RESEARCH ARTICLE

Quantile Regression Modelling of Gold Price Determinants in India

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Abstract

This study investigates the relationship between the price of gold and key economic indicators, namely the exchange rate, inflation, Nifty 50, and interest rate in the Indian context. The primary focus is on understanding how these variables influence the gold price across different quantiles, particularly in heteroscedasticity. This research focuses on analyzing the impact of the exchange rate, inflation, Nifty 50, and interest rate on the gold price and determining how these relationships vary across different quantiles of the gold price distribution. This analytical research examines factors influencing Indian gold prices from 2019-2020 to 2023-2024 using longitudinal data. Data is sourced from government reports, websites, and research papers. Employing quantile regression, the study investigates the impact of the Nifty 50, inflation, interest rates, and exchange rates on gold prices in India. It has been concluded that Exchange Rate and Interest across all quantiles, the exchange rate has a significantly positive impact, and the interest rate negatively impacts the gold price. Nifty 50 and Inflation do not significantly affect the gold price, as indicated by their P-values being higher than the significance level across all quantiles.

1. Introduction

Gold has emerged as a pivotal asset in the global economic landscape. Its price has surged dramatically, increasing by approximately 175% from Rs. 26,703 per ten grams in January 2014 to Rs. 73,390 by December 2023. This escalating value underscores the commodity's growing significance in business and geopolitical arenas. Historically recognized as a reliable hedge against inflation, gold's role has been extensively studied (Baber et al., 2013; M & Marisetty, 2023). Moreover, its price is intricately linked to exchange rate fluctuations, as the global commodity market is predominantly denominated in US dollars (Kavalis, 2006; Kannan & Dhal, 2008; Raza et al., 2021). Interest rates also substantially influence gold and financial market dynamics (Silva et al., 2023). Research has further demonstrated the negative impact of exchange rate and gold price volatility on stock market returns (Ali et al., 2020).

Gold has historically played a dual role in financial systems—both as a safe-haven asset and as a hedge against inflation and currency depreciation. In emerging economies like India, which is among the largest consumers of gold globally, the dynamics of gold price fluctuations are of significant interest to policymakers, investors, and researchers. Understanding the determinants of gold prices is particularly crucial because of their close linkages with macroeconomic variables such as exchange rates, inflation, stock markets, and global commodity prices. However, the relationship between these factors and gold prices is often nonlinear, asymmetric, and heterogeneous across different market conditions, making it important to explore the determinants using advanced econometric approaches such as quantile regression.

Several studies have highlighted the interconnectedness of gold with other financial and commodity markets. For instance, Arora, Daniel, and Aditya (2024) demonstrate that in India, gold prices exhibit intricate interdependencies with oil, stock, and forex markets, with macroeconomic shocks creating volatility spillovers across these sectors. Similarly, Asad et al. (2020) establish that the gold–oil exchange rate nexus is nonlinear and regime-dependent, showing that during the 2008 global financial crisis, asymmetric shocks to gold and oil prices significantly influenced the Bombay Stock Exchange, reflecting gold's importance as a stabilizing asset in turbulent times. Beyond the Indian context, Mohammed (2021) provides evidence from Ghana that oil price shocks can have differential effects on exchange rates, inflation, and monetary policy, underscoring the importance of considering multiple sources of shocks and their indirect influence on gold price behavior. At the global level, Davidson and Faff (1999) argue that gold acts as an "extra-market factor," influencing national market portfolios beyond standard market risks, thereby reinforcing its role as a unique financial instrument distinct from conventional asset classes.

The present study applies quantile regression modeling to analyze the determinants of gold prices in India, focusing on key macroeconomic and financial variables such as exchange rates, inflation, stock market indices, and interest rates. By examining the effects across different quantiles, this research seeks to capture the asymmetric and heterogeneous nature of these relationships, thereby providing deeper insights for policymakers, investors, and portfolio managers.

2. Literature review

Existing research has explored the multifaceted determinants of gold prices. Studies have identified varying relationships between gold and key macroeconomic indicators. While some research suggests a positive correlation between gold prices and inflation and the US dollar (Baber et al., 2013; M & Marisetty, 2023), others find this relationship to be weak or even negative (D'Silva et al., 2023). Exchange rate dynamics have also been linked to gold price movements. Several studies emphasize the significant impact of exchange rate fluctuations on gold prices, particularly the Indian rupee's strength against major currencies (Kannan & Dhal, 2008; Raza et al., 2021; M & Marisetty, 2023). However, the nature of this relationship can be complex, depending on the currency involved (Chen et al., 2017). The interplay between gold, exchange rates, and stock markets has also attracted scholarly attention. Research indicates that volatility in these markets can negatively impact stock market performance, as represented by indices like the BSE Sensex (Ali et al., 2020; Aftab et al., 2019; M & Marisetty, 2023). Nevertheless, the exact nature of the relationship between gold prices and stock market indices remains complex and requires further investigation.

