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The Impact of Macroeconomic Factors on Gold Prices

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Abstract:

This study analyzes the influence of significant macroeconomic variables, like interest rates, inflation, GDP growth rates, and currency rates, on gold prices. Analysis of a 20-year dataset from 2003 to 2023, employing descriptive statistics and regression techniques, demonstrates substantial connections between these variables and changes in gold prices. The results show that inflation and exchange rates have a positive relationship with gold prices, while GDP growth rate has a modest inverse relationship. Interest rates exhibit a weak inverse relationship, although it is not statistically significant. The model explains approximately 93% of the variation in gold prices, underscoring the complex interplay between macroeconomic factors and gold price movements. The results are significant for investors aiming to mitigate inflation or economic instability, as well as for policymakers evaluating the effects of monetary policy on gold demand. This research contributes to the understanding of gold's role in the global financial system and highlights areas for future investigation, including the incorporation of additional factors and advanced modelling techniques.

Keywords: Gold prices, Macroeconomic factors, GDP growth rate, Interest rates, Inflation, Exchange rates, Regression analysis.

1.1 Introduction:

Gold has significantly influenced the world economy for numerous years. It is sometimes seen as a "safe haven" investment due to its propensity to maintain or increase in value during periods of economic upheaval or uncertainty. During financial crises, periods of inflation, or political unrest, many investors turn to gold as a way to protect their wealth. Gold is also considered a hedge against inflation since its value usually rises when the purchasing power of money decreases. These qualities make gold a popular choice for investors seeking stability during uncertain economic times.

The price of gold is affected by multiple economic factors, including inflation, interest rates, and currency exchange rates. Inflation diminishes the value of currency, prompting investors to acquire gold to preserve their capital. Interest rates can influence the attractiveness of gold relative to alternative investments, such as bonds or savings accounts. Exchange rate fluctuations also affect gold prices, as they determine the cost of gold in different currencies and influence global demand.

This research seeks to analyze the influence of critical economic variables like inflation, interest rates, and currency rates on gold prices. This research aims to elucidate how economic factors affect the value of gold through the analysis

of these linkages. This understanding is valuable for investors who rely on gold to secure their investments and for policymakers and central banks who track economic trends and make decisions based on them.
This research seeks to elucidate how these factors affect gold prices, assisting investors in making informed decisions and managing risks more adeptly. It underscores the significance of comprehending gold's function in mirroring or shaping overarching economic patterns. This research will enhance the comprehension of gold's role in the global financial system.

1.2 Literature Review:

Gold has traditionally served as a crucial asset in financial markets, both as a hedge against inflation and a refuge during economic instability. Research conducted by Ghosh et al. (2004) and Capie et al. (2005) underscores gold's efficacy in value preservation during high inflation since its price typically increases as currency purchasing power diminishes. Similarly, Baur and McDermott (2010) and Malik and Sadiq (2019) underscore gold's role as a secure investment during financial crises, showing that it tends to perform well when traditional markets are unstable. These findings solidify gold's reputation as a reliable choice for safeguarding wealth in volatile economic conditions.
Macroeconomic variables like interest rates, monetary policies, as well as exchange rates profoundly affect gold prices. Joy and Jensen (2018) and Kumar and Dixit (2020) discovered that diminished interest rates and expansionary monetary policies frequently enhance the appeal of gold by decreasing returns on alternative investments. Exchange rate fluctuations also play a role, with studies by Fayaz and Bouri (2017) and Reboredo (2013) demonstrating that weaker currencies or a declining U.S. dollar typically drive gold prices higher, as gold becomes more expensive in local terms.
Emerging trends, including demographic changes, environmental policies, and technological innovations, are reshaping the gold market. Kumar and Zhang (2024) noted that aging populations in emerging economies are driving higher demand for gold as a long-term investment. Meanwhile, Stevens and Richardson (2023) highlighted the impact of environmental regulations on mining costs, potentially increasing gold prices. Additionally, advancements like gold-backed digital assets and AI-driven price predictions, as explored by Williams and Thompson (2024) and Yamamoto and Lee (2024), are transforming how gold is traded and valued. These developments reflect the evolving factors that influence gold's role in global financial systems.

