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Causal links between gold and silver prices of Indian commodity market

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Abstract

Indian commodity market is one of the emerging markets in the world. With the globalization and advances in technology the commodity trading has become feasible for market participants. The recent policy changes paved way for investors to play in the commodity market and that lead the commodities to emerge as an asset class and get shares in their portfolio. The market efficiency is one of the important feature that gives confidence for the investors to trade in any market. This also fits to the Indian commodity market. The precious metals such as Gold and Silver which has an emotional bonding with the Indians are now emerging more as an investment than a ritual. This study has investigated the efficiency of Indian Gold and Silver markets through the use of time series econometrics methodologies. The markets for Gold and Silver included in the study are efficient in long run as well as in short-run. Thus, the Gold and Silver has inter linkage between their markets which keeps these markets efficient and allows the investor to trade confidently.

Keywords: Commodity market, Gold, Silver, Efficiency

Introduction

Commodities has developed immense potential to become a separate asset class for market investors, arbitrageurs and speculators. The globalization and advances in technology have significantly changed the way of trading and increased the market participants in the commodity markets. The factors determining prices and the frequency with which prices change has increased exponentially in spite of this timely access to information and analysis is the only way to succeed in commodity market. The futures markets helps in managing the risk associated with the uncertainty of future prices. The efficiency of futures markets arises from their ability to predict the future price of an asset at a specified future date without any bias. A market is said to be efficient in an informational sense if the prices of the assets traded on that market promptly reflect all available information. This is a strong argument and in terms of weak argument prices will reflect all available information up to the point where the cost of gaining additional information is equal to the profits derived from that information. Efficiency can be achieved when traders make use of arbitrage opportunity.

The efficiency of the market is very important for the market growth. In an efficient market, the investor will use all possible opportunities to make best use of their investment. The spreads available in the market give better investment opportunities for investors as well as hedgers, to make better hedging. Such analysis may be of great relevance from the point of view of the investors as the existing literature also suggests that cross hedging opportunities provide the investors to make their investment better. Theoretically, the Futures contracts derives its value from the underlying spot prices and that a perfect correlation is expected, but is not so in real life due to the presence of imperfect information dissemination. Market efficiency also implies that futures market prices are equal to expected future spot prices and risk premium which may be constant or time varying. Alternatively, if markets are efficient and if no risk premium is present, futures prices will be unbiased predictors of future spot prices only. Under the conditions of market efficiency and risk neutrality, we can frame the hypothesis that futures prices provide unbiased forecasts of spot prices. The concept of market efficiency is to be understood while taking time dimensions into consideration i.e. Markets may be efficient and unbiased in the long run, but may experience short-run inefficiencies and pricing biases. The objective here is to test empirically the two separate hypotheses of market efficiency and un-biasedness in the long-run for two major commodity futures Gold and Silver and also determine if any short-run inefficiencies or pricing biases exist in these commodities. There has been a never ending effort to find best suitable way for investing by analyzing the market performance. In precious metals like Gold and Silver which are highly traded across the globe, the price risk is high. Unlike other commodities Gold and Silver are not only used for hedging instrument but also used as an investment avenue. Thus both the spot and futures prices are of high importance. The arbitrage between two markets are keenly watched and grabbed by the market participants. Thus, without a deep knowledge about the price relationship of these commodities it is hard to earn profit in the market. With this background, the present study makes an attempt to analyze the relationship of Gold and Silver prices and its causal relationship for building better trading and investment strategies.

Review of Literature

The Gold and Silver being the auspicious metal traded in Indian Commodity market several researchers were interested in knowing the inter-relationships between them and their causality. Dey and Maitra (2012) [8] studied the price discovery process of pepper by applying Granger causality, Co-integration, Error Correction model. They found a unidirectional causality from Futures to Spot prices in the pepper Futures market. Sehgal *et al.* (2012) [28] studied the price discovery relationship for Indian Agricultural Commodities. They found the price discovery process is efficient and also recommended to strengthen the market regulatory framework to the Forward Market Commission (FMC). Their study also revealed the need for warehousing and market linkages in India.

