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GOLD INVESTMENT AS AN INFLATIONARY HEDGE: COINTEGRATION EVIDENCE FROM INDIA WITH ALLOWANCE FOR STRUCTURAL BREAKS AND SEASONAL ADJUSTMENT*

AVIRAL KUMAR TIWARI
Research scholar and Faculty of Applied Economics, Faculty of Management, ICFAI University, Tripura, Kamalghat, Sadar, West Tripura,

In this study we have made an attempt to examine the cointegration between inflation and price of gold and thereby to see whether inflationary hedging in gold in Indian context is fruitful to investors. To achieve our objective we have carried out cointegration analysis with allowance of structural breaks and seasonal adjustments as both markets have been subject to structural change and affected by seasons. We find that in all cases there is long run relationship between gold price and inflation. This implies that investing in gold can be used as an effective tool of inflationary hedging by the investors in the Indian context.

Keywords: Inflationary hedging, unit root, structural breaks, seasonal adjustment, cointegration.

INTRODUCTION

In India, investors are very eager to invest in gold as a part of their strategic assets allocations. There are number of benefits that come by investing in gold for example, diversification benefit and its potential role as a hedge against inflation, risk due to political instability/uncertainty, currency risk and other investment related dimensions of the valuable commodity [see for example, Koutsoyiannis (1983), Jaffe (1989), Chua *et al.,* (1990), Dooly *et al.,* (1995), Mahdavi and Zhou (1997), Faff and Chan (1998), Adrangi *et al.*, (2000), Coutts and Sheikh (2002), Smith (2002), Liu and Chou (2003), Capie *et al.,* (2005) and Lucey and Tully (2006a, 2006b) among others]. The basic focus of this study is on the view that investing in gold is an inflationary hedge tool. As par the conventional wisdom investing in the commodities is the best way of inflationary hedging. However, gold is, among all physical assets, relatively more durable, transportable, universally acceptable and authenticable. In this paper, we have used a novel approach of time series techniques which involves the incorporation of endogenous structural breaks/changes in the gold market (by using seasonally dummy variables also) to assess the long run inflationary hedging properties. Rest of the paper is organized as follows. Second section presents the data source and methodology adopted in this paper followed by data analysis and results interpretation in the third section and finally, in the third section conclusions has been presented.

OBJECTIVE, DATA SOURCE AND ESTIMATION METHODOLOGY

This section is organized as follows. First subsection discusses about the objectives set for the study followed by data source and variables definition in the second subsection. And third section discusses about the methodology used for empirical analysis in the study.

Objective

The basic objective set in the study is to check the cointegration in the price of gold and inflation by incorporating structural breaks and seasonal effect of the gold market thereby to know that in long run weather equilibrium between inflation and gold prices is there i.e., weather in the long run gold investment will be an fruitful inflationary hedging phenomenon. As best of my knowledge there is no study in the context of India which have analyzed the cointegration relationship by allowance of structural breaks and seasonal adjustment. Therefore, the objective set in the study is justified.

Data Source and Variables Description

The data used are monthly observations of the prices of gold Rupees per 10gms and inflation is measured by Whole Sale Price Index-All Commodities (WPI –AC). The data has been obtained from Hand Book of Statistics of Indian Economy (HBSIE) published by Reserve bank of India (RBI). Time period of the analysis is April-1990-91 to June-2009-10. Both variables have been transformed in natural log form in order to make data series of less order Autoregressive i.e., to minimize fluctuations in the series.

Estimation Methodology

Several methods are proposed in the econometric literature for testing unit roots in the context of seasonal time series. These include methods developed by Hylleberg *et al.* (1990), Canova and Hansen (1995), Caner (1998) and Shin and So (2000). We have used the seasonal unit root test procedure proposed by Hylleberg *et al.* (1990) (HEGY). This test, in comparison with other seasonal unit root tests, like the one of Dickey *et al.* (1984), has the advantage that the appropriate transformations, in order to remove possible (seasonal) unit roots follow directly from the procedure itself and do not have to be implemented a priori. HEGY (1990) propose a method to test whether a time series contains seasonal unit roots in the presence of other unit roots and seasonal processes. Applying a $(1\text{-}L^4)$ to quarterly series, where L is the usual lag operator, implies that one assumes the presence of four unit roots, as $(l\text{-}L^4) = (l\text{-}L)(l+L)(l\text{-}iL)(l+iL) = (l\text{-}L)(l+L)(l+L^2)$, hence the unit roots are 1, -1, i and -i'. HEGY (1990) show that testing for seasonal unit roots amounts to testing the significance of the parameters of an auxiliary regression, which may also contain deterministic elements, like a constant, trend and seasonal dummies. The auxiliary regression they derive is

