

Modelling Volatility in the Indian Bullion Market: An EGARCH Approach

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Abstract: *The volatility characteristics of the Indian bullion market are examined in this study utilizing monthly statistics from April 2000 to March 2024, with a focus on gold, silver, platinum, and palladium. For investors, legislators, and researchers working on risk management, market regulation, and portfolio optimization, volatility a crucial indicator of market risk is essential. Bullion return clustering, persistence, and asymmetry are captured by the study using the GARCH(1,1) and EGARCH(1,1) models. In addition to highlighting variations in mean, dispersion, skewness, and kurtosis among metals, descriptive statistics validate the data's stationarity using the Augmented Dickey-Fuller test. All markets show considerable volatility clustering, according to GARCH data, with silver showing the strongest persistence ($\hat{\alpha} + \hat{\alpha} = 0.91$), suggesting that shocks diminish over time. EGARCH studies reveal significant asymmetric effects in gold and silver, where positive shocks result in greater volatility than negative shocks, whereas platinum and palladium exhibit symmetric volatility patterns. The large persistence coefficients ($\hat{\alpha}$) of all metals show that past shocks have a significant influence on future volatility. These findings highlight the need of accounting for asymmetric volatility when modelling bullion prices and show that gold and silver require more thought when it comes to risk management and the creation of investment strategies. By providing the first EGARCH-based analysis of the Indian bullion market, the study contributes to the literature by illuminating market behaviour, risk mitigation, and investment strategy. In order to manage financial risk and comprehend price dynamics in the Indian bullion market, traders, investors, and policymakers can benefit from the findings.*

Keywords: Indian Bullion Market, Volatility Modelling, GARCH(1,1), EGARCH(1,1), Asymmetric Volatility

INTRODUCTION

The bullion market, which comprises gold, silver, platinum, and palladium, is vital to India's financial and investment landscape. When the economy is unstable, all the metals are safe-haven investments that show distinct pricing patterns from more conventional financial instruments like stocks and bonds. Because bullion price volatility has implications for monetary policy, risk management, and portfolio diversification, investors and decision makers have been closely monitoring it in recent decades. Volatility, or the degree of change in an asset's price over time, is a key indicator of market uncertainty. Accurate modeling of bullion market volatility not only helps investors with risk assessment, portfolio optimization, and hedging strategy development, but it also enables regulators to monitor the stability of the financial system. The price of crude oil, fluctuations in exchange rates, and worldwide geopolitical events all have an impact on India's bullion market, which is one of the world's largest importers and consumers of gold. The market environment is dynamic and complex due to these factors, which makes the study of bullion price volatility extremely relevant. Econometric methods, including the family of Autoregressive Conditional Heteroskedasticity (ARCH) and Generalized ARCH (GARCH) models, have been widely used to examine financial time series with volatility clustering and asymmetric shock responses. Traditional GARCH models do a good job of capturing time-varying volatility, but they can ignore asymmetries in price reactions, such as markets' tendency to respond differently to positive and negative shocks. Nelson's (1991) Exponential GARCH (EGARCH) model addresses this limitation and is particularly useful for modeling the dynamics of bullion prices because it allows asymmetric effects and ensures that volatility remains non-negative. The purpose of this study is to use the EGARCH approach to investigate the dynamics of volatility in the Indian bullion market. Investors looking for risk managing techniques, and decision makers who are curious about the complex dynamics of precious metal pricing in India are all anticipated to find great value in the findings.

REVIEW OF LITERATURE

Using a variety of GARCH-based models, numerous research has investigated the interconnectedness and the characteristics of volatility in other financial markets and precious metals. Hammoudeh and Yuan (2008) investigated the volatility behaviour of gold, silver, and copper when oil and interest rate shocks were present. They found that the combination of rising interest rates and oil volatility could lower and negatively affect metal volatilities.