Recent empirical studies have revealed important relationships between macroeconomic factors and gold price dynamics. Soeharjoto et al. (2020) established that currency exchange rates positively influence gold prices while interest rates demonstrate an inverse relationship, though inflation showed no statistically significant impact. Their findings suggest monetary authorities should prioritize exchange rate stability to maintain gold price equilibrium, with manufacturers potentially increasing value through product innovation and diversification. Singh (2013) demonstrates gold's investment viability, showing a consistent 12.27% annual growth that reinforces its status as a reliable hedge asset. However, the study notes that post-2011 market conditions, particularly Eurozone capital flight and dollar appreciation, temporarily reduced gold's traditional risk-hedging performance. Rengarajan & Varshini

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(2024) provide a comparative institutional analysis of India's gold loan market, revealing distinct operational characteristics across financial sectors. Private banks emphasize processing efficiency at premium rates, public banks offer competitive rates with more stringent requirements, while NBFCs balance accessibility with higher costs - a trade-off that's increasingly attracting borrowers due to their responsive valuation methods and rapid disbursement. Kannan & Dhal's (2008) foundational work developed a comprehensive demand model for India's gold market, incorporating economic variables like real income, relative prices, and policy-sensitive indicators (interest rates, equity values, currency rates, taxation, and public expenditure). This established gold's dual role as both a consumption good and an investment asset in emerging economies. Advanced econometric analysis by Raza et al. (2021) identified asymmetric causal relationships in G7 nations, with exchange rate fluctuations particularly influencing gold prices during market extremes. These insights carry significant implications for monetary authorities and institutional investors managing currency-gold exposure. According to Wang & Lin (2024) introduces an innovative QRBiLSTM-MOALO hybrid model is introduced that achieves unprecedented prediction accuracy (AIS scores of -15.6240 and -11.5581 at 90%/95% confidence levels). This methodological advancement incorporates pandemic-related volatility factors, setting new standards for commodity price modeling in turbulent markets.

2.1 Objectives of the study

1. To examine the relation between gold prices, inflation, exchange rate, Nifty 50, and interest rates in India.

2. To analyze the impact of inflation, exchange rate, Nifty 50, and interest rates on gold prices in the Indian context.

2.2 Hypotheses of the study

$H0_1$: there is a significant relationship between gold prices, inflation, exchange rate, Nifty 50, and interest rates in India.

$H0_2$: there is a significant impact of inflation, exchange rate, Nifty 50, and interest rates on gold prices in India.

2.2.1 Sub-hypotheses

$H0_{2a}$: there is a significant impact of inflation on gold prices in India.

$H0_{2b}$: there is a significant impact of the exchange rate on gold prices in India.

$H0_{2c}$: there is a significant impact of Nifty 50 on gold prices in India.

$H0_{2d}$: there is a significant impact of interest rates on gold prices in India.

3. Research methodology

This analytical research examines factors influencing Indian gold prices from 2019-2020 to 2023-2024 using longitudinal data. Data is sourced from government reports, websites, and research papers. Employing quantile regression, the study investigates the impact of the Nifty 50, inflation, interest rates, and exchange rates on gold prices. This approach provides a detailed understanding of how these variables affect gold prices across different quantiles.

3.1 Limitations

The study is limited by its focus on the Indian market and the specific economic indicators chosen. The findings might not be generalizable to other markets or periods.

4. Interpretation and Results

4.1 Correlation Analysis

The correlation analysis indicates that there are several statistically significant relationships among gold prices, exchange rate, Nifty50 index, and interest rates in India. Strong and positive correlations were observed between

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gold price and exchange rate (r = 0.867, p < 0.01), gold price and Nifty50 (r = 0.780, p < 0.01), exchange rate and Nifty50 (r = 0.799, p < 0.01), and exchange rate and interest rate (r = 0.726, p < 0.01). Moderate but significant associations were also found between gold price and interest rate, and between interest rate and Nifty50. Weak yet statistically significant correlations emerged between gold price and inflation, and between exchange rate and inflation. However, no statistically significant relationship was detected between inflation and interest rate or between inflation and Nifty50, suggesting that inflation behaves independently of these variables within the sample period.