2.1 Data Collection

The examination of global gold price variations is based on descriptive and regression analysis of 20 years of annual data concerning gold prices, global interest rates, inflation rates, GDP growth rates, as well as exchange rates. The data we gathered spans from 2003 to 2023 to encompass the significant outliers presented by the 2008 subprime financial crisis and the COVID-19 pandemic. Data availability for all variables throughout the given period was assured to preserve consistency.

We collected gold price data in terms of dollars per oz from World Bank Commodity price data (The Pink Sheet) to serve as the dependent variable in our model. The scope of the analysis serves well with yearly data on the variables. The chosen independent macroeconomic variables in the model are: interest rate, inflation rate, GDP growth rate, and exchange rates. We derived the sample dataset from the benchmark index, Federal Reserve Bank. Interest rates are central bank interest rates, as they influence opportunity costs for holding gold, a non-interest-bearing asset. For inflation data, we chose Consumer Price Index (CPI), as it reflects the changes in purchasing power of the global economy. The exchange rate in the model illustrates the need for gold as a safeguard against currency devaluation. The focus was on U.S. Dollar Index, which measures the USD's value against major currencies, here, we took the measure of USD's value against EUR (USD/EUR).

2.2.1 Descriptive Analysis:

To find the data distribution of all the variables, we conducted descriptive statistics. The calculated summary statistics that involve mean, standard deviation, range, skewness, and kurtosis are analysed to infer broad understanding of each sample, that is the gold prices and the macroeconomic variables under consideration.

2.2.2 Hypothesis development

The descriptive framework performed previously gave the overview of each dataset as per the existing literature given by Malik, F., & Sadiq, M. (2019) in which they discuss the impact of economic crises on gold prices, such as the 2008 crisis which is implied in our model as outliers and thereby analysing its results in such events. The behaviour of gold prices can be examined through the lens of Ghosh, D et al. (2004); Ciner, C et al (2013); Reboredo, J. C. (2013); and Zhang, D., & Wei, Y. (2021). Based on the findings, we generate hypothesis as follows:
H1: Higher interest rates lead to a decrease in gold prices.
H2: An increase in inflation leads to an increase in gold prices.
H3: A higher GDP growth rate is associated with increasing gold prices.
H4: Increase in exchange rate leads to an increase in gold prices.

2.2.3 Hypothesis testing: t-test

To test the hypotheses developed previously we made use of a t-test for two samples, that is sample of gold prices and each macroeconomic variable and we assessed the statistical significance of each coefficient by making use of the p-values. Significance levels will indicate which factors are statistically influential in explaining changes in gold prices. P values less than 0.05 will imply that we fail to accept our null hypothesis.

2.2.4 Regression Analysis: Linear Regression:

In addition to our significant relationship between gold prices and macroeconomic variables in the t-test model, we performed a simple linear regression analysis to determine the relationship between gold prices and each macroeconomic indicator, as well as the degree of influence each independent macroeconomic variable exerts on gold prices by formulating a linear regression equation.

Regression equation:

$$\textbf{Gold Prices} = \alpha + \beta 1(\textbf{Interest rate}) + \beta 2(\textbf{Inflation Rates}) + \beta 3\ (\textbf{GDP growth Rates}) + \beta 4\ (\textbf{USD/EUR Rate}) + \epsilon$$

where,

α is intercept

B is the coefficient representing the influence of each macroeconomic variable on gold prices

ϵ is the error term.

The model diagnostic test was conducted by assessing goodness-of-fit statistics like R-squared and Adjusted R-squared, which indicate the extent to which the specified macroeconomic factors account for the fluctuation in gold prices.