Using GARCH models with several variables, Morales (2008) investigated the effects of volatility on palladium, platinum, silver, and gold between 1995 and 2007. They found that all metals had bidirectional volatility spillovers, with the exception of gold, which had an impact on other metals but was less affected by them. Conditional volatility and correlation interdependence among four major precious metals were added to this work by Hammoudeh et al. (2009). They concluded that while each metal is somewhat sensitive to its own shocks, they exhibit less short-term reactions to external news. The largest link was found between palladium and platinum, followed by gold and silver. Using data from several time periods and a GARCH framework, Baur (2012) examined the volatility of the gold market and found that asymmetries in volatility were frequently connected to storage or inventory variables. Additionally, because gold's volatility complimented its negative correlation with equities, he discovered that adding gold to equity portfolios increased the benefits of diversification. Using Markov Regime Switching (MRS)-GARCH models, Sopipan et al. (2012) forecasted the volatility of the gold price and shown that the MRS-GARCH outperformed standard GARCH in capturing regime transitions. According to Sensoy (2013), who studied volatility shift contagion among precious metals from 1999 to 2013, gold was comparatively impervious to reverse effects because of its store-of-value function, but it did transfer volatility to other metals. Using the GARCH and EGARCH models, Harper et al. (2013) examined the volatility of the silver market from 2008 to 2011 and concluded that both models were important in explaining changes in the price of silver. When Arouri et al. (2014) investigated the volatility spillovers between the Chinese stock market and gold from 2004 to 2011, they found that there were notable reciprocal effects, with previous gold shocks affecting the conditional volatility of stock returns. Persistent volatility was observed in the Iranian gold coin market by Athari (2014), who also reported asymmetric effects, which suggest that positive shocks had a stronger impact than negative ones. Bentes (2015) verified that gold acts as a hedge in volatile markets and that FIGARCH was the most effective model for capturing long-term dependence in gold price volatility using GARCH-type models from 1976 to 2015. By using VAR and multivariate GARCH models to gold, crude oil, S&P 500, and US dollar index futures, Bunnag (2016) broadened the focus to include various asset classes. The findings showed that volatility transmission is interrelated, with stocks driving the dollar index, oil influencing gold, and gold influencing stocks. Berna and Zorikto (2017) examined Russian precious metals from 2000 to 2014 and discovered strong long-memory features and significant connections between metals. Additionally, they discovered that gold was the least volatile and silver was an effective diversifier. Despite the abundance of international literature, there are currently relatively few studies on the Indian bullion market, particularly when it comes to asymmetric volatility modelling. Because most previous research in India has concentrated on standard GARCH, FIGARCH, or multivariate GARCH models, there is a knowledge gap about the impact of asymmetric shocks on bullion prices. By using the Exponential GARCH (EGARCH) model, which successfully accounts for asymmetries in volatility responses to positive and negative shocks, the current work seeks to close this gap. This study

aims to give traders, investors, and policymakers important insights into price dynamics, persistence, and asymmetry in volatility by concentrating on the market movements of gold and silver in India. The research questions are whether bullion price volatility has asymmetric effects, which means that positive and negative shocks have different effects, whether it shows persistence, which means that past shocks affect future movements, and whether the prices of gold, platinum, silver and palladium in India show notable fluctuations over time. Thus, the following hypotheses are put forth: (H) that the volatility of bullion prices is asymmetrically affected by both positive and negative shocks; (H₂) that the volatility of bullion returns varies significantly over time; and (H₃) that there is persistent volatility, with previous shocks having a lasting impact on future price movements.

METHODOLOGY

With an emphasis on gold, silver, platinum, and palladium, this study uses an empirical and quantitative research design to investigate the dynamics of volatility of the Indian bullion market. Utilizing monthly secondary data from April 2000 to March 2024, the study covers several economic cycles and significant events, including the global financial crisis of 2008, the COVID-19 pandemic of 2020, and geopolitical tensions in 2022–2023. The data was sourced from the Reserve Bank of India Handbook of Statistics on Indian Economy for gold and silver and Bloomberg Terminal for platinum and palladium. Gretl was used to estimate the GARCH (1,1) and EGARCH (1,1) model and Descriptive statistics were performed using Jamovi. To verify stationarity and ascertain the order of integration for every variable, the Augmented Dickey-Fuller was utilized. This study uses both the GARCH (1,1) and EGARCH (1,1) models to analyze the volatility dynamics of bullion, namely gold, silver, platinum, and palladium. The mean and variance equations for the GARCH(1,1) model, which is used to describe volatility clustering and the persistence of shocks in bullion returns, are as follows