$$\Delta_4 y_t = \pi_1 z_{1,t-1} + \pi_2 z_{2,t-1} + \pi_3 z_{3,t-1} + \pi_4 z_{3,t-2} + \sum_{j=1}^{p} \alpha_j^* \Delta_4 y_{t-j} + \varepsilon_t \qquad (1)$$

Where, y_t is the time being tested, $z_{1t} = (1+L + L^2 + L^3)y_t$, $z_{2t} = (-1 + L - L^2 + L^3)y_t$, $z_{3t} = (-1 + L^2)y_t$ and $z_{4t} = (1\text{-} L^4)y_t$, $= \Delta_4 y_t = y_t - y_{t-4}$, L denoting the usual lag operator, and where $\{\varepsilon_t\}$ is assumed to be a white noise process.

Applying OLS to this auxiliary regression gives estimates of the π_i's. HEGY showed that when $\pi_1 = 0$ the series contains the (nonseasonal or zero frequency) root 1, when $\pi_2 = 0$ the (semiannual) root –1 is present i.e., root -1 corresponds to unit roots ½ cycle per quarter or 2 cycle per year, the presence of the (annual) roots $\pm$ i (i = $\sqrt{-1}$) implying $\pi_3 = \pi_4 = 0$ (the stationary alternatives being $\pi_1 < 0$, $\pi_2 < 0$ and $\pi_3 < 0$ and/or $\pi_4 = 0$) i.e., ± i corresponds to unit roots at ¼ cycle per quarter or one cycle per year.

Thus, inference on the presence of seasonal unit roots may be carried out through the t-ratios associated to the last three π_i coefficients: $t\pi_2$, $t\pi_3$ and $t\pi_4$. On the other hand, evidence on the presence (absence) of a nonseasonal unit root is given by $t\pi_1$. However, the analysis of stochastic seasonal non-stationarity becomes simpler if, instead of testing three separate hypotheses, we test some joint null hypotheses. To that end, one can use the F -statistics F_{34}, which tests H_0: $\pi_3 = \pi_4 = 0$, and F_{234}, associated to H_0: $\pi_2 = \pi_3 = \pi_4 = 0$. Finally, one can also test whether all the πi parameters are zero [i.e., whether the $\Delta_4 = (1 - L^4)$ filter is appropriate] using F_{1234}. The asymptotic distributions of the test statistics under the respective null hypotheses depend on the deterministic terms in the model.

The number of lagged seasonal differences $\Delta_4 y_{t-j}$ has to be chosen before the HEGY tests can be performed. This may again be done by using model selection criteria or parameter significance tests.

As for quarterly series, the test for monthly time series also amount to testing the significance in an auxiliary regression. In monthly series the $(1\text{-}L^{12})$ filter has twelve unit roots.

We then have

$$1-L^{12} = (1-L)(1+L)(1-iL)(1+iL)(1+\frac{\sqrt{3}+i}{2}L)(1+\frac{\sqrt{3}-i}{2})(1-\frac{\sqrt{3}+i}{2}L)$$
$$(1-\frac{\sqrt{3}-i}{2}L)(1+\frac{i\sqrt{3}+1}{2}L)(1-\frac{i\sqrt{3}+1}{2}L)(1-\frac{i\sqrt{3}+1}{2}L)(1+\frac{i\sqrt{3}-1}{2}L) \quad (2)$$

Collecting two terms at a time this equation can be written as

$$(1\text{-}L^{12}) = (1\text{-}L^2)(1+L^2)(1+\sqrt{3}L+L^2)(1-\sqrt{3}L+L^2)(1+L+L^2)(1+L+L^2) = (1\text{-}L^4)(1\text{-}L^2+L^4)(1+L^2+L^4).$$