Ali and Gupta, (2011) [1] studied the long-term relationship between Futures and Spot Prices for the Agricultural Commodities like Maize, Chickpea, Black Lentil, Pepper, Castor Seed, Soybean and Sugar and found cointegration in the Futures and Spot prices. There exists a short-term relationship between them and the Futures markets was a good predictor of spot prices for Chickpea, Castor Seed, Soybean and Sugar. There was a bi-directional relationship in the short run among the Maize, Black Lentil and Pepper.

Torero (2009) performed Granger Causality test to determine the direction of information flows between Spot and Futures prices in the agricultural commodities. It was found that Spot prices are generally discovered in Futures Markets. They argued for formation of sufficient food grain reserves globally, to fight the volatility presence in the markets. Shivashankar (2007) [29] in his thesis "Marketing of dry Chillies in Karnataka – A management appraisal" studies the agricultural marketing in case of dry chillies and its price integration among the chillies markets in Karnataka by applying cointegration. The study found that the grading in chillies were still to be improved by providing standardized scientific practices. The cost of production and capital investments made in the chilli processing unit were inversely correlated. Hubli was found to be integrated for dry chillies whereas Kandangol and Byadgi markets were not. The Kudangol taluk incurred higher cost of processing compared to Hubli and Byadgi taluks which had the ill effects of uncertain weather conditions, lack of labour, high cost of pesticides, parking, transportation etc.

Ernst (1991) apply actual post cash settlement futures price data and found the basis variance was smaller after the introduction of cash settlement in the futures market when compared to physical delivery. However, the reductions in variance were not statistically significant. According to Pennings and Leuthold (1994) [18] hedging effectiveness is related to trading volume and this relationship is more prominent when the hedging effectiveness takes market depth risk into account. Dasgupta (2004) found a co-movement among futures prices, production decisions and inventory decisions. Yang (2005) showed that an unexpected increase in futures trading volume caused an increase in spot price volatility and Sahi (2006) [26] suggested that the volatility had not changed with the introduction of futures in wheat, turmeric, sugar, cotton, raw jute and soya oil.

Gosh (1993) [12] investigated the spot and futures index and found cointegration between two in long run. Chowdhary (1991) [6] examined the efficiency of futures for commodities copper, led, tin, and zinc in London Metal Exchange. Beck (1994) [5] tested market efficiency in commodities (cattle, orange juice, corn, copper, and cocoa) futures markets. Beck concluded that all five markets are inefficient at times but efficiency cannot be rejected all the time. Williams *et al.* (1998) studied the development and characteristics of Mung Bean trading at The Zhengzhou Commodity Exchange (CZCE). By examining price differentials in the same crop year between different futures contracts, they concluded arbitrage conditions exist in the CZCE.

Kellard *et al.* (1999) [16] analyzed the relative efficiency of commodity futures markets. They studied the unbiasedness and efficiency using a cointegration methodology across a range of financial and commodity futures markets, and developed a measure of relative efficiency. The findings suggested spot and futures prices are cointegrated. However, there is evidence of short run inefficiencies and spot price changes are explained by basis and lagged differences in futures and spot prices. Naik and Gopal (2001) used co-integration theory to examine the efficiency and unbiasedness of nine commodities in twenty exchanges of Indian commodity futures market. Their results of efficiency varied across exchanges and commodities. Holly and Ke (2002) [15] investigated the efficiency of Chinese agricultural futures markets and concluded mixed results market is efficient in case of soybean and inefficient in case of wheat.

Mckenzie and Holt (2002) examined market efficiency and unbiasedness for four agricultural commodity futures namely, live cattle, hags, corn and soybean meal. The results indicated that live cattle, hogs, corn and soybean meal futures markets are efficient and unbiased in long run, however, the results showed some inefficiencies and pricing biases in short run Sahadevan (2003) investigated the relationship between price return, volume, market depth and volatility in Indian agricultural commodities market. The sample consisted of 12 markets and six commodities. The results suggest that return and volatility of futures as well as spot markets does not significantly influence markets volume and depth. Mazighi (2003) [19] found the inefficiency of natural gas futures markets on both International Petroleum Exchange (IPE) in London and the New York Mercantile Exchange (NYMEX) in US.