3.1 Descriptive statistics

Table1: Descriptive summary of gold prices ($/oz)

Gold prices ($ per oz)	
Mean	1199.806568
Standard “Error	85.9770273
Median	1266.060284
Mode	#N/A
Standard Deviation	384.5009551
Sample Variance	147840.9845
Kurtosis	-0.544481745
Skewness	-0.488012315
Range	1326.971395
Minimum	481.2555373
Maximum	1808.226932
Sum	23996.13136
Count	20
Largest(1)	1808.226932
Smallest(1)	481.2555373
Confidence” Level(95.0%)	179.9519863

Table 2: Descriptive summary of interest rate

Interest “rate (%)	
Mean	1.497
Standard Error	0.39252898
Median	0.695
Mode	#N/A
Standard Deviation	1.75544296
Sample Variance	3.08158
Kurtosis	0.23481199
Skewness	1.20617554
Range	4.95
Minimum	0.08
Maximum	5.03
Sum	29.94
Count	20
Largest(1)	5.03
Smallest(1)	0.08
Confidence” Level(95.0%)	0.8215726

Table 3: Descriptive summary of inflation rate

Inflation rate (CPI) (%)	
Mean	2.570056
Standard Error	0.402861
Median	2.286347
Mode	#N/A
Standard “Deviation	1.801651
Sample Variance	3.245947
Kurtosis	3.451957
Skewness	1.287289
Range	8.358346
Minimum	-0.35555
Maximum	8.0028
Sum	51.40113
Count	20
Largest(1)	8.0028
Smallest(1)	-0.35555
Confidence” Level(95.0%)	0.843199

Table 4: Descriptive summary of GDP growth rate

GDP Growth rate (%)	
Mean	5.22906
Standard “Error	1.28475
Median	5.228414
Mode	#N/A
Standard Deviation	5.745578
Sample Variance	33.01167
Kurtosis	-0.56639
Skewness	-0.35508
Range	19.63902
Minimum	-5.6759
Maximum	13.96311
Sum	104.5812
Count	20
Largest(1)	13.96311
Smallest(1)	-5.6759
Confidence” Level(95.0%)	2.689013

Table 5: Descriptive summary of USD/EUR rate

Exchange "rates	
Mean	1.23761
Standard Error	0.027213
Median	1.24435
Mode	#N/A
Standard Deviation	0.121698
Sample Variance	0.01481
Kurtosis	-1.07497
Skewness	0.218916
Range	0.4192
Minimum	1.0534
Maximum	1.4726
Sum	24.7522
Count	20
Largest(1)	1.4726
Smallest(1)	1.0534
Confidence" Level(95.0%)	0.056957

3.2 Hypothesis testing using "t-test

Table 6: t-test Two-Sample Assuming Unequal Variances

	Gold price	*Interest rate*
Mean	1199.81	1.50
Variance	147840.98	3.08
Observations	20.00	20.00
Hypothesized Mean Difference	0.00	
Df	19.00	
t Stat	13.94	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.73	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.09"	

	Gold price	*Inflation "rate*
Mean	1199.8066	2.570056362
Variance	147840.98	3.245946842
Observations	20	20
Hypothesized Mean Difference	0	
df	19	
t Stat	13.924922	
P(T<=t) one-tail	1.011E-11	
t Critical one-tail	1.7291328	
P(T<=t) two-tail	2.021E-11	
t Critical two-tail	2.0930241"	

	Gold price	*GDP "Growth rate*
Mean	1199.806568	5.229060185
Variance	147840.9845	33.01166633
Observations	20	20
Hypothesized Mean Difference	0	
Df	19	
t Stat	13.89259664	
P(T<=t) one-tail	1.05216E-11	
t Critical one-tail	1.729132812	
P(T<=t) two-tail	2.10432E-11	
t Critical two-tail	2.093024054"	

	Gold price	*Exchange rate*
Mean	1199.8066	1.23761
Variance	147840.98	"0.014810482
Observations	20	20
Hypothesized Mean Difference	0	
df	19	
t Stat	13.940572	
P(T<=t) one-tail	9.91E-12	
t Critical one-tail	1.7291328	
P(T<=t) two-tail	1.982E-11	
t Critical two-tail	2.0930241"	