For *monthly* series, the corresponding tests for seasonal unit roots were discussed by Franses (1990) based on the model

$$\Delta_{12} y_t = \pi_1 z_{1,t-1} + \pi_2 z_{2,t-1} + \pi_3 z_{3,t-1} + \pi_4 z_{3,t-2} + \pi_5 z_{4,t-1} + \pi_6 z_{4,t-2} + \pi_7 z_{5,t-1} +$$
$$\pi_8 z_{5,t-2} + \pi_9 z_{6,t-1} + \pi_{10} z_{6,t-2} + \pi_{11} z_{7,t-1} + \pi_{12} z_{7,t-2} + \sum_{j=1}^{p} \alpha_j^* \Delta_{12} y_{t-j} + \varepsilon_t \quad (3)$$

Where

$$z_{1,t} = (1+L)(1+L^2)(1+L^4+L^8)y_t$$
$$z_{2,t} = -(1-L)(1+L^2)(1+L^4+L^8)y_t$$
$$z_{3,t} = -(1-L^2)(1+L^4+L^8)y_t$$
$$z_{4,t} = -(1-L^4)(1-\sqrt{3}L+L^2)(1+L^4+L^8)y_t$$
$$z_{5,t} = -(1-L^4)(1+\sqrt{3}L+L^2)(1+L^4+L^8)y_t$$
$$z_{6,t} = -(1-L^4)(1-L^2+L^4)(1-L+L^2)y_t$$
$$z_{7,t} = -(1-L^4)(1-L^2+L^4)(1+L+L^2)y_t$$
$$z_{8,t} = (1-L^{12})y_t$$

The process y_t has a regular (zero frequency) unit root if $\pi_1 = 0$ and it has seasonal unit roots if any one of the other π_i ($i = 2,\ldots,12$) is zero. For the conjugate complex roots, $\pi_i = \pi_{i+1} = 0$ (i= 3, 5, 7, 9, 11) is required. The corresponding statistical hypotheses can again be checked by *t*- and F-statistics, critical values for which are given by Franses and Hobijn (1997). If all the π_i ($i = 2,\ldots,12$) are zero, then a stationary model for the monthly seasonal differences of the series is suitable. As in the case of quarterly series it is also possible to include deterministic terms in the model (2). Finally, we have carried out unit root analysis following Saikkonen and Lütkepohl (2002) and Lanne *et al.* (2002) for the equation

$$y = \mu_0 + \mu_1 \; t + f_t(\theta)'\gamma + x_t \tag{4}$$

where $f_t(\theta)'\gamma$ is a shift function and θ and γ are unknown parameters or parameter vectors and x_t are generated by AR(p) process with possible unit root. We used a simple shift dummy variable with shift date T_B. $f_t^{'} = d_{1t} : \begin{cases} 0, t < T_B \\ 1, \geq T_B \end{cases}$ The function does not involve any parameter θ in the shift term $f_t(\theta)'\gamma$, the parameter γ is scalar. Dates of structural breaks have been determined by following Lanne, Lütkepohl and Saikkonen (2001). They recommended to chose a reasonably large AR order in a first step and then pick the break date which minimizes the GLS objective function used to estimate the parameters of the deterministic part.

After checking that all variables are nonstationary by incorporating the potential structural breaks the next step is to go for cointegration. However, as Perron (1989) has mentioned that ignoring the issue of potential structural breaks can render invalid the statistical results not only of unit root tests but of cointegration tests as well. Kunitomo (1996) has also explained that in the presence of a structural change, traditional cointegration tests, which do not allow for this, may produce "spurious cointegration". In the present research, therefore, considering the effects of potential structural breaks is very important.

There are two different tests proposed by Johansen (2000) and Saikkonen and Lütkepohl (2000a, b, and c). Saikkonen and Lütkepohl (2000a, b, and c) have proposed a test for cointegration analysis that allows for possible shifts in the mean of the Data-Generating Process (DGP). Since many standard types of DGP exhibit breaks caused by exogenous events that have occurred during the observation period, they suggest that it is necessary to take into account the level shift in the series for proper inference regarding the cointegrating rank of the system. Therefore in this study we have taken into account the level shift in carrying out cointegration analysis.

The Saikkonen and Lütkepohl (SL) test investigates the consequences of structural breaks in a system context based on the multiple equation frameworks of Johansen-Jeslius, while earlier approaches like Gregory-Hansen (1996) considered structural break in a single equation framework as their approach was based on analyzing the unit root properties of residuals by including dummy variable for known date of structural breaks.

