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Does Gold Act as a Hedge against Inflation in the UK? Evidence from a Fractional Cointegration Approach Over 1257 to 2016

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Abstract

This paper examines the inflation hedging ability of gold in the UK based on a fractional integration and cointegration framework. This gives more flexibility as it does not restrict the order of integration between zero and 1. Annual time series data covering 1257 to 2016 were used. We conducted both full sample and sub-sample analysis. Using the full sample, the findings shows that gold and retail price index (RPI) are both I(1). However, based on the sub-sample analyses, gold is I(1) for most sub-periods while RPI is mean reverting (d<1) for most periods. However, both series exhibit the same degree of integration, I(1), during the last sub-sample, specifically between 1903 and 2016. We also find the existence of cointegration between gold and RPI but this is exclusively due to the data from the last century. It is therefore concluded that gold provides protection against inflation since its value would be maintained in the presence of inflation.

Keyword: Inflation, gold price, hedging, fractional cointegration, long memory.
JEL Classification: C32, E31, E44, G15, Q02.

1. Introduction

The value of investment portfolios often get eroded by inflation. This poses a risk to investors. Therefore investors would prefer to buy assets whose values remain the same or increase with increase in inflation. One of such assets often considered is gold. There are some features of gold that make it attractive and unique relative to other commodities namely its durability, universal acceptability and authentication, transportability, its role as a store of

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value, positively skewed returns (Worthington and Pahlavani, 2007; Lucey, 2011) and purchasing power (Wang and Lee, 2011). Gold differs from other mineral commodities in terms of both price and production behaviour. For instance, during the 2008 financial crisis, the price of gold increased by 6% while many key mineral prices fell and other equities plunged by around 40% (Shafiee and Topal, 2010).

Following the cessation of Bretton Woods in 1971, a freely floating period of gold price was initiated. Similar to most commodities, gold price is determined by its demand and supply. The supply of gold is stable and relatively inelastic. This has been attributed to the challenging extraction process, tediousness of creation of new mines and passive keeping of stocks of gold by Central Banks irrespective of the patterns of the real gold price (Aizenman and Inoue, 2012; Beckmann and Czudaj, 2013). Two components of demand for gold have been identified in the literature namely the use and the asset demand (Ghosh et al., 2004; Levin and Wright, 2006). The use demand is related to the direct use of gold for producing jewellery, coins, electrical components, medals, among others. The use demand is mainly affected by the business cycle, specifically by the purchasing power of firms and households. However, due to the appealing features of gold during crisis and recessions, the asset demand could act counter-cyclical (Beckman and Czudaj, 2013). The asset demand emphasises the use of gold as an investment by individuals, governments and fund managers to hedge inflation, recession and other forms of uncertainty (Aye et al., 2016). According to Wang et al. (2011), investors purchase gold to hedge against any economic, political, or currency crises, for diversification as well as financial arbitrage purposes.

This paper study investigates whether gold serves as a hedge against UK inflation. This is necessary because any evidence of the inflation hedge effectiveness of gold could assist investors in reducing losses arising from inflation as well as in making better decisions about their asset portfolio. This could also help the government to improve public finance as it gradually cover its gold reserve or accumulate more gold at low price variation (Wang et al., 2011). Two different hypotheses have been used in the literature to explain the relationship between expected inflation and gold prices namely the expected inflation effect and the carrying cost hypothesis (Blose, 2010; Beckmann and Czudaj, 2013). The first hypothesis argues that changes in expected inflation will cause immediate changes in gold prices. This is called the expected inflation effect hypothesis. This is because upward revisions in expected inflation spur investors to purchase gold as a hedge against the expected decline in money or for speculating the associated increase gold price (Blose, 2010). The second hypothesis, relates to the Fisher effect which argues that higher expected inflation will cause higher interest rates, consequently causing a higher cost of carry for gold investment, thereby offsetting any speculative profit from investing in gold over the inflationary period. Thus, the cost of carrying hypothesis argues changes in expected inflation will not cause a change in the price of gold.

