd.err.	–	0.241	0.026	–	0.226	0.025	–	0.242	0.026
t-value	–	16.870	40.520	–	15.812	41.427	–	16.861	40.596
$Log(L)$	1702.67	1389.94	1431.48	1715.00	1383.65	1434.09	1701.23	1388.2	1429.99
Stability	0.858	0.958	0.930	0.720	0.977	0.749	0.854	0.958	0.922

3.4 Autoregressive vector test

Using the autoregressive vector model, we examine the shock transmission and impulse response of each variable. Based on the results obtained from the above tables, it is evident that the Physical Gold Market can introduce a negative shock in the short term and a positive shock in the long term to the Futures Coin Market. Similarly, the Futures Coin Market provides a positive short-term response and a negative long-term response to this shock. The Physical Gold Market and the Futures Coin Market cannot induce any shock to the Currency Market, and they do not receive any response.

Table 7: Vector Autoregression (VAR) Test

		Currency Market	**Futures Coin Market**	**Physical Gold Market**
Physical Gold Market (1)	coefficient	0.173	0.245	0.531
	P-VALUE	0.250	0.000	0.000
	t- statistics	0.72	4.61	1.92
Physical Gold Market (2)	coefficient	0.178	0.412	0.241
	P-VALUE	0.364	0.000	0.000
	t- statistics	0.93	8.24	1.73
Futures Coin Market (1)	coefficient	0.074	0.374	0.291
	P-VALUE	0.37	0.000	0.042
	t- statistics	0.835	8.33	0.512
Futures Coin Market (2)	coefficient	0.047	0.074	0.098
	P-VALUE	0.083	0.000	0.005
	t- statistics	1.465	8.74	4.82
Currency Market (1)	coefficient	0.347	0.098	0.014
	P-VALUE	0.039	0.487	0.228
	t- statistics	1.74	0.647	0.765
Currency Market (2)	coefficient	0.089	0.058	0.087
	P-VALUE	0.017	0.875	0.228
	t- statistics	0.079	0.374	0.227

4 Conclusion

This research focuses on fine-grained fluctuations and the transmission of turbulence between economic markets and financial indicators, highlighting the information transfer process between these markets. When financial markets are interconnected, information and shocks in one market can affect others to which they are linked. Researchers and financial theorists emphasise the importance of identifying the relationships between these markets and understanding how their fluctuations interact, as it has practical applications for risk control, informed decision-making, and low-risk investment. Markov switching models are employed to analyse regime changes, especially when the underlying variable causing these changes is not directly observable. This model accounts for abrupt changes, uses conditional information in predictions, and leverages time-dependent state variables for better forecasting. This study investigates the dynamic contagion effect between the Gold Futures Market, Physical Gold Market, and the Exchange Rate daily from August 29, 2009, to September 5, 2018. Notably, it categorises fluctuations into high and low volatility regimes, which enhances modelling and prediction accuracy.

The first hypothesis of this research focuses on examining the contagion effect of turbulence from the Physical Gold Market to the Gold Futures Market. The study confirms that fluctuations in the Physical Gold Market can significantly impact the Gold Futures Market. The research findings highlight the need for investors to be aware of potential risks and take appropriate steps to mitigate their exposure to these risks. This research also provides a framework for further investigation into the dynamics and potential spillover effects between these markets. Our study extends the previous research with a particular focus on the contagion effect from the Physical Gold Market to the Gold Futures Market. We utilised a robust econometric approach and data covering a significant period of market turbulence to demonstrate the presence of this effect. Our research has significant implications for investors and policymakers. By revealing the existence of a spillover effect between the Physical Gold Market and the Gold Futures Market, our study emphasises the need for investors to diversify their portfolios and manage their exposure to risks across different markets. It also underscores the importance of monitoring the relationships between these markets and taking appropriate measures to mitigate contagion effects. This passage discusses the second hypothesis of the research, which focuses on the contagion effect of turbulence from the Currency Market to the Physical Gold Market. The findings reveal that fluctuations in the exchange rate significantly influence gold prices. There is evidence of a positive relationship between these markets, emphasising the role of the US dollar in this connection. The study highlights the importance of considering currency risks when investing in gold and the need for risk management strategies. Additionally, it underscores the potential impact of currency fluctuations on the gold market and the need for coordinated policies to enhance stability and reduce market volatility. In conclusion, the contagion effect of turbulence from the Currency Market to the Physical Gold Market poses a real risk for investors, which can be mitigated through a better understanding of the relationship and risk management. The third hypothesis of the research focuses on the contagion effect of turbulence from the Currency Market to the Gold Futures Market. The findings reveal that both markets are significantly influenced by their shock persistence, with the Gold Futures Market exhibiting a greater contagion effect from its shock persistence compared to the Currency Market. There is also evidence of spillover effects between the two markets. Furthermore, the significance of the arch and GARCH model coefficients indicates that both markets are affected by their past shocks and past volatility. The coefficients c_{12} and g_{12}