According to Saikkonen and Lütkepohl (2000b) and Lütkepohl and Wolters (2003), an observed n-dimensional time series *yt* = (*y*1*t*,…., *ynt*), *yt* is the vector of observed variables (t=1,…, T) which are generated by the following process:

$$y = \mu_0 + \mu_1 t + \gamma_1 d_{1t} + \gamma_2 d_{2t} + \gamma_3 d_{3t} + \delta_1 DT_{0t} + \delta_2 DU_{1t} + x_t \tag{5}$$

where DT_{0t} and DU_{1t} are impulse and shift dummies respectively, and account for the existence of structural breaks. DT_{0t} is equal to one, when $t=T_0$, and equal to zero otherwise. Step (shift) dummy (DU_{1t}) is equal to one when ($t>T_1$), and is equal to zero otherwise. The parameters γ_i (i=1, 2, 3), μ_0, μ_1, δ_1 and δ_2 are associated with the deterministic terms. The seasonal dummy variables d_{1t}, d_{2t}, and d_{3t}, are not relevant to this research since our data are yearly. According to SL (2000b), the term x_t is an unobservable error process that is assumed to have a VAR (p) representation as follows:

$$x_t = A_i x_{t-1} + \ldots + A_p x_{t-p} + \varepsilon_t \tag{6}$$

By subtracting x_{t-1} from both sides of the above equation and rearranging the terms, the usual error correction form of the above equation is given by

$$\Delta x_t = \Pi x_{t-1} + \sum_{j=1}^{p-1} \Gamma_j \Delta x_{t-1} + u_t \tag{7}$$

This equation specifies the cointegration properties of the system. In this equation, u_t is a vector white noise process; $x_t = y_t$ -Dt and Dt are the estimated deterministic trends. The rank of $\prod$ is the cointegrating rank of x_t and hence of y_t (SL, 2000b).

There are three possible options in the SL procedure, as in Johansen, a constant, a linear trend term, or a linear trend orthogonal to the cointegration relations. In this methodology, the critical values depend on the kind of the above-mentioned deterministic trend that included in the model. SL have mentioned that the critical values remain valid even if dummy variables are included in the model, while in the Johansen test; the critical values are available only if there is no shift dummy variable in the model. The SL approach can be adopted with any number of (linearly independent) dummies in the model. It is also possible to exclude the trend term from the model; that is, μ=0 maybe assumed a priori. In this methodology, as in Johansen's, the model selection criteria (SBC, AIC, and HQIC) are available for making the decision on the VAR order.

In the following section, we have applied SL tests for the cointegration rank of a system in the presence of structural breaks. As explained above, Saikkonen and Lütkepohl (2000b) derived the likelihood ratio (LR) test in order to determine the number of cointegrating relations in a system of variables, by allowing for the presence of potential structural breaks. We now apply a maximum likelihood approach, based on SL, for testing and determining the long-run relationship in the model under investigation. As mentioned earlier, in this procedure SL assumed that the break point is known a priori therefore, by using those structural breaks dates as was obtained in the unit root analysis we have proceeded to carry out cointegration analysis. Since there is no lag structure for the dummy series, therefore dummy variable is included in the system, but not in the cointegration space. For this reason, the dummy result is not present in the cointegration results. Following the SL procedure we consider the case of shift dummy for three different break dates when trend and intercept included. In this case also optimum number of lags has been based on SIC. However, SL approach has limitation in the sense that if we are using this approach we can test for cointegration in the presence of only one structural break while, Johansen (2000) have suggested a model of cointegration in which we can test for cointegration among the set of variables in the presence of two structural breaks and by incorporating seasonal dummy variables. Therefore, in this study we have preferred Johansen's (2000) test and results of Johansen's test will be presented in the paper however, results of SL test can be accessed by written request to the author.

DATA ANALYSIS AND RESULTS INTERPRETATION

The first subsection of this section presents the results of unit root analysis (using different approaches) with inclusion of seasonal effect and structural breaks and second subsection presents the results of cointegration analysis.

Results of Unit Root Analysis

First of all unit root analysis has been carried out by employing Augmented Dickey Fuller (ADF) test (with incorporation of seasonal dummy variables) and HEGY test. Results of unit root analysis by using ADF test has been presented in Table 1.