Some empirical studies have been conducted to assess the effectiveness of gold as a hedge against inflation as evidenced in the literature section. The results from these studies have so far been inclusive. Moreover, results vary depending on the market being considered, the time period examined and method employed. Using the fractional integration / cointegration framework, we contribute to the literature on whether gold acts as hedge for UK inflation, by using an unique data set on gold prices and general price level covering the annual period of 1257 to 2016. The advantage of this long span of data is that it allows us to study the evolution of the gold market and the price-structure of UK economy, by going as far back as possible in history. We are not aware of any studies on gold inflation hedge ability that employ the fractional methods. The approach accounts for long memory behaviour often found in most financial and economic time series. It allows one to simultaneously and endogenously determine the order of integration without a priori restricting the order between zero and one. This flexibility makes the fractional framework employed in this paper more flexible than conventional integration-cointegration methods.

The rest of the paper is organized as follows: section two reviews the literature on previous empirical studies. The data and empirical model are presented in section three. In section four, the results and discussion are presented, while section five concludes.

2. Literature Review

Although the role of gold as a hedge has been examined for the case of inflation, national currencies, stocks and bond markets, the review here focuses on its role as an inflation hedge. The empirical conclusion as to whether gold is a hedge against inflation is mixed. For instance, Wang et al., (2011) examined the inflation hedge ability of gold in the short and long run using US and Japan annual data during January 1971 to January 2010 period. Analysis based on threshold cointegration and error correction models suggest gold's inflation hedging ability differ from time to time and from one market to the other. Specifically, it was found that in the short run, while gold acts as effective inflation hedge during high momentum period especially in the US and partially in Japan, the contrary is the case during low momentum period where it failed to play the hedging role in both countries. In the long run gold was unable to respond to changes in the consumer price index due to price rigidity.

Using annual data on the US economy from 1933 to 2013, and a battery of cointegration tests including an interrupted nonlinear cointegration model, Aye, et al. (2016) concluded that the empirical evidence of gold as an effective hedge against inflation is mixed. Their study shows that while the standard tests find no evidence of the inflation hedge role of gold, the nonlinear model find a temporary role. Beckmann and Czudaj (2013) test the gold inflation hedge hypothesis using data for the USA, the UK, the Euro Area, and Japan and Markov switching vector error correction model (MS-VECM) approach for a sample period ranging from January 1970 to December 2011. They find that gold partially acts as hedge for future inflation in the long run with the ability being stronger for the USA and the UK relative to Japan and the Euro Area. Also gold's hedging ability depends on the time horizon considered and the two regimes represent different states of the economy with one accounting for turbulence and the other normal times.

Adrangi et al. (2003) find that the correlation between gold prices and expected inflation is positive. They conclude that a gold investment may be a reliable inflation hedge in both the short-run and the long-run. Ghosh et al. (2004) use monthly U.S. data covering from 1976 to 1999. Results based on cointegration regression techniques show that the gold price rises over time at the general rate of inflation and hence is an effective hedge against inflation. Using cointegration and VECM techniques with data from 1976–2005, Levin and Wright (2006) find that gold acts as an inflation hedge for US inflation and inflation volatility as well as those of Turkey, India, Indonesia, Saudi Arabia, and China.

Using a modified cointegration method which allows for instabilities in the long run relationship and USA monthly data from 1945 to 2006 and from 1973 to 2006, Worthington and Pahlavani (2007) provide evidence in favour of a cointegrating relationship between the price of gold and inflation in both sample periods and thus, conclude that a gold investment can serve as an effective inflationary hedge. McCown and Zimmerman (2006) find a significant relationship between measures of inflation and gold prices while Tully and Lucey (2007) using a power GARCH approach, do not find a significant relationship between inflation and gold. Mahdavi and Zhou (1997) examine the extent to which gold and other commodity prices are leading indicators of inflation using data from 1958–1994. Results based on cointegration and vector error correction model (VECM) indicate that gold's contribution to inflationary predictions is not statistically significant.