Research Methodology

The study is of analytical nature and makes use of secondary data. The required secondary data of daily Gold and Silver spot and futures prices were collected from www.mcx.com for a period of ten years from April 2005 to March 2015. The period is considered for the study so as to grab more impact of relation among the Gold and Silver traded in India. Appropriate research methods were applied in the study for analysis. To examine the stationary properties of the data Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test were applied. The long-run and short-run relationship between spot and futures markets of Gold and Silver was examined by Error Correction Model (ECM) and Johansen Cointegration. The unidirectional or bidirectional relationship between the two markets (i.e.,) Spot and Futures markets were examined by applying Granger Causality test.

Augmented Dickey-Fuller (ADF) test

The stationarity of the time series is investigated with the Augmented Dickey-Fuller (ADF) test, where the null hypothesis, H_0 is $\delta = 0$; There is a unit root or the time series is non-stationary. The ADF unit root regression is:

$$\Delta Y_t = \beta_1 D_t + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \varepsilon_t$$

Phillips-Perron (PP) test

$$\Delta Y_t = \beta_1 D_t + \delta Y_{t-1} + u_t$$

The PP unit regression tests the null hypothesis, H_0: $\delta = 0$; There is a unit root or the time series is non-stationary.

Error Correction Model (ECM)
The presence of both the short-run and the long-run relationship between the variables, X_t and Y_t can be examined by the ECM, proposed by Engle and Granger. In the below equation, the ECM model investigates the potential long-run and short-run impact of the variable, Y_t on the variable, X_t:

$$X_t - X_{t-1} = \alpha_0 + \alpha_1 \hat{Z}_{t-1} + \sum_{i=1}^{m} c_i (Y_{t-i} - Y_{t-i-1}) + \sum_{j=1}^{m} d_j (X_{t-j} + X_{t-j-1}) + \varepsilon_t$$

The ECM represented by the equation decomposes the dynamic adjustments of the response variable X_t, to changes in the predictor variable Y_t, into two components: first, a long-run component given by the cointegration term, $\alpha_1 \hat{Z}_{t-1}$, also known as the error-correction term; and, second, a short-term component given by the first summation term in the right-hand side of equation. In other words, a long-run relationship refers to one established during the entire sample period. On the other hand, a short-term relationship is shown in the equation by the lagged values of the response and predictor variables.

Johansen Cointegration
If spot and futures prices are both non-stationary and require first differencing to render each series stationary, then in general most linear combinations of the two series will also be non-stationary. A cointegrating vector may, however, exist that makes a specific linear combination of the two series stationary. For example, if u_t in $U_t = S_t - \alpha - \delta F_{t-1}$, is a stationary series, α and δ are the cointegrating terms and the regression $S = \alpha + \delta F_{t-1} - u_t$ is the cointegrating or equilibrium regression. The stochastic relationship in the equation implies that in the long run S_t and F_{t-1} cannot move too far apart from each other despite the fact that they are both non stationary.
Two different likelihood ratio tests proposed by Johansen of the significance of the canonical correlations and thereby the reduced rank of the Π matrix are the trace test and maximum eigen value test, shown in equations below.

$$j_{trace} = -T \sum_{i=r+t}^{n} \ln(1 - \lambda_t^{\wedge})$$

$$j_{max} = -T \ln(1 - \lambda_{r+1}^{\wedge})$$

Where T is the sample size and $\lambda_t^{\wedge}$ is the i^{th} highest canonical correlation. The trace test of Johansen tests the null hypothesis that there are *r* cointegrating vectors against the alternative hypothesis of n cointegrating vectors. On the other hand the maximum eigen value test, tests the presence of *r* cointegrating vectors (null hypothesis) against the alternative hypothesis of r+1 cointegrating vectors.

Granger Causality
Granger causality test is test of the prediction ability of time series models. Specifically, Y is said to cause or lead X provided some coefficient, α_i is not zero in the following equation:

$$X_t = c_o + \sum_{i=1}^{m} \alpha_i Y_{t-i} + \sum_{j=1}^{m} \beta_j X_{t-j} + \varepsilon_t$$

Similarly, X is causing or leading Y if some coefficient, α_i, is not zero in the equation below:

$$Y_t = \gamma_o + \sum_{i=1}^{m} \alpha_i X_{t-i} + \sum_{j=1}^{m} \beta_j Y_{t-j} + \mu_t$$

Regression equations can be used to test for the existence of a short-term relationship between the variables X and Y. The test for causality is based on an F-statistic that is computed by running the regressions in both the unconstrained form (full model) and the constrained form (reduced model). The reduced model is obtained from the equations by dropping the lagged values of the predictor variables. The F-statistic is given by

$$F_1 = \frac{(SSE_r - SSE_f)/m}{SSE_f/(T - 2m - 1)}$$

Where SSE_r and SSE_f are the sum of squares of residuals of the reduced as well as the full models respectively; m is the number of lags; and T is the number of observations.