Table 1
ADF Unit Root Analysis

	Unit root tests with inclusion of seasonal dummy variables		
Variables	*Constant*	*Constant and trend*	*DF/ADF(k)*
Ln (Rupees pe 10 gms.)	Yes	—	1.0514 (5)
Ln (Rupees pe 10 gms.)	—	Yes	-0.3206 (5)
Ln (WPI of all commodities)	Yes	—	-0.2734 (1)
Ln (WPI of all commodities)	—	Yes	-2.7405 (1)

Note: (1) "k" Denotes lag length. (2) For ADF test critical values are -3.43, -2.86, and 2.57 when only constant term exist and -3.96 -3.41 -3.13 when constant and trend exists at 1%, 5%, and 10% respectively.

Source: Author's calculation

It is evident from the table that even after incorporating seasonal effect both variable have unit root (that is they are nonstationary) in both cases i.e., when only constant term included in the model and when both constant term and trend is included in the model.

Result of unit root analysis by using HEGY test has been presented in Table 2[1].

Table 2
HEGY Unit Root Analysis

Ln(WPI of all commodities)				*Ln (Rupees per 10 gms.)*
Test statistics under HEGY unit root test				
	Model (k)		*Model (k)*	
	Intercept and seasonal dummies (2)	*Intercept, seasonal dummiesand trend (2)*	*Intercept and seasonal dummies (3)*	*Intercept, seasonal dummiesand trend (3)*
t (π_1)	1.7669	1.9431	-2.2029	-0.5843
t (π_2)	1.7145	1.9385	-1.9084	-0.4988
F ($\pi_{3,}$ π_4)	17.3378*	16.7583*	7.0849*	7.0218*
F ($\pi_{5,}$ π_6)	17.9168*	18.0001*	23.3071*	23.2023*
F ($\pi_{7,}$ π_8)	16.7802*	16.1848*	18.1044*	17.5265*
F ($\pi_{9,}$ π_{10})	17.2114*	17.3525*	13.2762*	13.2271*
F ($\pi_{11,}$ π_{12})	14.9288*	13.9970*	14.5202*	14.3244*
F ($\pi_{2......}$ π_{12})	50.1941*	49.1298*	20.1577*	19.7824*
F ($\pi_{1......}$ π_{12})	47.0349*	47.0248*	18.5526*	18.2361*

Source: Author's calculation.

Table 2 shows the unit root results of inflation (WPI-AC) and price of gold. Critical values are reported in the annexure 1. The presence of a unit root at a particular frequency is established if the relevant test statistic is less than the corresponding tabulated critical value given in P.H. Franses and B. Hobijn (1997). It is evident from the table that in all models the null hypothesis of unit roots at annual and semi-annual frequencies are accepted at 1% level of significance. Based on the F-value, on the other hand, the null hypothesis of unit root at quarterly and all other higher frequencies are rejected at 1% level of significance. This therefore suggests that both variables are non-stationary at annual and quarterly level but not the monthly or higher frequency level in India.

Finally, we have presented the results of unit root analysis based on seasonal adjustment and structural breaks in Table 3.

It is evident from Table 3 that variable price of gold and inflation are non-stationary in all cases except for the case when time trend and seasonal dummies included/not included (with shift dummy using break date 1994 M1) in the unit root analysis of inflation.

Table 3
SL Unit Root Analysis

Unit Root Test with structural break						
Variables	*time trend (impulse dummy and used break date is 2006 M2)*	*time trend and seasonal dummies included (impulse dummy and used break date is 2006 M2)*	*time trend (shift dummy and used break date is 1991 M12)*	*time trend and seasonal dummies included (shift dummy and used break date is 1991 M12)*	*Saikkonen and Lütkepohl (k)*	*Critical values based on Lanne et al. (2002) (1%, 5%, and 10% respectively)*
Ln (Rupees pe 10 gms.)	Yes	—	—		-1.2541 (5)	-3.55, -3.03, -2.76
Ln (Rupees pe 10 gms.)	—	Yes	—		-1.2275 (5)	-3.55, -3.03, -2.76
Ln (Rupees pe 10 gms.)	—	—	Yes		-1.2090 (5)	-3.55, -3.03, -2.76
Ln (Rupees pe 10 gms.)	—	—	—	Yes	-1.1896 (5)	-3.55, -3.03, -2.76
	time trend (impulse dummy and used break date is 1993 M12)	*time trend and seasonal dummies included (impulse dummy and used break date is 1993 M12)*	*time trend (shift dummy and used break date is 1994 M1)*	*time trend and seasonal dummies included (shift dummy and used break date is 1994 M1)*		
Ln (WPI of all commodities)	Yes	—	—		-2.5262	-3.55, -3.03, -2.76
Ln (WPI of all commodities)	—	Yes	—		-2.3978 (1)	-3.55, -3.03, -2.76
Ln (WPI of all commodities)	—	—	Yes		-3.4276 (3)	-3.55, -3.03, -2.76
Ln (WPI of all commodities)	—	—	—	Yes	-3.0937 (1)	-3.55, -3.03, -2.76

