Exploring the Relationship of Gold (24 Carat) and the Sensex Using Regression in the Context of Vector Error Correction Model

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Abstract: *Using the robust Vector Error Correction Model (VECM), the present study investigates the dynamic relationship between Gold (24 Carat) and the Sensex, a significant stock market index. The study is analytical in nature and is based on secondary data pertaining Sensex and Gold price (24 Carat) for the period ranging from 1996 to 2023. The study found that Sensex corrects the error of the gold price (24 Carat) since the coefficient of C1 is negative and substantial. The error correction term in the VECM captures the short - term dynamics between gold prices and the Sensex.*

Keywords: Financial Markets, Sensex, Gold (24 Carat), Vector Error Correction Model

1. Introduction

Understanding the complicated interplay of important assets is critical in the ever - changing world of financial markets. Using the robust Vector Error Correction Model (VECM), the present study investigates the dynamic relationship between Gold (24 Carat) and the Sensex, a significant stock market index. This work tries to uncover the subtle linkages, probable causalities, and equilibrium tendencies between these diverse yet interconnected parts of the financial sphere by combining the strengths of co - integration analysis with short - term adjustments.

2. Need and Significance of the Study

The Sensex, a famous stock market index, and gold (24 carat) are two key assets with substantial implications for wealth preservation, risk management, and economic stability. Investors are continuously looking for ways to improve their portfolios and limit risk. Diversification techniques rely heavily on gold and the stock market. Using the VECM to investigate the link between Gold (24 Carat) and the Sensex can provide insights into how these assets interact over time, allowing investors to fine - tune their portfolio allocations for improved risk - adjusted returns. Historically, gold has been seen as a safe - haven asset, frequently sought during times of economic instability and market volatility. The Sensex, on the other hand, represents broader economic conditions and investor mood. Using the VECM framework to investigate their relationship can offer light on whether Gold keeps its safe - haven properties in the face of stock market and economic changes thereby has the potential to improve portfolio management, assess safe - haven properties, contribute to market efficiency understanding, inform economic policies, and facilitate risk management strategies. This study has far - reaching consequences for investors, financial institutions, politicians, and academia as they navigate the complexity of today's volatile financial market. As a result, there is a strong need for extensive research in this field. The findings can help policymakers and central banks understand the possible effects of financial markets on the broader economy.

3. Review of Related Literature

1) Sidhu & Katoch (2021) there is a cause - and - effect link between gold prices and the NIFTY 50 index. In the near run, the Indian stock market is silently affected by gold price swings, according to the findings.
2) Singhal, Choudhary& Biswal (2019) Analyzing daily data from January 2005 to April 2019, researchers examined the long - term dynamic relationships between the price of crude oil and gold with the Mexico stock market index and the rate of currency exchange. Impacts in the economy cause the oil price, gold price, and currency rate to fluctuate first, followed by fluctuations in the stock market. According to the results of the ARDL bound test, the price of gold has an advantageous impact on the price of Mexican stocks, whereas crude oil prices have a negative effect. Among the variables, crude oil was highly volatile and had a vibrant impact on the foreign exchange rate and stock prices.
3) Tursoy & Faisal (2018) investigated the links between Turkish stock market, gold, and crude oil prices over the long and short terms from January 1985 to November 2018. The Granger causality test is used to determine the short run, while an Auto Regressive Distributed Lag (ARDL) model is used to estimate the longer time period. The cointegration test's findings support the notion that crude oil and stock prices are positively correlated with stock prices, while gold is negatively

correlated with stock prices. The findings of the Granger causality test reveal that there is a considerable impact of global prices on the price of Turkish stocks, with unidirectional causality from the gold price to stock price and no causality between stock and oil price.

4) Khan, M. S, Aziz, and Herani (2016) examined the Asia's most volatile market, the Pakistan stock exchange (Karachi stock exchange). Using monthly data from October 1992 to May 2016, he investigated how gold prices affected the KSE - 100. The association is examined using the ADF, Johnsen cointegration, and VAR model. The findings indicate that there is no long - term relationship between the price of stocks and the price of gold, meaning that the price of gold serves as a substitute for the price of stocks.