Analysis and Interpretation
The market efficiency is been tested by the long-run and short-run between the spot and futures prices. Before applying econometric models the time series data has to be tested for stationarity. Two different unit root tests, the Augmented Dickey Fuller (ADF) Test and the Phillips Perron (PP) Test are employed to test for stationarity. For both the Gold and Silver spot and future prices the ADF and PP tests indicated the presence of unit root at levels and become stationary on first difference as shown in Table -1.
The long-run and short-run equilibrium evaluation is very important while studying the market efficiency, as the price spread between markets give arbitrage opportunity of commodity prices. Further, it arise the query of lack of information flow between markets which do not exist in efficient market. The existence of long-run equilibrium relationship can be confirmed by Error Correction Model (ECM) of Engle & Granger, 1987 [10]. The spot and futures prices of Gold and Silver can be expressed by individual regression models at levels and testing the stationarity of their residuals.
The result of ECM is given in the Table -2 and Table -3.

Table 1: Unit Root Analysis

	Futures Price						Spot Price					
	ADF			PP			ADF			PP		
	At Level	First Difference		At Level	First Difference		At Level	First Difference		At Level	First Difference	
	t-stat	t-stat		t-stat	t-stat		t-stat	t-stat		t-stat	t-stat	
Gold	-1.1993	-56.5814	***	-1.1941	-56.5134	***	-1.1852	-53.6238	***	-1.1856	-53.6238	***
Silver	-1.5970	-24.4641	***	-1.5487	-58.2459	***	-1.5742	-56.1143	***	-1.5644	-56.0391	***

Note: ***1% Significance level

Table-2 shows the Augmented Dickey Fuller (ADF) Test and the Phillips Perron (PP) Test of unit root of residuals of regression between the spot and futures prices. The result shows that the residuals are stationary at level and hence provides an evidence for the long-run relationship between the spot and futures prices for both the Gold and Silver. Thus, there is long-run relationship among the spot and futures prices for Gold as well as Silver.

Table 2: Regression Residual Unit Root

	ADF	PP
Gold residual (At level)	-9.3930***	-41.4773***
Silver residual (At level)	-12.0588***	-55.7084***

Note: ***1% Significance level

Table-3 shows the Error Correction Model (ECM) of Gold and Silver. The spot price coefficients of both Gold and Silver are significant at 1% level which affects the future prices. R^2 of Gold is 0.2640 which means that Gold spot price explains 26.4% of the Gold future price. Similarly, R^2 of Silver is 0.3229 which means that Silver spot price explains 32.29% of the Silver future price. As Durbin-Watson statistics of both Gold and Silver is around 2, there is no serial correlation in the regression equations. The residual coefficients of both Gold and Silver are negative and significant at 1% level which evidences the existence of short-run relationship between the spot and futures market in both Gold and Silver. Thus, there is short-run relationship among the spot and futures prices for Gold as well as Silver.

Table 3: Error Correction Model

	GOLD		SILVER	
	Coefficient		Coefficient	
Constant	2.8259		3.0117	
D(Spot price)	0.5934	***	0.6867	***
Residual(-1)	-0.2617	***	-0.5668	***
R^2	0.2640		0.3229	
Durbin-Watson stat	2.4111		2.1367	
F statistic	512.1430	***	676.0572	***

Note: ***1% Significance level

The long-run and short-run relationship between Gold and Silver were individually examined by ECM, now to examine the long-run and short-run between the commodities in spot and futures market together the Johansen's cointegration and VAR/VECM can be applied. Given that the commodity's spot and futures prices are integrated of the same order, I (1), we can use cointegration techniques to determine if a stable long-run relationship exists between the price pairs. The unit root test for residual obtained is stationary so it can be concluded that spot and futures are cointegrated in the long run (Engle Granger 1987) [10]. Using Johansen's (1988) procedure, tests for cointegration is performed. Johansen's procedure a multivariate approach is based on maximum likelihood estimates of the cointegrating regression. The VAR (Vector Autoregressive) specification was estimated by using from one to four lags, with the AIC criterion used to choose optimal lag length.