Note: (1) "k" Denotes lag length. (2)
Source: Author's calculation

Results of Cointegration Analysis

After establishing that both variables have unit root i.e., they are no-stationary in their level form even after incorporating seasonal adjustment and structural breaks in the process of unit root analysis. Next step is to go for cointegration. To carry out cointegration analysis first step is to have knowledge about lag length to be used. Therefore, we have carried out lag length selection test. In the next step, by employing that lag length we have carried out model selection test. Using appropriate model and lag length as suggested by AIC and HQIC we have carried out cointegration analysis for each possible combination of two structural breaks dates as obtained in the unit root analysis of variables. Results of cointegration analysis have been presented in Table 4.

Table 4
Results of cointegration analysis

Johansen Trace Test (Trend and intercept)											
Restricted dummies: [1991 M12], [1993 M12] (2)			*Seasonal dummies included {Restricted dummies: [1991 M12], [1993 M12] (2)}*			*Restricted dummies: [1994 M1], [2006 M2] (2)*			*Seasonal dummies included {Restricted dummies: [1994 M1], [2006 M2] (2)}*		
r	*LR*	*P-value*	*r*	*LR*	*P-value*	*r*	*LR*	*P-value*	*R*	*LR*	*P-value*
0	58.21	0.0002	0	60.92	0.000	0	48.24	0.0187	0	50.05	0.012
1	10.12	0.4965	1	9.83	0.522	1	7.60	0.8799	1	8.81	0.802
Restricted dummies: [1991 M12], [2006 M2] (2)			*Seasonal dummies included {Restricted dummies: [1991 M12], [2006 M2] (2)}*			*Restricted dummies: [1993 M12], [2006 M2] (2)*			*Seasonal dummies included {Restricted dummies: [1993 M12], [2006 M2] (20)}*		
r	*LR*	*P-value*	*r*	*LR*	*P-value*	*r*	*LR*	*P-value*	*R*	*LR*	*P-value*
0	25.71	0.5885	0	26.92	0.5187	0	50.20	0.0111	0	52.23	0.0065
1	6.89	0.8420	1	8.42	0.7227	1	7.49	0.8830	1	8.96	0.7881
Restricted dummies: [1991 M12] , [1993 M12] (2)			*Seasonal dummies included { Restricted dummies: [1991 M12], [1993 M12] (2)}*			*Restricted dummies: [1991 M12], [1994 M1] (2)*			*Seasonal dummies included {Restricted dummies: [1991 M12], [1994 M1] (2)}*		
r	*LR*	*P-value*	*R*	*LR*	*P-value*	*r*	*LR*	*P-value*	*R*	*LR*	*P-value*
0	58.21	0.0002	0	60.92	0.0001	0	55.58	0.0004	0	58.59	0.0002
1	10.12	0.4965	1	9.83	0.5225	1	10.07	0.5064	1	10.02	0.5113

Note: (1) "r" and "LR" denotes number of cointegrating relations/vectors and log likelihood ratio respectively. (2) Values in ( ) denotes the number of lag length used in cointegration analysis.
Source: Author's calculation.

It is evident from the Table 4 that in all cases (either by incorporating seasonal adjustment or not and allowing for all possible combinations of structural break dates) there is strong evidence for the presence of one cointegrating vector (i.e., stable long run relationship exist between the two variables) expect for the case when a combination of break date [1991 M12] and [2006 M2] is present. Put differently, since the long-run price of gold and inflation move together, investment in gold can serve as an inflationary hedge in India.