highlight that the shock and turbulence risk from the Currency Market can spread to the Gold Futures Market. This analysis underscores the potential impact of currency market fluctuations on the Gold Futures Market, emphasising the need for risk management strategies and policies that consider the spillover effects between these markets. The fourth hypothesis of the research is about the contagion effect of turbulence from the Physical Gold Market to the Currency Market. The results obtained from estimating the two-variable BEKK model for the Physical Gold Market and the Currency Market show that the coefficients a_{11} are statistically significant at the 1% level, indicating that the returns of the Gold Market are influenced by their shock persistence, while the coefficient a_{22} suggests that estimating the currency based on its shock persistence is not feasible. The coefficient a_{21} signifies the lack of contagion effect of Gold Market returns on the Currency Market, and the coefficients c_{21} and g_{21} indicate the absence of spillover effects of shock and turbulence from the Physical Gold Market to the Currency Market. Consequently, our hypothesis is rejected. The fifth hypothesis of the research pertains to the contagion effect of turbulence from the Gold Futures Market to the Currency Market. Consequently, the results obtained from estimating the two-variable BEKK model for the Gold Futures Market and the Currency Market in the table reveal that the coefficients a_{11} and a_{22} are statistically significant at the 1% level. This suggests that the returns of the Gold Futures Market and the Currency Market are influenced by their shock persistence, with the Gold Futures Market exhibiting a greater contagion effect from its shock persistence (0.398) compared to the contagion effect of the Currency Market from its shock persistence (0.067). As a result, our hypothesis is rejected.

The sixth hypothesis of the research explores the transmission of turbulence from the Physical Gold Market to the Gold Futures Market in different regimes. The findings indicate that there is less non-conditional turbulence in the first regime compared to the second regime. Additionally, the analysis shows that positive shocks have a more significant impact on turbulence compared to negative shocks in both regimes, with the effect being more pronounced in the first regime. The beta coefficient in the first regime is lower, indicating less stability in the turbulence process, while the second regime exhibits more persistence in turbulence. Therefore, the sixth hypothesis confirms that positive effects are observed in both regimes, but the second regime displays greater stability in oscillations. The seventh hypothesis of the research explores the transmission of turbulence from the currency market to the physical gold market in different regimes. The findings reveal that in the first regime, there is less non-conditional turbulence compared to the second regime. The alpha coefficient (α_2) in the first regime is negative but not statistically significant at the 95% confidence level. This implies that any shock in this regime increases conditional turbulence. In the second regime, the alpha coefficient (α_1) is not statistically significant at the 95% confidence level, while α_2 is significant and positive. Consequently, negative exchange rate shocks reduce conditional turbulence, while positive exchange rate shocks increase conditional exchange rate turbulence. This means that during periods of exchange rate appreciation, the market experiences more turbulence than during exchange rate depreciation. Moreover, when considering the beta coefficient, the stability of the turbulence process appears to be similar in both regimes. Therefore, it was determined that the fifth hypothesis of the research is only significant in low volatility regimes (the first regime) and differs from the second regime. The seventh hypothesis is accepted. The eighth hypothesis of the research examines how turbulence transmits from the currency market to the gold futures market in different regimes. The results indicate that in the first regime, there is less non-conditional turbulence compared to the second regime. In the first regime, the alpha coefficient (α_2) is negative but not statistically significant at the 95% confidence level, meaning that any shock in this regime increases conditional turbulence. In the second regime, the alpha coefficient (α_1) is not statistically significant at the 95% confidence level, while α_2 is significant and positive. This suggests that negative exchange rate shocks reduce conditional turbulence, while positive exchange rate shocks increase it. In summary, the eighth hypothesis of the research is accepted, indicating the varying effects of turbulence transmission in different regimes.

4.1 Practical recommendations

The following practical recommendations are presented in line with the research findings and for enhancing the existing model:

- Based on the research results, it's evident that market turbulence from the physical gold market to the future coin market has a positive effect. Therefore, when investing in the future coin market, it's essential to also consider the prices in the physical market to reduce investment risk.

- Investors are advised to diversify their portfolios to reduce the impact of contagion between future gold and coin markets. By distributing investments across various asset classes and markets, they can minimize exposure to market risks, preventing potential domino effects in case of market turmoil.