Table 4: Johansen Cointegration

	λ_{Trace}	λ_{Max}
None	327.1468***	227.8138***
At most 1	99.3330***	91.1959***
At most 2	8.1371	6.0563
At most 3	2.0808	2.0808

Note: ***1% Significance level

Table-4 shows the Johansen cointegration result for Gold futures, Gold spot, silver futures and Silver spot. The null hypothesis of Johansen cointegration is that there is no cointegration which is rejected at 1% level in both the Trace test statistics and Maximum Eigen value. Similarly, the null hypothesis of having one cointegrating relationship between the price pairs also gets rejected at 1% significance level.

Whereas, the null hypothesis of having two cointegrating relationship between price pairs cannot be rejected even at 10% significance level. Overall, Johansen test results support the hypothesis that spot and futures prices of Gold and Silver are cointegrated and hence can say the market is efficient in long run for these commodities.

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Table 5: Vector Error Correction Model (VECM)

	D(Gold Futures)		D(Gold Spot)		D(Silver Futures)		D(Silver Spot)	
	Coefficient		Coefficient		Coefficient		Coefficient	
Cointegration Eq.1	-0.1101	***	0.0230		-0.0534		-0.0291	
Cointegration Eq.2	0.1070	***	-0.0222		0.0511		0.0294	
D(Gold Futures)(-1)	-0.0502		0.5424	***	0.0313		0.3224	***
D(Gold Futures)(-2)	-0.0531		0.2303	***	0.0543		0.3123	***
D(Gold Futures)(-3)	0.0130		0.0655	**	-0.0936		0.0075	
D(Gold Futures)(-4)	0.0678	**	0.0343		-0.1412		0.0725	
D(Gold Spot)(-1)	0.0916	**	-0.3722	***	0.1083		-0.3833	***
D(Gold Spot)(-2)	0.0653		-0.1312	***	-0.0186		-0.1798	
D(Gold Spot)(-3)	0.0018		-0.0623		0.1793		0.0021	
D(Gold Spot)(-4)	-0.0271		0.0256		0.0061		-0.0685	
D(Silver Futures)(-1)	0.0283	**	0.0211	**	0.0257		0.4553	***
D(Silver Futures)(-2)	0.0300	**	0.0316	***	0.0396		0.2735	***
D(Silver Futures)(-3)	-0.0006		0.0155		0.1315	***	0.1932	***
D(Silver Futures)(-4)	0.0098		0.0064		0.2041	***	0.0947	***
D(Silver Spot)(-1)	-0.0397	***	-0.0303	***	-0.0815		-0.3396	***
D(Silver Spot)(-2)	-0.0165		-0.0224	**	-0.0398		-0.2321	***
D(Silver Spot)(-3)	-0.0156		-0.0170		-0.1782	***	-0.1872	***
D(Silver Spot)(-4)	-0.0088		-0.0115		-0.0487		-0.0234	
Constant	6.4840		4.8051		7.8830		6.3010	
R^2	0.0304		0.3740		0.0400		0.3810	
Durbin Watson	1.9973		2.0024		1.9939		2.0234	

Note: ***1% Significance level, **5% Significance level.

Although the cointegration test provides evidence for the hypothesis of long-run market efficiency but might still exhibit short-run inefficiencies and pricing biases among the Gold and Silver markets. To test for short-run inefficiencies and pricing biases the standard VECM model is applied. The results of variable coefficients and respective probability value are recorded in Table-5.

The Vector Error Correction Model (VECM) estimates variables at I (1) and with 0 to 4 lags. As per Table-5, the 2 cointegration equations are significant only in D (Gold futures) as dependent variable regression. The 4th lag of Gold Futures, 1st lag of Gold Spot, 1st and 2nd lag of Silver Futures and 1st lag of Silver Spot prices are the variables affecting Gold Futures at various levels of significance. Similarly, the 1st to 3rd lag of Gold Futures, 1st and 2nd lag of Gold Spot, 1st to 3rd lag of Silver Futures and all the 4 lags of Silver Spot prices affects the Gold Spot price. Whereas, Silver Futures is affected by its own lags and lag of Silver Spot prices. Silver Spot is been affected by 1st and 2nd lags of Gold Futures and Gold Spot, all 4 lags of Silver Futures and 1st to 3rd lag of Silver Spot.