Long et al. (2013) investigate the inflation-hedging ability of gold in Vietnam using data from 2001 to 2011. They find that gold provides a complete hedge against both the ex post and ex ante inflation. They also find that gold return is positively related to unexpected inflation, and a support in favour of the Fisher hypothesis that nominal gold returns move in a one-for-one correspondence with expected inflation. Hoang et al. (2016) examine the role of gold as a hedge against inflation based on monthly gold prices in China, India, Japan, France, the UK and the USA from1955 to 2015. Employing the nonlinear autoregressive distributed lags (NARDL) model they find that gold has no hedging ability for inflation in the long run in all the countries. However, gold hedges against inflation in the short run only in the UK, USA, and India.

The foregoing clearly shows that the inflation hedging ability of gold has not been investigated using the fractional approach despite the advantages of this method. Thus, we fill this gap in the literature by using a long span of historical data for the UK covering over eight centuries of data.

3. Methodology

As earlier mentioned in the manuscript, we focus on fractional integration and cointegration techniques. The main advantage of these approaches is that it is more flexible than the standard methods that simply consider integer degrees of differentiation. In particular, an I(d) process is defined as

$$(1 - L)^d x_t = u_t, \qquad t = 0, \pm 1, \ldots, \tag{1}$$

where L is the lag operator, that is, $Lx_t = x_{t-1}$, and u_t is supposed to be integrated of order 0 or short memory, in the sense that the infinite sum of the autocovariance must be finite. In this context, we allow the differencing parameter d to be any real value, including thus fractional numbers. Note that, using the Binomial expansion, the polynomial $(1 - L)^d$ can be expressed as:

$$\sum_{j=0}^{\infty} \binom{d}{j} (-1)^j L^j = 1 - dL + \frac{d(d-1)}{2} L^2 - \frac{d(d-1)(d-2)}{6} L^3 - \ldots,$$

and thus equation (1) can be expressed as:

$$x_t = d\, x_{t-1} - \frac{d(d-1)}{2} x_{t-2} + \frac{d(d-1)(d-2)}{6} x_{t-3} - \ldots + u_t .$$

We see that if d is a non-integer value, x_t not only depends on a finite number of previous values but on all its past history, and, higher the value of d is, higher the level of dependence between the observations will be, implying a higher level of persistence.

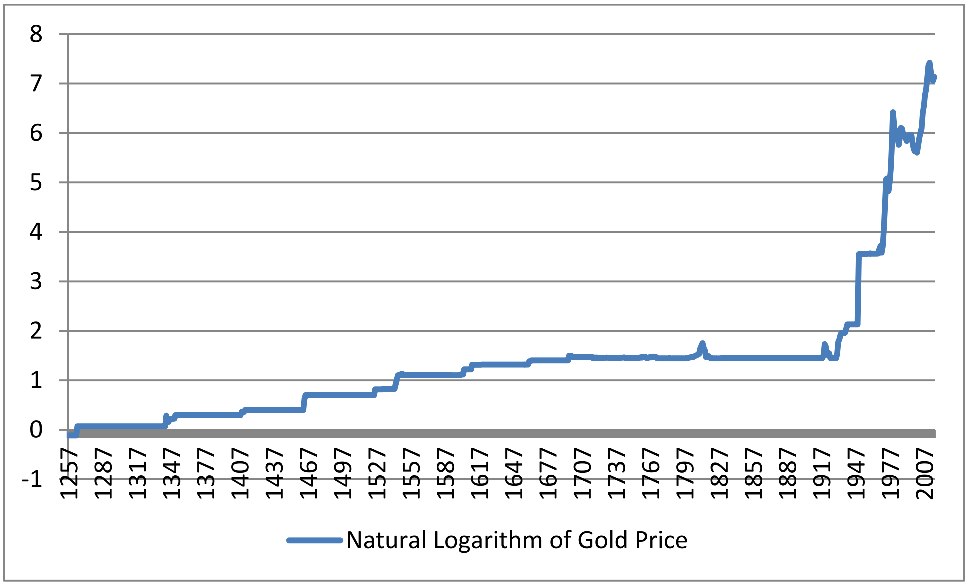
In the I(d) context, three values play important roles: one is the value 0: An I(0) process is said to be short memory as opposed to a long memory process when $d > 0$; the second one is 0.5: if $d < 0.5$ in (1), x_t is still covariance stationary as opposed to the case where $d \geq 0.5$ which is nonstationary in the sense that the variance of the partial sums increases in magnitude with d; finally, the value 1 is also very important: if $d < 1$ the series is mean reverting in the sense that shocks will disappear by themselves in the long run contrary to what happens if $d \geq 1$, with shocks persisting forever. These processes, originally proposed by Granger (1980, 1981), Granger and Joyeux (1980) and Hosking (1981) have been widely applied in the economics literature during the last twenty years. Examples of applications in economics and finance are Baillie (1996), Gil-Alana and Robinson (1997), Lobato and Savin (1998), Michelacci and Zaffaroni (2000), Gil-Alana and Moreno (2012), Abritti et al. (2016), etc.