In order to test the first hypothesis, the authors have used multiple correlation analysis in SPSS, and the following is the result.

Table I Correlation Matrix

		goldprice	exchangerate	inflation	interesetrate	nifty50
Correlations						
goldprice	Pearson Correlation	1	.867¨	.341¨	.457¨	.780¨
	Sig. (2-tailed)		0.000	0.009	0.000	0.000
	N	60	60	58	57	60
exchangerate	Pearson Correlation	.867¨	1	.260˙	.726¨	.799¨
	Sig. (2-tailed)	0.000		0.048	0.000	0.000
	N	60	60	58	57	60
inflation	Pearson Correlation	.341¨	.260˙	1	-0.152	0.083
	Sig. (2-tailed)	0.009	0.048		0.269	0.537
	N	58	58	58	55	58
interesetrate	Pearson Correlation	.457¨	.726¨	-0.152	1	.526¨
	Sig. (2-tailed)	0.000	0.000	0.269		0.000
	N	57	57	55	57	57
nifty50	Pearson Correlation	.780¨	.799¨	0.083	.526¨	1
	Sig. (2-tailed)	0.000	0.000	0.537	0.000	
	N	60	60	58	57	60

¨¨. Correlation is significant at the 0.01 level (2-tailed).

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*. Correlation is significant at the 0.05 level (2-tailed).

According to the table above, the first null hypothesis is rejected, indicating a significant relationship between the variables, except for the two pairs: Inflation-Interest rate and Inflation-Nifty 50.

Therefore, the null hypothesis of no relationship is rejected for most variable pairs, and the findings partially support the hypothesis that there is a significant relationship between gold prices, inflation, exchange rate, Nifty50, and interest rates in India, except for inflation's non-significant links to interest rates and the stock market.

4.2 Empirical Analysis

Based on the Variance Inflation Factor (VIF) test results, the model demonstrates moderate multicollinearity, with all predictor variables (exchange rate, Nifty50, and interest rate) showing VIF values above 2 but below the common critical threshold of 5. The mean VIF of 2.94 confirms that multicollinearity is present to a degree that warrants attention but is not severe enough to critically undermine the regression model or necessitate the removal of variables.

Table II: Variance inflation factor

Variable	VIF	1/VIF
exchangerate	6.59	0.151852
nifty50	3.76	0.266241
interesetr~e	2.73	0.366496
inflation	1.33	0.753614
Mean VIF	3.60	

Source: STATA Output

None of the variables cross the critical VIF value of 10 (or even the stricter cutoff of 5 used in some studies). Therefore, your regression model does not suffer from problematic multicollinearity, and the independent variables can be reliably used to explain gold price determinants.

According to the Breusch-Pagan test results showing a statistically significant p-value of 0.0351, we reject the null hypothesis of constant variance and conclude that heteroscedasticity is present in the regression model, indicating that the error variance systematically changes with the fitted values of gold price.

There are five variables, namely price of Gold (the outcome variable), exchange rate, inflation, Nifty 50, and Interest rate are the predictor variables. As mentioned above, the data is collected for the preceding 5 years. The data is found to bear heteroscedasticity as the Pagon test verifies that the data is not homogeneous, as the p-value is 0.0351, which is less than the significance level of 0.05. That is why the authors used Quantile Regression to study the relationship between the price of gold and the predictor variables.

The model employed for the study is:

$$Q_{Y_t}(\tau) = \beta_0(\tau) + \beta_1(\tau)N_t + \beta_2(\tau)I_t + \beta_3(\tau)R_t + \beta_4(\tau)E_t + \epsilon_t(\tau) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \textit{(1)}$$

$Q_{Y_t}(\tau)$ is the quantile τ of the gold price at time t; $\beta 0(\tau)$ is the intercept for quantile τ;