3.3 Regression Analysis

Table 7: Linear "Regression Summary

Regression Statistics	
Multiple R	0.96
R Square	0.93
Adjusted R Square	0.85
Standard Error	383.39
Observations	20.00

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	4.00	29247867.45	7311966.86	49.74	0.00
Residual	16.00	2351827.25	146989.20		
Total	20.00	31599694.71			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.00	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A"
Interest rate (%)	-79.25	54.65	-1.45	0.17	-195.11	36.60	-195.11	36.60
Infaltion rate (CPI%)	149.11	56.91	2.62	0.02	28.47	269.75	28.47	269.75
GDP Growth rate	-43.73	18.42	-2.37	0.03	-82.77	-4.68	-82.77	-4.68
US/EU Exchange rate	927.84	121.41	7.64	0.00	670.46	1185.22	670.46	1185.22

Regression equation: $Y = -79.25 X1 + 149.11 X2 - 43.73 X3 + 927.84 X4$

3.4 Analysis

3.4.1 Descriptive Statistics

This shows the central tendencies and variability of each macroeconomic factor ie. Interest Rate (%), Inflation Rate (CPI) (%), GDP Growth Rate (%), and Exchange Rates for each year and gold prices (in $ per ounce) during the observed period. We tabulated the key findings from Table 1 – Table 5 to draw broad implications:

GOLD PRICES:

S.no.	Descriptive statistics	Value
1	Mean	1199.81
2	Standard deviation	384.5
3	Range	$481.26 to $1,808.23
4	Skewness	-0.49
5	Kurtosis	-0.54

Inference 1: The mean (1199.81) and the standard deviation (384.5) are both high and show a large oscillation range in the gold prices; hence, the descriptive statistics portray gold as a very volatile asset. The vast gap of $1,808.23 to $481.26 can be interpreted as a high peak and must have been caused because of periods of depression or hyperinflation. A negative skewness value (-0.49) means that low prices dominate and are very often witnessed, while a flat kurtosis value (-0.54) indicates that there is an average distribution and not too many extreme outlier values. All these trends together suggest a common feature of the market – it is very dynamic, but the prices are usually in the lower ranges.

INTEREST RATE (%)

S.no.	Descriptive statistics	Value
1	Mean	1.50%
2	Standard deviation	1.75%
3	Range	0.08% to 5.03%
4	Skewness	1.21

Inference 2: The analysis shows that the period in consideration had low interest rates on average, with the average interest rate being 1.50%. On the other hand, there is a notable standard deviation of 1.75%, which shows quite a bit of fluctuation. The broad range (0.08% to 5.03 respectively) is representative of variances due to different economic phases. With a positive skewness figure of about 1.21, while it was common to have low rates there were short bursts of high rates during the periods of economic distress.

INFLATION RATE (CPI) (%)

S.no.	Descriptive statistics	Value
1	Mean	2.57%
2	Standard deviation	1.8%
3	Range	-0.35% to 8.00%

Inference 3: The average figure of 2.57% can be interpreted as low average inflation over the evaluated period. The moderating impact of a standard deviation of 1.8% shows that inflation rates have not been static and have recorded significant changes over the period measured. A -0.35% to 8.00% range shows images of periods of deflation and also periods of hyperinflation which might have been triggered by global economic happenings. Such variability calls for consideration of the impact of other factors in the analysis of inflation patterns.

GDP GROWTH RATE (%)

S.no.	Descriptive statistics	Value
1	Mean	5.23%
2	Standard deviation	5.75%
3	Range	-5.68% to 13.96%

Inference 4: The dataset, as expected, exhibits a large diversity of economic growth rates, as illustrated by the rather broad range (from –5.68% to 13.96%) and also the high standard deviation (5.75%). This implies that the economies under analysis had great recessions and great expansions which could be the case of history-changing events such as the 2008 recession. A 5.23% mean growth rate, in and of itself, points toward a positive trend for the economies but is deceptive as it conceals a lot of oscillations. Consequently, such average figures should be taken with caution in understanding and forecasting economic stability over a long horizon.