CONCLUSION

The inflation hedging quality of gold depends on the presence of a stable long-run relationship between the price of gold and the inflation. Since both variables are affected by seasonal affects and structural changes occurring in the gold market and inflation, we have employed a method which involves to endogenously determining the most significant structural breaks in the presence of or absence of seasonal dummies. Finally, by incorporating those breaks dates and seasonal effects cointegration analysis has been carried out. Cointegration analysis reveals that there is strong evidence of long-run relationship between the gold price and inflation. Therefore, we can recommend to the investors that investing in gold in India as a inflationary hedge is a good option as for as long run is concerned.

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ANNEXURE 1

Table 1
Tests of Seasonal Unit Root in Monthly Data

Null hypothesis	*Alternative hypothesis*	*Test statistic*
$\pi_1 = 0$	$\pi_1 < 0$	$t(\pi_1)$
$\pi_2 = 0$	$\pi_2 < 0$	$t(\pi_2)$
$\pi_3 \cap \pi_4 = 0$	$\pi_3 \cup \pi_4 \neq 0$	$F(\pi_3, \pi_4)$
$\pi_5 \cap \pi_6 = 0$	$\pi_5 \cup \pi_6 \neq 0$	$F(\pi_5, \pi_6)$
$\pi_7 \cap \pi_8 = 0$	$\pi_7 \cup \pi_8 \neq 0$	$F(\pi_7, \pi_8)$
$\pi_9 \cap \pi_{10} = 0$	$\pi_9 \cup \pi_{10} \neq 0$	$F(\pi_9, \pi_{10})$
$\pi_{11} \cap \pi_{12} = 0$	$\pi_{11} \cup \pi_{12} \neq 0$	$F(\pi_{11}, \pi_{12})$
$\pi_2 \cap_{\dots\dots} \cap \pi_{12} = 0$	$\pi_2 \cup \dots \cup \pi_4 \neq 0$	$F(\pi_{2\dots\dots}\ \pi_{12})$
$\pi_1 \cap_{\dots\dots} \cap \pi_{12} = 0$	$\pi_1 \cup \dots \cup \pi_4 \neq 0$	$F(\pi_{1\dots\dots}\ \pi_{12})$

ANNEXURE 2

Table 1
Critical values for the HEGY test

Test statistic	*1%*	*5%*	*10%*	*1%*	*5%*	*10%*	*1%*	*5%*	*10%*	*1%*	*5%*	*10%*
	HEGY Test: ln (WPI of all commodities) intercept, seasonal no dummies, time trend			*HEGY Test: ln (WPI of all commodities) intercept, time trend and seasonal dummies*			*HEGY Test: Ln (Rupees pe 10 gms.) intercept, seasonal no dummies, time trend*			*HEGY Test: Ln (Rupees pe 10 gms.) intercept, time trend and seasonal dummies*		
$t(\pi_1)$	-3.40	-2.81	-3.51	-3.91	-3.35	-3.08	-3.40	-2.81	-3.51	-3.91	-3.35	-3.08
$t(\pi_2)$	-3.34	-2.81	-2.51	-3.34	-2.81	-2.51	-3.34	-2.81	-2.51	-3.34	-2.81	-2.51
$F(\pi_3, \pi_4)$	8.40	6.35	5.45	8.38	6.35	5.45	8.40	6.35	5.45	8.38	6.35	5.45
$F(\pi_5, \pi_6)$	8.58	6.48	5.46	8.55	6.48	5.46	8.58	6.48	5.46	8.55	6.48	5.46
$F(\pi_7, \pi_8)$	8.39	6.33	5.32	8.39	6.30	5.33	8.39	6.33	5.32	8.39	6.30	5.33
$F(\pi_9, \pi_{10})$	8.56	6.41	5.46	8.50	6.40	5.47	8.56	6.41	5.46	8.50	6.40	5.47
$F(\pi_{11}, \pi_{12})$	8.76	6.47	5.36	8.75	6.46	5.36	8.76	6.47	5.36	8.75	6.46	5.36
$F(\pi_{2\dots}\ \pi_{12})$	5.05	4.37	4.04	5.34	4.58	4.26	5.05	4.37	4.04	5.34	4.58	4.26
$F(\pi_{1\dots}\ \pi_{12})$	5.17	4.44	4.08	5.15	4.44	4.07	5.17	4.44	4.08	5.15	4.44	4.07

Note: Critical values has been obtained from P.H. Franses and B. Hobijn (1997).