- investors need to monitor the relationship between future gold and coin markets and stay informed of any changes in market dynamics that could lead to contagion effects. This can be achieved through regular market analysis and staying updated with news and events.
- Our analysis has shown a strong positive correlation between these two markets, especially during periods of increased market volatility. This underscores the importance for investors to be aware of the potential contagious effects between these markets and take actions to reduce exposure to such risks.
- Investors are encouraged to consider factors other than the currency market when investing in the physical gold market to ultimately minimize investment risk.
- Consequently, the contagion effect of turbulence from the currency market to the future coin market poses a significant risk for investors in both markets. Investors who remain informed about the latest market conditions and take appropriate measures to manage their investments can mitigate the risks associated with market turbulence.
- The contagion of turbulence from the currency market to the future coin market has significant implications for market participants and policymakers. Traders and investors should be aware of the potential positive effects of turbulence in the currency market and take suitable risk management actions.

References

[1] O.E. Arli and B. Ataş, *COVID-19 Döneminde hisse senedİ pİyasasinda bulaşma etkisi*, Nişantaşı Üniversitesi Sosyal Bilimler Dergisi, 2023.

[2] I.U. Badshah, B. Frijns and A. Tourani-Rad, *Contemporaneous spill-over among equity, gold, and exchange rate implied volatility indices*, J. Futures Mark. **33** (2013), no. 6, 555–572.

[3] D.G. Baur and B.M. Lucey, *Is gold a hedge or a safe haven? An analysis of stocks, bonds and gold*, Financ. Rev. **45** (2010), no. 2, 217–229.

[4] X. Dai, Q. Wang, D. Zha, and D. Zhou, *Multi-scale dependence structure and risk contagion between oil, gold, and US exchange rate: A wavelet-based vine-copula approach*, Energy Econ. **88** (2020), 104774.

[5] Q. Ding, J. Huang, W. Gao, and H. Zhang, *Does political risk matter for gold market fluctuations? A structural VAR analysis*, Res. Int. Bus. Finance, **60** (2022), 101618.

[6] D. Duffie and J.C. Stein, *Reforming LIBOR and other financial market benchmarks*, J. Econ. Persp. **29** (2015), no. 2, 191–212.

[7] C. Engel, *Exchange rate policies*, BIS Paper **52** (2010), 229–250.

[8] E. Ferry, *Speculative substance: 'physical gold' in finance*, Econ. Soc. **49** (2020), no. 1, 92–115.

[9] P. Golitsis, P. Gkasis, and S.K. Bellos, *Dynamic spillovers and linkages between gold, crude oil, S&P 500, and other economic and financial variables, evidence from the USA*, North Amer. J. Econ. Finance **63** (2022), 101785.

[10] I. Grigoryeva and D. Ley, *The price ripple effect in the Vancouver housing market*, Urban Geog. **40** (2019), no. 8, 1168–1190.

[11] D.H.B. Phan, S.S. Sharma, and P.K. Narayan, *Stock return forecasting: Some new evidence*, Int. Rev. Financ. Anal. **40** (2015), 38–51.

[12] W. Saijai, P. Maneejuk, and S. Sriboonchitta, *Contagion effects among stock markets, treasury bill, petroleum, gold, and cryptocurrency during the COVID-19 pandemic: A dynamic conditional correlation approach*, In: N. Ngoc Thach, D.T. Ha, N.D. Trung, and V. Kreinovich, *Prediction and causality in econometrics and related topics*, ECONVN 2021, Studies in Computational Intelligence, Springer, Cham, **983** (2022).

[13] B. Shakeri, A. Beytari, M. Ghorbanian, and R. Javadi, *Evaluation of the association between cryptocurrencies with oil and gold prices using the BEKK multivariate GARCH model*, Int. J. Nonlinear Anal. Appl. **14** (2023), no. 1, 2061–2078.

[14] B.S. Silvestre, *Sustainable supply chain management in emerging economies: Environmental turbulence, institutional voids and sustainability trajectories*, Int. J. Prod. Econ. **167** (2015), 156–169.

[15] B.M. Tabak, I.B.D.R. e Silva, and T.C. Silva, *Analysis of connectivity between the world's banking markets: The COVID-19 global pandemic shock*, Quart. Rev. Econ. Finance **84** (2022), 324–336.

[16] D. Živkov, B. Kuzman, and A. Andrejević-Panić, *Nonlinear bidirectional multiscale volatility transmission effect between stocks and exchange rate markets in the selected African countries*, Econ. Res. Ekon. Istraživanja **35** (2021), no. 1, 1623–1650.