Exchange Rate: USD/EUR

S.no.	Descriptive statistics	Value
1	Mean	1.24%
2	Standard deviation	0.12%
3	Range	1.05 to 1.47

Inference 5: A slight variation in the data set is reflected in 1.24% mean value, meaning stability in performance or slight change. The lower standard deviation of 0.12% continues to sustain stability by showing close clustering of individual values around the mean. The observed range from 1.05% to 1.47% confirms a narrow spread of less volatility. Overall, the data tends to reflect a stable environment for the exchange rate with limited deviations from its mean.

3.4.2 Hypothesis testing:

The hypotheses (H1, H2, H3, and H4) were formulated to elucidate the relationship between essential macroeconomic variables—interest rates, inflation, GDP growth rate, and exchange rates—and their impact on gold prices, as evidenced by the findings in Table 6:

H0: Higher interest rates do not lead to a decrease in gold prices, or there is no significant relationship between interest rates and gold prices.

H1: Higher interest rates lead to a decrease in gold prices.

The t-test analysis produced a statistically significant result (p-value = 0), rejecting the null hypothesis and thereby endorsing the alternative hypothesis. This finding is consistent with economic theory, which posits that elevated interest rates raise opportunity cost of holding non-yielding assets like gold, resulting in diminished demand and a decline in gold prices.

Ho: An increase in inflation does not lead to an increase in gold prices, or there is no significant relationship between inflation and gold prices.

H2: An increase in inflation leads to an increase in gold prices.

The t-test results show a significant positive relationship between inflation and gold prices as the p-value is near 0, which is less than standard significance level of 0.05. This is consistence with gold being considered as a hedge against inflation. Therefore, higher inflation rates increase demand for gold, thus increasing the prices.

H0: Higher GDP growth rate is not associated with increasing gold prices, or there is no significant relationship between GDP growth rate and gold prices.

H3: Higher GDP growth rate is associated with increasing gold prices.

The t-test results indicate that the p-value shows a positive significant relationship, suggesting that GDP growth rate may be one of the drivers of gold. Therefore, higher growth rate in the GDP is associated with increase in gold “prices.

H0: An increase in exchange rate does not lead to an increase in gold prices, or there is no significant relationship between exchange rate and gold prices.

H4: An increase in exchange rate leads to an increase in gold prices.

The identified p-value is less than significant level of significance of 0.05, therefore supports the hypothesis” of an increase in the exchange rate or in other words, depreciation of local currency against major currencies like the USD would lead to an increase in gold prices. This indicates that a weaker currency drives up the local price of gold, making it more expensive and potentially more attractive as a hedge against currency depreciation.

3.4.3 Regression Analysis:

The conducted regression study illustrates the correlation between gold prices and macroeconomic variables, including interest rates, inflation rate, GDP growth rate, and exchange rates. The coefficient signifies the extent to which the gold price fluctuates in response to each macroeconomic factor. Positive coefficients indicate a direct correlation, whilst negative coefficients denote an inverse correlation. We can ascertain which macroeconomic factors

significantly influence gold prices by analyzing p-values. A p-value below 0.05 signifies a statistically significant association between the macroeconomic component and gold prices.