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$\beta_1(\tau)$, $\beta_2(\tau)$, $\beta_3(\tau)$, and $\beta_4(\tau)$ are the coefficients for Nifty 50, inflation, interest rate, and exchange rate, respectively, for quantile τ; $\epsilon_t(\tau)$ is the error term for quantile τ.
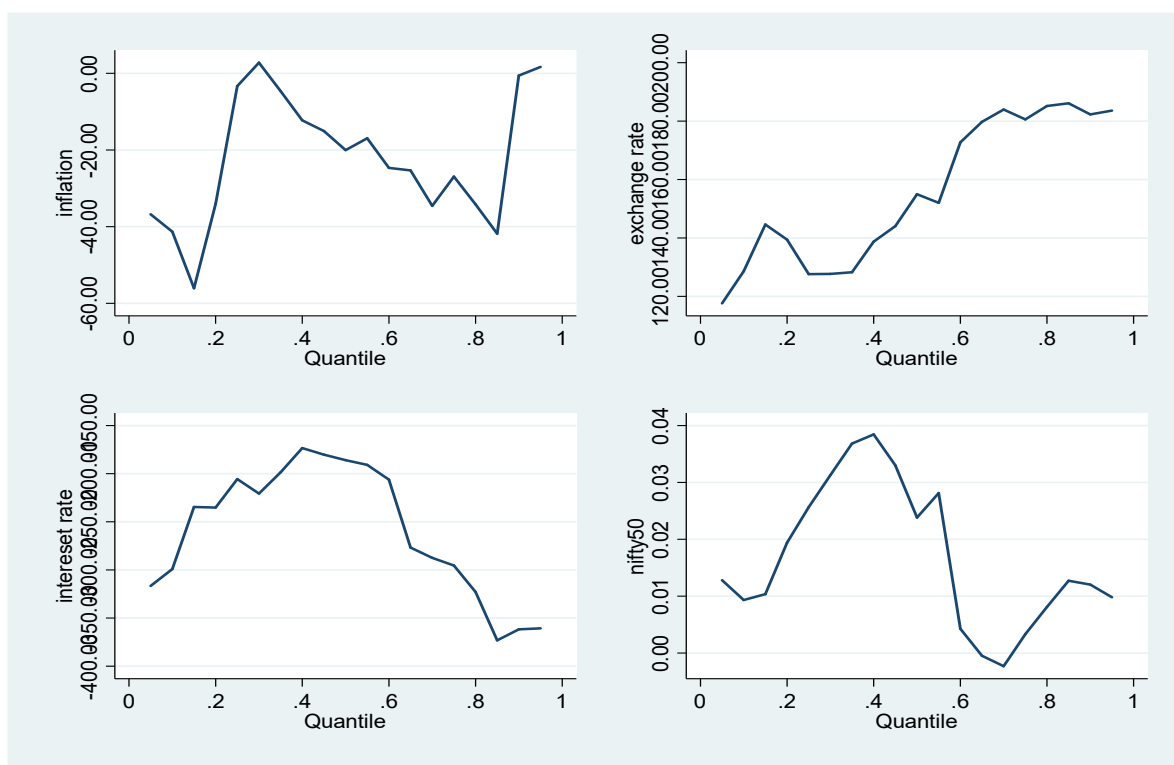
Table III: Quantile Regression Results

Quantiles	Quantile (0.10) (I)		Quantile (0.25) (II)		Quantile (0.50) (III)		Quantile (0.75) (IV)		Quantile (0.90) (V)	
gold price	Coef.	t (P>t)	Coef.	t (P>t)	Coef.	t (P>t)	Coef.	t (P>t)	Coef.	t (P>t)
exchange rate	128.6181	4.19 (0.000)	127.6342	3.83 (0.000)	154.9966	5.81 (0.000)	180.5958	6.33 (0.000)	182.3175	7.19 (0.000)
inflation	-41.31078	-0.77 (0.444)	-3.321521	-0.06 (0.955)	-20.02422	-0.43 (0.669)	-26.94634	-0.54 (0.590)	-.5812002	-0.01 (0.990)
nifty50	.0093297	0.30 (0.763)	.0256494	0.77 (0.445)	.0238276	0.89 (0.376)	.0033303	0.12 (0.908)	.0120417	0.47 (0.637)
interest rate	-299.1012	-3.54 (0.001)	-205.6761	-2.24 (0.029)	-185.9367	-2.53 (0.015)	-295.4037	-3.76 (0.000)	-361.7668	-5.18 (0.000)
_cons	-4140.865	-2.62 (0.011)	-4846.219	-2.83 (0.007)	-6750.825	-4.92 (0.000)	-7635.599	-5.21 (0.000)	-7552.552	-5.80 (0.000)

