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An Investigation of the Determinants of Gold Price in India

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Abstract: This paper intends to examine for relationships between gold price and some important macroeconomic variables like interest rate, INR/USD Exchange rate, NSE Index, Crude Oil price and Silver Price. The research in this area has not shown any clear empirical pattern. Moreover, not much work has been available since the 2008 financial crisis. This paper intends to test for any relationship between gold price and the above mentioned variables using daily data from July 2008 to December 2018.

Keywords: Vector Autoregression , Granger Causality, Gold Price, NIFTY, Crude Oil, Exchange Rate, Silver Price, MIBOR, JEL Classification: G10, C22

INTRODUCTION

India is considered to be the largest consumer of Gold in the world. This fact assumes more importance because most of the gold consumed in India is imported, with gold being the second biggest item on India's import bill after crude oil. As is widely known, gold prices have outperformed most other investment avenues, especially since the 2008 crisis. This, added to our cultural affinity towards gold, makes matters difficult for RBI and the Govt. of India to manage the balance of payments. The problem assumes more importance as our export income is negatively affected due to the current weakness of the World Economy, with a few developed countries facing economic crisis.

These facts make holding gold all the more attractive to investors who are not sure of the future. If not checked, this can become a self-fulfilling prophecy. However, there are some signs that suggest that such a situation may not arise. Gold is usually held as hedge against inflation. With the World Economy still struggling to stand on its feet, inflation is not a concern for most economies of the world. Hence, there are opposing forces acting both on the demand and supply side for gold. This paper aims to study the effect of various macroeconomic variables on gold prices in India in the recent past. This paper is planned as follows: In section 2, we review the extant literature to study previous methodologies and results obtained. Based on that, in section 3, we will progress with a chosen methodology on the identified dataset. A brief mathematical overview of the models will also be provided. In section 4, we will analyse the data. Results will be interpreted and any relevant comments will be recorded. Section 5 will conclude the paper by providing an overall summary of results and interpretations.

LITERATURE REVIEW

This section attempts to discuss the existing research on the determinants (if any) of the Gold Prices in India. There are numerous studies that attempt to understand the relationship between quite a few variables of macroeconomic importance vis-à-vis gold prices.

Batten, Ciner, Lucey (2010) studied the macroeconomic determinants of volatility in four precious metals markets: gold; silver; platinum; and palladium. Several US-based Stock Market indices, Bond Yield spread, Money Supply(M2), Index of Industrial Production (IIP), consumer price index (CPI), a specially defined "consumer confidence index" were the factors studied alongside the prices of the four precious metals. VAR and GARCH modeling were employed. The data spanned the period between January 1986 and May 2006, for a total of 245 monthly observations. The Study concluded that macroeconomic factors jointly influence the volatility processes of the examined precious metals series.

Tully and Lucey (2007) investigated macroeconomic influences on gold using the asymmetric power GARCH model (APGARCH). Monthly Data on gold, both cash and futures prices (in USD), and a set of macroeconomic variables (namely, USD/GBP exchange rate, FTSE 100 price index, Brent Crude Oil Price, S&P 500 and FTSE 100 equity indices in both cash and continuous futures form, UK and US CPI, unemployment, T-bill interest rates and industrial production indices), were modeled over the 1984–2003 period. VAR analysis suggested that the following variables influenced the price of gold: FTSE cash, dollar/pound exchange rate and United States T-Bill interest rates and UK consumer price index.

However, the APGARCH modeling exercise concluded that interest rates and the FTSE index had no influence on gold prices.

Ray (2012) tested for granger causality between gold prices and various macroeconomic variables such as CPI, IIP, Oil, Call market rates, INR/USD Exchange rate, FDI, Money supply, GDP, India's Foreign Exchange Reserve and FDI using annual data ranging from 1990-91 to 2010-11. The study concluded that Stock Market index does not granger cause Gold Price.

Hammoudeh and Yuan (2008) examined the volatility behavior of three strategic commodities: gold, silver and copper, in the presence of crude oil and interest rate shocks. Oil shock was defined as the absolute value of the change in the log of the three-month crude price. Similarly, interest rates shocks were incorporated in the model as the first difference of the 3-month Treasury bill rate lagged one period. The findings were that past volatilities strongly dominate past shocks to gold price. This implies that past volatilities and not shocks should be used to predict volatilities in the future. Moreover, past positive oil shocks and rising interest rates decrease current gold volatility. It is possible that these positive shocks entice investors and traders away from the precious metal markets towards the oil and bond markets.

Jain and Ghosh (2013) examined for cointegration and Granger causality among global oil prices, precious metal (Gold, Platinum and Silver) prices and INR–USD rate. Daily time series data (5-day week) is used for a period of three years, from 2nd January 2009 to 30th December 2011. VAR, Granger Causality Tests and ARDL modeling (for cointegration testing) were employed. This study establishes cointegration among gold price, INR/USD exchange rate, platinum and silver prices. The study reports that gold prices granger cause oil prices. The authors admit that this causation is difficult to explain theoretically.