1. Interest Rate: Coefficient of -79.25 suggests a weak inverse relationship with gold prices, implying that higher interest rates might slightly reduce gold's appeal. The p-value is 0.166, beyond the established threshold of 0.05; thus, accepting the null hypothesis indicates no significant correlation between gold prices and inflation rates in a country.
2. Inflation Rate: Positive coefficient of 149.11 indicates a strong, positive relationship with gold prices. As inflation rises, gold prices are likely to increase, as investors seek gold as an inflation hedge. The p-value is 0.019, which is below the established threshold of 0.05; thus, rejecting the null hypothesis indicates a substantial link between gold prices and interest rates in a country.
3. GDP Growth Rate: The negative coefficient of -43.73 indicates a slight inverse correlation. This indicates that robust economic expansion may diminish the demand for gold as a secure asset. The p-value is 0.030, which is below the established threshold of 0.05; thus, rejecting the null hypothesis indicates a significant connection between gold prices and interest rates in a country.
4. Exchange Rate (USD/EUR): The positive correlation of 927.84 indicates that a depreciation of the USD against the EUR correlates with an increase in gold prices, perhaps attributable to enhanced purchasing power in alternative currencies. The p-value is 0.000001, which is below the established threshold of 0.05; hence, rejecting the null hypothesis indicates an important connection between gold prices and interest rates in a country.
5. A high R-squared value approaching 1 signifies the model's efficacy in elucidating the majority of the volatility in gold prices. This metric will measure the influence of macroeconomic factors on predicting gold prices.

- The R-squared value is 0.93, signifying that almost 93% of variability in gold prices is accounted for by the model, demonstrating a strong match.
- Adjusted R-squared is 0.85, indicating that the model remains robust even when there are multiple predictors.

4.1: Key Insights:

Primary Findings: Analysis of Descriptive Statistics and Regression Results indicates that significant macroeconomic factors affecting gold prices include interest rates, inflation (CPI), GDP growth rates, and exchange rates. A strong correlation (Multiple R of 0.962) shows that these factors collectively have a notable influence on gold prices.
In comparison with Previous Research, these results are consistent with prior studies that identify interest rates and inflation as major drivers of gold price movements. However, this study highlights the importance of multiple factors interacting, suggesting a more complex relationship than previously established by single-factor analyses.

4.2: Economic Implications:

For Investors, the findings suggest that gold serves as an effective hedge during periods of rising inflation or declining interest rates, offering investors a potential strategy to adjust their portfolios accordingly. Additionally, understanding gold's sensitivity to economic indicators can help policymakers anticipate demand fluctuations, especially when making interest rate or inflation-related policy decisions.

4.3: Global Perspective:

Regional Patterns: If the relationship between macroeconomic factors and gold prices holds globally, this indicates that gold's response to these indicators may be consistent across markets. However, examining differences between developed and emerging markets may reveal variations, with gold potentially being more responsive in specific economic contexts.

Section 5: Conclusion

This analysis demonstrates a significant association between gold prices and essential macroeconomic variables, including interest rates, inflation, GDP growth, and exchange rates. These factors jointly influence variations in gold prices, underscoring gold's responsiveness to overarching economic trends. However, the analysis possesses specific limitations. While it focuses on significant macroeconomic factors, it does not account for other potential influences, such as geopolitical tensions, shifts in trade policies, or consumer sentiment, which could provide deeper insights. The study is also confined to a specific time period, limiting its ability to capture the effects of varying economic cycles or extraordinary events like the COVID-19 pandemic on gold prices.

The reliance on regression models that assume linear relationships may oversimplify the intricate nature of financial markets, particularly during periods of significant volatility or structural changes in the economy. Additionally, the use of aggregate data may overlook regional differences in gold market dynamics, especially between developed and emerging economies with distinct economic conditions and policy frameworks. Moreover, data discrepancies or deficiencies may compromise the accuracy and reliability of the results.

To mitigate these limitations, next research should include supplementary elements, including political instability, natural disasters, and global economic shocks, to achieve a more comprehensive knowledge of the determinants of gold price fluctuations. Employing advanced, non-linear models, such as machine learning techniques or vector autoregression (VAR), could capture the complex relationships between gold prices and macroeconomic variables, particularly during turbulent economic periods. Cross-regional and longitudinal studies could provide insights into how macroeconomic factors impact gold prices differently in developed and emerging markets, while also accounting for various economic cycles and external shocks. Furthermore, analyzing central bank activities, such as quantitative easing and interest rate adjustments, could offer valuable perspectives, as central banks' significant gold reserves and trading patterns underscore gold's strategic role in monetary policy.

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