$$r_t = \mu + \varepsilon_t, \sigma_t^2 = \omega + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2$$

where r_t represents bullion returns at time t , σ_t^2 is the conditional variance, ε_t is the error term, and ω, α, β are model parameters. The EGARCH (1,1) model is used to take into consideration asymmetric effects, in which positive and negative shocks may have distinct effects

$$\ln(\sigma_t^2) = \omega + \beta \ln(\sigma_{t-1}^2) + \alpha \frac{|\varepsilon_{t-1}|}{\sigma_{t-1}} + \gamma \frac{\varepsilon_{t-1}}{\sigma_{t-1}}$$

In this case, γ reflects the asymmetry in the way that bullion volatility reacts to market shocks by capturing the leverage impact. By using both models, the study not only looks at each metal's general volatility patterns but also determines how distinct market events both positive and adverse impact price fluctuations.

RESULTS

Table 1: Showing ADF (Augmented Dickey Fuller Test Statistic)

	ADF t-statistic	p-value		ADF t-statistic	p-value
Gold	-14.21	()**	Platinum	-16.07	()**
Silver	-12.45	()**	Palladium	-16.02	()**

The results of the ADF test demonstrate that the four bullion commodities, are all stationary at their current values. 0 is the associated p-value, which is much below the 5% significance limit, and the t-statistic values are extremely negative. This indicates that the null hypothesis of a unit root has been rejected, proving that the price series are mean-reverting over time and free of stochastic trends.

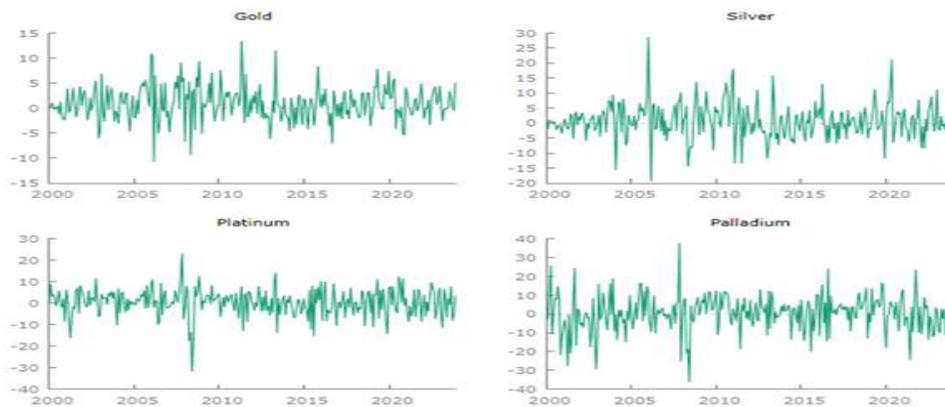
Table 2: Showing Descriptives Statistics

	Mean	Std. Dev.	Skewness	Kurtosis
Gold	0.93	3.33	0.23	4.26
Silver	0.76	5.65	0.46	5.90
Platinum	0.42	6.2	-0.64	5.47
Palladium	0.41	9.583	-0.29	4.50

Source: Authors Compilation

Gold has the highest mean monthly return (0.932%), followed by silver (0.767%), platinum (0.426%), and palladium (0.411%), according to the descriptive data. This implies that out of the four metals; gold continues to be the most lucrative and reliable investment. On the other hand, gold has the lowest standard deviation (3.339%), indicating that it is a reasonably safe-haven asset, while palladium has the highest (9.583%), indicating the biggest volatility. The skewness values show that whereas platinum and palladium show negative skewness, suggesting a propensity for negative price fluctuations, gold and silver returns are favorably skewed, suggesting a higher likelihood of significant positive returns. Kurtosis values larger than three are seen in all series, indicating leptokurtic distributions with fat tails and sharp price swings.

Figure 1: Monthly Return Time Series Plots for Bullion



Source: Gretl

The time series plots of bullion return (2000–2024) reveal clear volatility clustering, where stages of high volatility are followed by similar episodes. Gold shows relatively stable fluctuations, while silver, platinum, and especially palladium exhibit stronger and more frequent spikes, notably around the 2008 financial crisis and 2020 pandemic.