Source: STATA Output

Quantile regression considers the extreme values to reveal the impact of the predictor on the outcome. Table no. III at Q=0.10 depicts that the price at the lower quantile is significantly affected by the exchange rate and interest rate, as their (P> t) is less than the significance level. With an additional increase in the exchange rate, the price of gold rises by ₹128.618, which is the coefficient of the exchange rate that shows the magnitude change among the quantiles, but as the coefficient of interest rate is negative implies that an additional increase in the interest rate leads to a fall in the prices of gold by ₹299.1012. which is depicted in Graph I of the interest rate, which starts from the negative y-axis. The reason behind the converse association of exchange rate and interest rate with gold price the outcome variable can be that since U.S. dollars are usually used to trade gold, a rise in the exchange rate—that is, a decline in the value of the local currency in relation to the dollar—raises the price of gold in local currency and hence increases investor demand. While the other two variables, Nifty 50 and inflation, are not significant predictors of the gold price, as their (P>t) is more than the significance level.   Similarly, the effect of the result as depicted by column II in Table II is almost the same as that of Column I. So, both the lower quantiles have the same impact on the gold price, but the magnitude of change is different; the positive impact has been improved, while the negative impact has been reduced, and that's why the graph of all four quantiles under the lower quantile is improving overall.

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Graph I

Source: STATA Output

At the median quantile 0.50, the exchange rate and interest rate are again significant predictors of the gold price by ₹154 and a fall in price by ₹185, respectively, due to an additional increase in the variable units, respectively. While the Nifty 50 and inflation are not significant predictors of the gold price. At the higher quantiles 0.75 and 0.90, the exchange rate is again a positive significant predictor, and the interest rate is a negative significant predictor of the gold price.

While analyzing Graph I, the impact of the exchange rate is positive at lower quantiles of gold price, between 0.20-0.30 quantiles, the impact remains stable, after that it starts increasing and reaches the peak at the higher quantiles of gold price. The exchange rate is a significant predictor.

The impact of the interest rate is negative across all the quantiles, implying a fall in gold price due to an increase in interest rate, but the magnitude of the fall in price starts falling at higher quantiles. The magnitude keeps on increasing till the 0.30 quantile and starts dropping gradually after the 0.40 quantile, and reaches a minimum at the extreme level of the quantile of the gold price. This implies that higher interest rates are associated with lower gold prices across all the quantiles. It implies that lower gold quantiles are more sensitive to changes in the interest rate. A decline in the demand for gold and consequently lower prices could result from investors preferring interest-bearing bonds or savings accounts. The robust and stable negative correlation underscores the noteworthy impact of interest rates on the price of gold. Nifty 50 starts with a positive impact before the 0.25 quantile and reaches the peak till the median quantiles and gradually lowers at a higher quantile, say 0.70. After a short peak, it again starts falling at extreme quantiles. In this way, the second objective of the study is achieved.

4.3 Results

H0₁: There exists a significant relationship between gold prices, inflation, exchange rate, Nifty50, and interest rates in India. Correlation analysis confirmed strong positive links of gold prices with the exchange rate and Nifty50, and moderate associations with interest rates, while inflation showed a weak but significant influence.

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H0$_d$: Inflation, exchange rate, Nifty50, and interest rates significantly impact gold prices in India. Quantile regression established exchange rate (positive) and interest rates (negative) as consistent predictors across quantiles, while Nifty50 and inflation showed no significant impact.

H0$_{2a}$: Inflation does not have a significant impact on gold prices, as both correlation and quantile regression results indicate weak or insignificant influence.

H0$_{2b}$: The exchange rate has a significant and positive impact on gold prices across all quantiles, with stronger effects at higher quantiles.

H0$_{2c}$: Nifty50 does not significantly influence gold prices in the regression model, despite showing a positive correlation with gold prices.

H0$_{2d}$ Interest rates exert a significant and negative impact on gold prices across all quantiles, with stronger sensitivity observed at lower quantiles.

5. Conclusion

The quantile regression analysis establishes that exchange rates and interest rates are the primary determinants of gold prices in India, with the former exerting a positive effect and the latter a negative effect across quantiles. The magnitude of these impacts varies, highlighting gold's asymmetric sensitivity to macroeconomic conditions. In contrast, inflation and the Nifty50 index show no significant influence on gold prices during the study period, suggesting their limited role as predictors in this context. Overall, the findings reject the null hypothesis and confirm that variations in key macroeconomic and financial factors critically shape gold price dynamics in India.

Statements and Declarations

Author(s) declaration

The author(s) declares that the manuscript has not been published elsewhere and is not under consideration by any other journal.

Ethical considerations

Not applicable. The study is based on secondary data sources and does not involve human participants or animals.

Declaration of conflicting interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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