Mishra et al (2010) investigated the relationship between gold prices and stock market (BSE) returns in India using monthly data for the period 1991 to 2009. Johansen's Cointegration test and Granger Causality test were employed. The study found that gold prices and BSE are cointegrated. Also, there is bi-directional granger causality running between gold and BSE returns.

Bhunia and Das (2012) examined the gold price volatility and the causal relationship between gold prices and stock market returns in India. The study takes the domestic gold prices and NSE stock market returns, and test for Granger causality in the Vector Error Correction Model for the period from April 2001 to March 2011. The study establishes that the Gold prices Granger-causes stock market returns and vice-versa during the study period.

In contrast to the above study, Kannan (2011) examined whether yield on investments on Gold and Sensex are cointegrated or not. Yearly data from 1991 to 2011 was used. Engle-Granger co-integration and Johansen Cointegration were among the tests employed. They concluded that yield on gold investments and yield on capital investments are not cointegrated.

In an updated study, Bhunia (2013) used data from 1991 to 2012 to test for causality in between gold, crude, Nifty and foreign exchange rates. He concluded that bi-directional granger causality exists between gold price and Nifty.

Lucey and Tully (2006) examined the relationship between gold and silver using weekly data from COMEX (Jan 1978 to Nov 2002). VAR and Johansen cointegration testing were employed. The study concluded that gold prices are cointegrated over the long term; however, the relationship does appear weak or broken when tested over shorter durations.

Ciner (2001) examined the long run trend between the prices of gold and silver futures contracts using daily closing prices of gold and silver futures contracts traded on the Tokyo Commodity Exchange (TOCOM). The data cover the period from the first trading day in 1992 until the last trading day in 1998, for a total of 1720 observations. Johansen's cointegration test was employed. It was concluded that the stable relationship between gold and silver prices has disappeared in the 1990s.

Toraman, Basarir and Bayramoglu (2011) examined for association between Gold Price and several other variables like Oil prices, Dollar Index, Dow Jones Industrial Production Index, USA CPI, USA real interest rate. A multivariate GARCH model was built using monthly data from January 1992 to March 2010. It was concluded that gold prices and dollar index are negatively correlated. Secondly, a positive correlation was found between gold prices and oil prices.

Zhang and Wei (2010) investigated for any evidence of cointegration and causality between crude oil and gold prices. Daily data (in USD) from January 4, 2000 to March 31, 2008 was taken from London Commodity Exchange. It was concluded that significant cointegration relationship is present between the crude oil price and the gold price. Crude Oil granger causes Gold Price, Gold price does not granger cause crude oil.

Singh (2013, 2015) and studied the impact of several macroeconomic variables including gold price on Nifty using data from 2002 to 2013. He concluded that Gold and Nifty have no causality relation between them.

However, any new analysis using latest data seems to be missing in the extant literature. In a fast changing economic scenario, it may be possible that new associations may have cropped up in the variables chosen since the last five years. This paper attempts to do a comprehensive analysis using latest data and provide latest insights.

Objectives, Methodology and Data

In this section, we test for any association between Gold Prices and several macroeconomic variables (identified from the literature) using VAR Modeling, Co-integration test and Granger Causality test.

The identified variables are as follows:

Table 3.1: Identified Variables for VAR Modeling

Variable	Intent	Data Source
Daily Gold Price (INR)	Dependent Variable	Multi-Commodity Exchange (MCX), India
Daily NSE MIBOR (Mumbai Inter-Bank Offer Rate)	Proxy for Interest Rates	National Stock Exchange (NSE), India
Daily INR/USD Exchange Rate	Relative Strength of Indian Currency	Federal Reserve, USA
Daily S&P CNX Nifty Closing Index Value	Confidence in the economy	National Stock Exchange (NSE), India
Daily Spot Crude Oil Prices (INR)	Economic Activity and Inflation	Multi-Commodity Exchange (MCX), India
Daily Spot Silver Prices	Close substitute for jewellery and alternative investment	Multi-Commodity Exchange (MCX), India

Methodology

(i) To check for time series stationarity of the five identified variables.

(ii) To build a Vector Autoregression model.

(iii) To test for Co-integration relationships between the variables.

(iv) To check for Granger Causality between the variables.

Data

Daily Data from July 2009 to Dec 2018 is used for all the variables. Some data points were removed if all the relevant data values were not available for all variables on a given date.