Table 3: Showing GARCH output

	Parameter	Coefficient	Std. Error	z-Statistic	p-Value	
Gold	Const	0.84	0.19	4.4	0**	Log-Likelihood −749.16
	α_0 (ARCH)	2.11	1.61	1.3	0.19	AIC 1508
	α_1	0.09	0.04	1.98	0.04**	
	β_1	0.71	0.17	4.02	0**	
Silver	Const	0.03	0.28	0.1	0.91	Log-Likelihood −888.73
	α_0 (ARCH)	4.72	2.65	1.77	0.07*	AIC 1787
	α_1	0.36	0.1	3.59	0**	
	β_1	0.54	0.11	4.71	0**	
Platinum	Const	0.47	0.3	1.58	0.11	Log-Likelihood −915.82
	α_0 (ARCH)	8.8	3.57	2.46	0.01**	AIC 1841
	α_1	0.3	0.08	3.43	0**	
	β_1	0.47	0.12	3.68	0**	
Palladium	Const	0.68	0.54	1.25	0.2	Log-Likelihood −1052.15
	α_0 (ARCH)	24.76	13.49	1.83	0.06*	AIC 2114
	α_1	0.16	0.09	1.83	0.06*	
	β_1	0.56	0.19	2.86	0**	

Source: Authors Compilation

Significant volatility clustering is seen in all bullion markets, according to the GARCH (1,1) model results for bullion returns. This is a typical occurrence in financial time series. The ARCH and GARCH coefficients for gold are both positive and substantial, and the persistence level ($\hat{\alpha} + \hat{\alpha} = 0.81$) shows that shocks fade over time and volatility is mean-reverting. With a greater persistence value ($\hat{\alpha} + \hat{\alpha} = 0.91$), the ARCH and GARCH effects are similarly strong in the case of silver, suggesting that volatility is extremely persistent and takes longer to normalize following market shocks. With a moderate persistence level ($\hat{\alpha} + \hat{\alpha} = 0.78$)

and significant ARCH and GARCH coefficients, platinum suggests mean-reverting volatility that is comparable to that of gold. Palladium's combined persistence value ($\hat{\alpha} + \hat{\alpha} = 0.74$), which indicates that long-term volatility impacts outweigh short-term shocks, shows that the GARCH component is strongly significant and the ARCH term is marginally significant. Overall, the results show that silver has the highest persistence, indicating a comparatively slower reaction to market shocks than the other metals, even though all four bullion markets show volatility clustering.

Table 4: Showing EGARCH output

	Equation	Parameter	Coefficient	Std. Error	z-Statistic	p-Value	
Gold	Mean	Constant (μ)	0.87	0.2	4.2	0***	Log-Lik-745.07
	Variance	ω (omega)	0.02	0.08	0.32	0.74	AIC: 1500.13574
		γ (gamma)	0.07	0.03	1.98	0.04**	BIC: 1518.45054
Silver	Mean	Constant	0.52	0.28	1.83	0.06*	Log-Lik-873.83
		AR (1)	0.17	0.06	2.55	0.01**	AIC: 1759.65885
	Variance	ω (omega)	0.26	0.23	1.1	0.27	BIC: 1781.61575
γ (gamma)		0.2	0.08	2.45	0.01**		
Platinum	Mean	Constant	0.68	0.32	2.12	0.03**	Log-Lik-912.31
		AR (1)	0	0.06	0.02	0.97	AIC: 1836.61088
	Variance	ω (omega)	0.45	0.41	1.09	0.27	BIC: 1858.56778
γ (gamma)		0.09	0.08	1.08	0.27		
Palladium	Mean	Constant	0.63	0.48	1.3	0.19	Log-Lik-1044.96
		AR (1)	0.09	0.07	1.3	0.19	AIC: 2101.92996
	Variance	ω (omega)	1.04	0.74	1.4	0.16	BIC: 2123.88686
		γ (gamma)	0.05	0.08	0.58	0.55	
	β_1	0.56	0.19	2.86	0**		