5) Naliniprava, Tripathy & Amit, Tripathy (2016) attempted to use monthly time data from July 1989 to April 2016 to analyse the effect of gold's price on the Nifty index of Indian stocks. ADF, PP, and Kwatkowski - Phillips - Schmidt - Shin (KPSS) test findings demonstrate that the variables are stationary at the level. The findings of the Johansen cointegration test show that the stock market has a longer - term relationship with the price of gold and that there is no causative relationship between the stock market's price and the price of gold, as determined by the Granger causality test. A long - term relationship between stock return and gold return was proven by the Cusum test, as well as stability coefficient.

6) S. kaliya, moorthy, (2012) it was discovered that the prices of stocks and gold had nothing to do with one another. It shown that there is no connection between fluctuations in stock market price and the price of gold.

4. Objective of the Study

To explore the relationship of Gold (24 Carat) and the Sensex using regression in the context of Vector Error Correction Model

5. Hypothesis of the Study

There is no meaningful the relationship of Gold (24 Carat) and the Sensex using regression in the context of Vector Error Correction Model

6. Research Methodology

The study is analytical in nature and is based on secondary data pertaining Sensex and Gold price (24 Carat) for the period ranging from 1996 to 2023. Augmented Dickey - Fuller test, Vector Auto Regression Estimates, VAR Lag Order Selection Criteria, Unrestricted Co - integration Rank Test (Trace), Gauss - Newton / Marquardt, and Breusch - Pagan - Godfrey were used. The data source is Yahoo Finance.

7. Discussion of Findings

Table 1.1: Unit Root (Augmented Dickey - Fuller test) - Gold price (24 Carat) and Sensex

Null Hypothesis: **Gold (24 Carat) has a unit root**			
Exogenous: Constant			
Lag Length: 0 (Automatic - based on SIC, maxlag=6)			
		t - Statistic	Prob. *
Augmented Dickey - Fuller test statistic		2.029404	0.9998
Test critical values:	1% level	- 3.711457	
	5% level	- 2.981038	
	10% level	- 2.629906	
Null Hypothesis: **Sensex has a unit root**			
Exogenous: Constant			
Lag Length: 0 (Automatic - based on SIC, maxlag=6)			
		t - Statistic	Prob. *
Augmented Dickey - Fuller test statistic		3.223001	1.0000
Test critical values:	1% level	- 3.737853	
	5% level	- 2.991878	
	10% level	- 2.635542	

Source: Authors' own calculation (www.yahoo finance)

The Augmented Dickey - Fuller (ADF) tests for Gold (24 Carat) and the Sensex revealed that the given time series has a unit root, indicating that it is non - stationary. As a result, at this point, regressing to the original series is not an option. Because regression is a long - term model that requires steady data. However, regression is feasible if there is Co - integration. The tables below serve to show whether a long - term association between Gold (24 Carat) and Sensex can be established using regression with original data.

Table 1.2: Vector Auto Regression Estimates - Gold price (24 Carat) and Sensex

	Gold (24 carat)	Sensex
Gold (24 carat) (- 1)	0.904917	0.276643
	(0.20552)	(0.29450)
	[4.40315]	[0.93937]
Gold (24 carat) (- 2)	- 0.247808	- 0.090473
	(0.20296)	(0.29084)
	[- 1.22097]	[- 0.31108]
Sensex (- 1)	0.133936	0.618417
	(0.14928)	(0.21392)
	[0.89719]	[2.89089]
Sensex (- 2)	0.284314	0.327434
	(0.16889)	(0.24202)
	[1.68339]	[1.35292]
C	560.5219	373.4676
	(966.423)	(1384.86)
	[0.58000]	[0.26968]
R - squared	0.976755	0.959511
Adj. R - squared	0.972105	0.951413
Sum sq. resids	1.64E+08	3.36E+08
S. E. equation	2860.201	4098.586
F - statistic	210.0956	118.4910
Log likelihood	- 231.6503	- 240.6441
Akaike AIC	18.93203	19.65153
Schwarz SC	19.17580	19.89530
Mean dependent	22967.56	23950.23
S. D. dependent	17125.24	18594.14
Determinant resid covariance (dof adj.)	1.37E+14	
Determinant resid covariance	8.79E+13	
Log likelihood	- 472.2898	