Models

Vector autoregression (VAR) is a statistical model used to capture the linear interdependencies among multiple time series. VAR models generalize the univariate autoregression (AR) models.

$$Y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + e_t$$

where the 1-periods back observation y_{t-1} is called the l[st] lag of y, c is a k × 1 vector of constants (intercepts), A_i is a time-in-variant k × k matrix and e_t is a k × 1 vector of error terms satisfying

$E(e_t) = 0$, — every error term has mean zero;

$E(e_t e'_t) = \Omega$, — the contemporaneous covariance matrix of error terms is Ω

$E(e_t e'_{t-k}) = 0$, for any non-zero k — there is no serial correlation across time

The VAR(p) is stable if the roots of its reverse characteristic polynomial lie outside the complex unit circle (have modulus greater than one) or if the eigenvalues of the companion matrix have modulus less than one.

Johansen test is a procedure for testing cointegration of several I(1) time series. This test is better than Engle–Granger test as it can test for more than one cointegrating relationship and hence is more generally applicable. Engle Granger Cointegration test is based on the ADF test for unit roots in the residuals from a single regression relationship between two variables.

Mathematically, there are two possible specifications for error correction model. ECMs are a category of multiple time series models that directly estimate the speed at which a dependent variable Y returns to equilibrium after a change in an independent variable X.

The long-run VECM Model:

$$\Delta X_t = \mu + \Phi D_t + \Pi X_{t-p} + \Gamma_{p-1}\Delta X_{t-p+1} + \ldots + \Gamma_1 \Delta X_{t-1} + \varepsilon_t,\ t = 1, \ldots, T$$

The transitory VECM Model:

$$\Delta X_t = \mu + \Phi D_t + \Gamma_{p-1} X_{t-p+1} - \ldots - \Gamma_1 \Delta X_{t-1} + \Pi X_{t-1} + \varepsilon_t,\ t = 1, \ldots, T$$

where,

$$\Gamma_i = (\Pi_{i+1} + \ldots + \Pi_p),\ \textit{vis-à-vis} = 1, \ldots, p-1$$

However, in the both the forms, the Π matrix is the same and is given by:

$$\Pi = \Pi_{i+1} + \ldots + \Pi_p - I$$

If the Π matrix is zero, there is no co-integration between the variables.

Analysis & Results

Vector autoregression (VAR) modeling is a statistical model used to capture the linear interdependencies among multiple time series. It is observed that VAR can provide superior prediction than univariate time series models.

Estimating a VAR involves choosing which variables to include in the system, and deciding on the number of lags. The results obtained can be sensitive to both of these choices. The number of lags is usually determined by statistical criteria, and variable selection is generally informed by economic theory. In this project, the variables that were chosen have been reported to be associated with gold prices in the available literature.

The first step in building a VAR model is to do a unit root test to identify the variables which are non-stationary.

The results indicate all the variables to be non-stationary. Just like a linear difference can make a raw series stationary, a linear combination of two or more non-stationary series can also be stationary. If such a stationary linear combination exists, the non-stationary time series are said to be cointegrated. The stationary linear combination is called the cointegrating equation and may be interpreted as a long-run equilibrium relationship among the variables.

As have been mentioned earlier, the variables identified for Cointegration Testing vis-à-vis Gold Prices are:

- Daily NSE MIBOR (Mumbai Inter-Bank Offer Rate)
- Daily INR/USD Exchange Rate
- Daily S&P CNX Nifty Index value
- Daily MCX Spot Crude Oil Price (INR)
- Daily MCX Spot Silver Price (INR)

Descriptive Statistics

Table 4.1: Descriptive Statistics for the Identified Variables

	MCXGOLD	MIBOR	INRUSD	NIFTY	MCXCROL	MCXSILV
Min	14431	3.25	0.013443	3974.05	1783	21150
Max	32943	11.99	0.022742	11738.5	7527	73288
Average	26535.618	6.916331	0.017552	7213.111	4208.152	41973.89
Std. Deviation	4648.4427	1.529082	0.002756	1971.978	1101.911	9509.678
Skewness	-1.151165	-0.67304	0.589205	0.473028	0.430939	0.330577
Kurtosis	0.1019163	0.575942	-1.14823	-1.04099	-0.67664	-0.32102

The variables have different characteristics w.r.t their skewness and kurtosis values. The distributions vary from slightly leptokurtic to somewhat platykurtic.

Before doing VAR Modeling, we first test if the variables are stationary at level or not. It is obserbed that all variables are I(1) stationary. Hence, we ensure that the variables are differenced at level. This ensures that the transformed variables are stationary.

Since we will be using a VAR in difference, we also test for cointegration. To that end, Johansen's test is employed. Subsequently, Grangers causality tests are done.