Source: Authors Compilation

Expanding on the findings of GARCH, the EGARCH(1,1) model investigates the asymmetric volatility in bullion markets. In contrast to the conventional GARCH model, EGARCH takes into consideration the varying effects of positive and negative shocks. The EGARCH(1,1) results show that the bullion markets have asymmetric volatility effects, which the typical GARCH model cannot account for. The significant $\tilde{\alpha}$ coefficients for gold and silver (0.071 and 0.207, respectively) show that negative shocks affect volatility more than positive shocks of the same size. The leverage effect frequently seen in financial assets is confirmed by this. On the other hand, palladium and platinum show negligible $\tilde{\alpha}$ terms, indicating symmetric volatility responses. In line with previous GARCH findings, the high $\hat{\alpha}$ values for all metals confirm ongoing volatility. The EGARCH model better reflects the asymmetric nature of price changes and has superior explanatory power (lower AIC and BIC values) than the GARCH model.

DISCUSSION

Bullion prices have stable statistical characteristics, such as a constant mean and variance, according to the stationarity results, which makes them appropriate for GARCH-type models of volatility. The absence of a unit root implies

that price shocks are transient, which is in line with research by Bentes (2015) and Hammoudeh et al. (2009) and supports the application of GARCH and EGARCH frameworks. In order to capture persistence and asymmetry, descriptive statistics validate time-varying volatility patterns and show non-normal returns and volatility clustering. Palladium and platinum exhibit higher volatility and speculative behaviour, which is consistent with Sensoy (2013) and Hammoudeh et al. (2009), whereas gold exhibits greater stability and serves as a safe-haven asset. The output of GARCH(1,1) validates the importance of ARCH and GARCH terms by confirming strong volatility persistence across all metals. Strong persistence ($\hat{\alpha} + \hat{\alpha} > 1$) and asymmetric effects ($\tilde{\alpha}$) in gold and silver are further highlighted by EGARCH(1,1) results, which show that negative shocks exacerbate volatility additional than positive ones. Baur and Lucey (2010) and Athari (2014), who connected asymmetry to the safe-haven qualities of gold and silver, are in agreement with this leverage effect. Similarly, EGARCH successfully captures these trends in commodities markets, as demonstrated by Arouri et al. (2015). The findings underline the applicability of GARCH and EGARCH models in assessing persistent and asymmetric volatility in bullion markets. Overall, the results confirm that gold is still the most stable metal, transmitting

but absorbing less volatility, while other metals show more sensitivity.

CONCLUSION

This study used GARCH (1,1) and EGARCH (1,1) models using monthly data from April 2000 to March 2024 to examine the volatility characteristics of the Indian bullion market, with a focus on platinum, gold, silver, and palladium. As is typical of financial time series, the data show notable volatility clustering across all metals, showing that periods of high volatility are frequently followed by additional instability. Gold exhibited comparatively stable and mean-reverting behaviour, reinforcing its position as a safe-haven asset, while silver demonstrated the highest persistence of volatility among the metals. By exposing asymmetric volatility effects in the gold and silver markets where negative shocks raise volatility more than positive shocks of similar magnitude the EGARCH results provide greater understanding. This leverage impact emphasizes how susceptible these metals are to unfavorable market circumstances. Palladium and platinum, on the other hand, showed symmetric responses, suggesting more evenly distributed responses to market swings. All metals have great persistence (high $\hat{\alpha}$ values), which is indicative of sustained volatility transmission, especially during significant world events like the 2020 pandemic and the 2008 financial crisis. These results are in keeping with additional studies that found volatility clustering, persistence, and asymmetry in precious metal markets, including Hammoudeh et al. (2009), Bentes (2015), and Arouri et al. (2015). The findings highlight how crucial it is to use asymmetric models, like as EGARCH, rather than conventional GARCH frameworks in order to better represent the complex nature of bullion price changes. Every research topic that was posed in this study whether asymmetric effects exist, if volatility persists over time, and whether bullion price changes are time-varying has been sufficiently addressed. Gold is still a reliable investment choice overall, but silver and other metals are riskier and react more strongly to adverse shocks. In order to create effective hedging and risk management plans for the Indian bullion market, traders, investors, policymakers can all benefit from these insights.

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