Table 6: Granger Causality

S. No.	NULL HYPOTHESIS	F-Statistic	
1	D(GOLD_SPOT) does not Granger Cause D(GOLD_FUTURES)	6.9373	***
	D(GOLD_FUTURES) does not Granger Cause D(GOLD_SPOT)	744.2910	***
2	D(SILVER_FUTURES) does not Granger Cause D(GOLD_FUTURES)	0.7086	
	D(GOLD_FUTURES) does not Granger Cause D(SILVER_FUTURES)	2.1498	
3	D(SILVER_SPOT) does not Granger Cause D(GOLD_FUTURES)	0.5758	
	D(GOLD_FUTURES) does not Granger Cause D(SILVER_SPOT)	213.6450	
4	D(SILVER_FUTURES) does not Granger Cause D(GOLD_SPOT)	258.3450	
	D(GOLD_SPOT) does not Granger Cause D(SILVER_FUTURES)	5.8098	
5	D(SILVER_SPOT) does not Granger Cause D(GOLD_SPOT)	1.5143	
	D(GOLD_SPOT) does not Granger Cause D(SILVER_SPOT)	1.3904	
6	D(SILVER_SPOT) does not Granger Cause D(SILVER_FUTURES)	10.8296	
	D(SILVER_FUTURES) does not Granger Cause D(SILVER_SPOT)	677.3500	

Note: ***1% Significance level

The long-run and short-run relationship between markets and commodities explains about the market efficiency but that is not enough for taking an investment decision. The Granger causality explains the directional relationship between the spot and futures markets of the Gold and Silver.

Table-6 shows the directional relationship between the spot and futures markets of Gold and Silver. The Gold spot and Gold futures markets, Silver futures and Gold spot markets and Silver spot and Silver futures markets has a bi-directional relationship among them as the probability value of 1st , 4th and 6th pair null hypothesis gets rejected at 1% level. The Silver spot and Gold futures markets has an uni-directional relationship where Gold futures prices causes Silver spot prices with a probability value significant at 1% level. The Silver futures and Gold futures markets and Silver spot and Gold spot markets has no relationship among them as the probability value of 2nd and 5th pair null hypothesis gets accepted at 5% level. Thus, there is causal relationship between the spot and futures prices for Gold and Silver.

Conclusion

Commodity market in India is an emerging market. Identifying the hedging opportunities is an important task for a hedger in the market. A stable rationale market provides a stable hedging however, in reality the market participants are irrational and there exists speculative and arbitrage opportunities. The Gold and Silver are highly traded when compared to the metal commodities and agricultural commodities; hence, analyzing the commodity market as a whole is not only enough. Thus, against this background, the study makes an attempt to analyze the influence of Gold and Silver markets to find whether these two commodities have an efficient market.

The study has been carried out on Gold and Silver only by empirically analyzing the relationship and impact of inter-commodity and the inter-market price spread opportunity in India over the period of ten years from April 2005 to March 2015. The relevant data required for the study are collected from MCX on 15th May 2015. The ECM is used to determine the relationship among the Gold markets and Silver markets. Granger Causality is used to determine the collective relationship between the Gold and Silver markets.

Analysis made with the help of the research methods brought some concrete results regarding the inter-commodity and inter-market spread between Gold and Silver in India. The Gold and Silver has inter linkage between their markets which keeps these markets efficient and allows the investor to trade confidently. It has been summed up that the Gold and Silver are related with each other but still macro-economic factors influence is high in these commodities. Hedging continues to be a research area because of the fast and constant development in the commodity markets and economic policies in India. The study summarized the impact of Gold and Silver markets, resulting in to a cross-hedging opportunity. The study may be used as a ready reference for future researchers on the area under discussion. Further, for the hedgers of Gold and Silver in India, the study may prove to be valuable for re-drafting for their hedging decision keeping in view the outcome of the study.

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