Akaike information criterion	38.58318
Schwarz criterion	39.07073

Source: Authors' own calculation (www.yahoo finance)

The Vector Auto Regression (VAR) model is used to investigate the dynamic relationship between a numbers of time series variables. To forecast the future values of both variables, the model considers their past values. The coefficients represent the lags in the relationships between the variables. The coefficient for the lagged value of Gold price (24 Carat) and Sensex at lag 1 is represented by Gold price (24 Carat) (- 1) and Sensex (- 1). The values in brackets are the coefficient standard errors, while the values in square brackets are the t - statistics. The F - statistic tests reveal that the model's overall fit is significant. The values of Log Likelihood, AIC, and Schwarz SC are connected to the model's quality of fit and complexity. Overall, the VAR model seems to fit the data well, as indicated by high R - squared and Adj. R - squared values.

Table 1.3: VAR Lag Order Selection Criteria - Gold price (24 Carat) and Sensex

Endogenous variables: Gold price (24 Carat) and Sensex						
Exogenous variables: C						
Lag	Log L	LR	FPE	AIC	SC	HQ
0	- 487.1024	NA	1.01e+16	42.53065	42.62938	42.55548
1	- 439.3812	82.99348*	2.27e+14*	**38.72880***	39.02501*	38.80329*
2	- 436.2697	4.870167	2.48e+14	38.80606	39.29975	38.93022
3	- 433.9015	3.294917	2.93e+14	38.94795	39.63912	39.12178
4	- 433.1504	0.914315	4.08e+14	39.23047	40.11912	39.45396
* indicates lag order selected by the criterion						

Source: Authors' own calculation (www.yahoo finance)

The output includes Lag Order Selection Criteria for a Vector Auto Regression (VAR) model with endogenous variables Gold price (24 Carat) and Sensex, as well as the exogenous variable C. According to the Akaike Information Criterion (AIC), lag 1 indicates that the model uses the current and immediately prior values.

Table 1.4: Unrestricted Co - integration Rank Test (Trace) - Gold price (24 Carat) and Sensex

Lags interval (in first differences): 1 to 1				
Hypothesized		Trace	0.05	
No. of CE (s)	Eigen value	Statistic	Critical Value	Prob. **
None *	0.404410	17.23216	15.49471	0.0271
At most 1 *	0.157248	4.277075	3.841466	0.0386
Trace test indicates 2 co - integrating eqn (s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon - Haug - Michelis (1999) p - values				
Gold price (24 Carat)	Sensex			
- 0.000144	0.000189			
0.000183	- 0.000117			
Unrestricted Adjustment Coefficients (alpha):				
D (Gold price (24 Carat))	2045.906	- 266.3200		
D (Sensex)	671.3526	1543.913		
1 Co - integrating Equation (s):		Log likelihood	- 474.4283	
Normalized co - integrating coefficients (standard error in parentheses)				
Gold price (24 Carat)	Sensex			
1.000000	- 1.315768			
	(0.14059)			
Adjustment coefficients (standard error in parentheses)				
D (Gold price (24 Carat))	- 0.294128			
	(0.08069)			
D (Sensex)	- 0.096516			
	(0.12479)			

Source: Authors' own calculation (www.yahoo finance)

The co - integration analysis of Gold price (24 Carat) and Sensex suggests a long - term association between non - stationary variables. It implies that, despite short - term changes, these variables tend to move in lockstep over time. The Unrestricted Co - integration Rank Test (Trace) compares the eigenvalues of a matrix to determine the number of co - integrating equations. The null hypothesis states that no co - integrating equations exist. At the 0.05 significance level, the results indicate the existence of two co - integrating equations. The presence of a co - integrating link between the gold price (24 Carat) and the Sensex suggests a long - term association.

Table 1.5: Least Squares (Gauss - Newton / Marquardt steps) - Gold price (24 Carat) and Sensex

Dependent Variable: D (Gold price (24 Carat))			
D (Gold price (24 Carat) = C (1) * (Gold price (24 Carat (- 1) - 1.31576767297			
* Sensex (- 1) + 7522.41006151) + C (2) *D (Gold price (24 Carat (- 1)) + C (3) *D (Sensex (- 1)) + C (4)			
	Coefficient	Std. Error	t - Statistic	Prob.