VAR Modeling

The VAR Model Estimation Results

Table 4.2: VAR Results

	Estimate	Std. Error	t-value	Pr(>|t|)	Significance
MCXGOLD = MCXCROL.l2					
MCXCROL.l2	-0.017073	0.008219	-2.077	0.0379	*
MIBOR = MIBOR.l1 + MIBOR.l2 + MIBOR.l3 + NIFTY.l3 + MIBOR.l4					
MIBOR.l1	-0.17923	0.02064	-8.682	2.00E-16	***
MIBOR.l2	-0.20428	0.02074	-9.85	2.00E-16	***
MIBOR.l3	-0.15093	0.02074	-7.277	4.66E-13	***
NIFTY.l3	-0.12517	0.06253	-2.002	0.0454	*
MIBOR.l4	-0.10644	0.02064	-5.156	2.73E-07	***
INRUSD = MCXGOLD.l1 + MCXSILV.l2 + MCXCROL.l3 + MCXGOLD.l4 + INRUSD.l4					
MCXGOLD.l1	-0.036895	0.012119	-3.044	0.00236	**
MCXSILV.l2	-0.015439	0.006571	-2.35	0.01887	*
MCXCROL.l3	-0.01079	0.004818	-2.24	0.0252	*
MCXGOLD.l4	-0.025054	0.012171	-2.059	0.03965	*
INRUSD.l4	0.056779	0.020755	2.736	0.00627	**
NIFTY = INRUSD.l1 + MCXGOLD.l3 + constant					
INRUSD.l1	0.20744	0.04176	4.967	7.28E-07	***
MCXGOLD.l3	-0.0535	0.02447	-2.186	0.0289	*
constant	-0.04594	0.02094	-2.194	0.0284	*
MCXCROL = NIFTY.l1 + MCXCROL.l1 + MCXGOLD.l2 + INRUSD.l2					
NIFTY.l1	0.22375	0.04372	5.117	3.35E-07	***
MCXCROL.l1	-0.12042	0.02046	-5.885	4.57E-09	***
MCXGOLD.l2	0.14538	0.05165	2.815	0.00493	**
INRUSD.l2	-0.50515	0.08846	-5.71	1.27E-08	***
MCXSILV = INRUSD.l1 + MCXSILV.l1 + MCXGOLD.l4 + MCXSILV.l4					
INRUSD.l1	0.2228	0.06496	3.43	0.000615	***
MCXSILV.l1	-0.0668	0.02067	-3.232	0.001248	**
MCXGOLD.l4	-0.14748	0.055	-2.681	0.007386	**
MCXSILV.l4	0.11329	0.02987	3.793	0.000152	***

The resulting VAR equations are provided in the table 4.2. We see that crude oil has some association with Gold. Similarly, Among other variables, INRUSD, NIFTY and MCXSILV also have significant associations with gold.

Johansen's Test

Johansen Cointegration test is used to find out the number of cointegration relationship between the variables.

Values of test-statistic and critical values of test (at selected acceptance levels):

Table 4.3: Results for Johansen's Test

Hypothesised No. of CE(s)	Test Statistic	10%	5%	1%
At most five	0.81	6.5	8.18	11.65
At most four	7.46	12.91	14.9	19.19
At most three	8.17	18.9	21.07	25.75
At most two	11.33	24.78	27.14	32.14
At most one	20.73	30.84	33.32	38.78
None	44.51	36.25	39.43	44.59

This suggests that there are no cointegrating relationships among the five chosen variables.

Granger Causality Test

Table 4.4: Results for Granger-Causality Tests

Granger Causality (Row to Column)	MCXGOLD	MIBOR	INRUSD	NIFTY	MCXCROL	MCXSILV	Significance (p-value)
MCXGOLD		Y	Y	Y	Y	Y	0.01018
MIBOR	N		N	N	N	N	0.5265
INRUSD	Y	Y		Y	Y	Y	9.158e-10
NIFTY	Y	Y	Y		Y	Y	0.001376
MCXCROL	N	N	N	N		N	0.2727
MCXSILV	N	N	N	N	N		0.2025

The granger causality tests results are provided in Table 4.4. This table is read as follows: MCXGOLD returns Granger-cause MIBOR, INRUSD, NIFTY, MCXCROL, MCXSILV returns. Similarly, MIBOR returns do not Granger-cause MCXGOLD, INRUSD, NIFTY, MCXCROL and MCXSILV returns and so on. The important interpretation to be noted here is that INRUSD returns and NIFTY returns have a bi-directional causality relationship with gold returns.

We will not delve deeper into the other associations since this paper's focus is on associations between gold and other macroeconomic variables.

Conclusion

The analysis done so far suggests that some of the chosen variables have an association with Gold returns. This finding is somewhat echoed in the published literature. As mentioned earlier, some researchers have mentioned that cointegration relations seem to break down during certain durations within the total period of analysis.

It is possible that more complex models may be useful in this situation. Options include Multivariate GARCH modelling and Structural-VAR (SVAR) modelling (used in cases when variables are found to be NOT cointegrated). However, SVAR needs additions restrictions that should be backed by economic theory for further modelling. This paper suggests this as future research direction.

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