C (1)	**- 0.294128**	0.080691	- 3.645131	**0.0015**
C (2)	0.203196	0.175546	1.157504	0.2601
C (3)	- 0.284079	0.165713	- 1.714281	0.1012
C (4)	2517.812	754.7600	3.335910	0.0031
R - squared	0.439280	Mean dependent var		2254.200
Adjusted R - squared	0.359178	S. D. dependent var		3505.691
S. E. of regression	2806.354	Akaike info criterion		18.86281
Sum squared resid	1.65E+08	Schwarz criterion		19.05783
Log likelihood	- 231.7851	Hannan - Quinn criter.		18.91690
F - statistic	5.483958	Durbin - Watson stat		2.118911
Prob (F - statistic)	0.006077			

Source: Authors' own calculation (www.yahoo finance)

The output appears to be the result of a regression analysis with the dependent variable D (Gold price (24 Carat)). The model attempts to explain variations in D (Gold price (24 Carat) using additional variables such as lagged and differenced versions of Gold price (24 Carat) and Sensex, as well as a constant term. The model equation includes several lagged and differenced components of the Gold price (24 Carat) and the Sensex, as well as four coefficients (C (1), C (2), C (3), C (4)) and a constant term (C (4)). C1 describes the long - term relationship (Co - integration). The Sensex corrects the error of the gold price (24 Carat) since the coefficient of C1 is negative and substantial. D (Price of gold (24 Carat) (- 1)) —C2 - - - Short - run relationship - First difference in gold price (24 Carat) - Insignificant. D (Price of gold (24 Carat) (- 2)) Short run relationship - Second difference in gold price (24 Carat) - Not substantial. (Sensex (- 1)) D—C4 - - - Short run relationship - First Sensex difference - Significant. C - Alpha - Intercept. The R - squared and adjusted R - squared values measure the model's goodness of fit, indicating that the model explains a moderate fraction of the variability in the dependent variable.

Table 1.6: Heteroscedasticity Test: Breusch - Pagan - Godfrey - Gold price (24 Carat) and Sensex

F - statistic	0.024816	Prob. F (1, 25)		0.8761
Obs*R - squared	0.026775	Prob. Chi - Square (1)		0.8700
Scaled explained SS	0.032189	Prob. Chi - Square (1)		0.8576
Dependent Variable: Resid^2				
Variable	Coefficient	Std. Error	t - Statistic	Prob.
C	24068706	11955820	2.013137	0.0550
SENSEX	- 65.01134	412.6890	- 0.157531	0.8761
R - squared	0.000992	Mean dependent var		22610839
Adjusted R - squared	- 0.038969	S. D. dependent var		38587256
S. E. of regression	39331917	Akaike info criterion		37.88416
Sum squared resid	3.87E+16	Schwarz criterion		37.98015
Log likelihood	- 509.4361	Hannan - Quinn criter.		37.91270
F - statistic	0.024816	Durbin - Watson stat		0.850056
Prob (F - statistic)	0.876092			

Source: Authors' own calculation (www.yahoo finance)

The F - statistic on the Breusch - Pagan - Godfrey test for Heteroscedasticity contrasts the null hypothesis of constant residual variance (homoskedasticity) with the alternative hypothesis of variable variance (Heteroscedasticity). A high p - value suggests that there is insufficient evidence to reject the null hypothesis of homoskedasticity.

8. Conclusions

The VECM model incorporates both the short - term dynamics and the long - term equilibrium relationship between variables, which is also the essence of regression analysis. The VECM research shows evidence of co - integration between Gold (24 Carat) prices and the Sensex. This shows that the two variables have a long - term equilibrium connection. The findings point to a bidirectional causal association between gold prices (24 carat) and the Sensex. Changes in the Sensex have an impact on gold prices, and vice versa. This suggests that in certain market conditions, both assets can act as leading indications for one another. The error correction term in the VECM captures the short - term dynamics between gold prices and the Sensex. Adjustments in both variables are used to compensate deviations from the long - term equilibrium relationship. This indicates that any short - term asset imbalances will be addressed in succeeding times. Economic developments, geopolitical issues, and investor mood all play a role in the volatility of both assets.

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