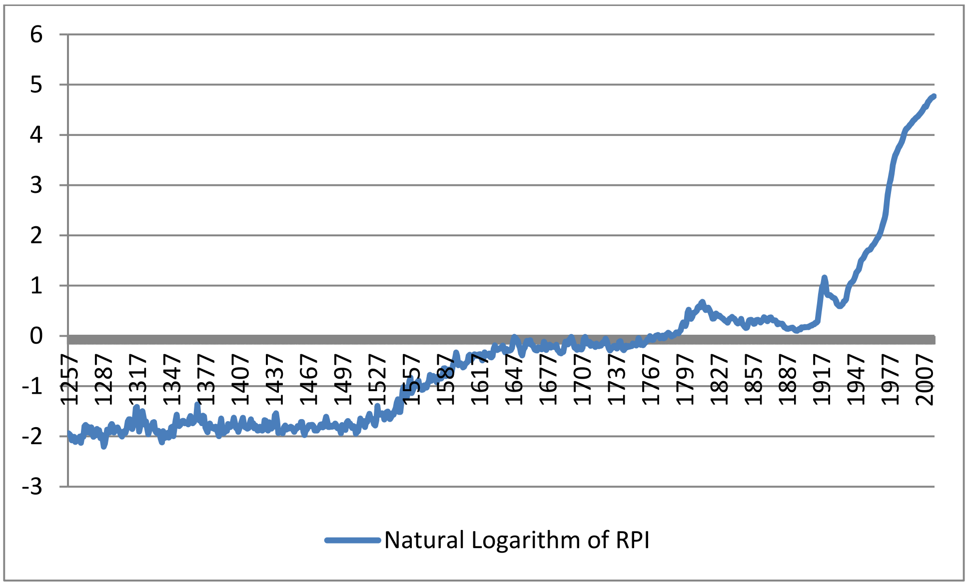
The natural multivariate extension of fractional integration to the multivariate case is the concept of fractional cointegration. This was initially proposed by Engle and Granger (1987) in their seminal paper on cointegration though practically all the empirical applications using this method focused on integer degrees of differentiation. Theoretical contributions on fractional cointegration include the papers of Peter Robinson and his coautors (Robinson and Yajima, 2002; Robinson and Marinucci, 2003; Robinson and Hualde, 2003; Hualde and Robinson, 2007; etc.). In this paper we employ a generalization of the multivariate cointegration CVAR model of Johansen (1996) to the fractional case that was introduced by Johansen (2008) and further expanded by Johansen and Nielsen (2010, 2012).

4. Data and empirical results

Annual time series data on UK covering 1257 to 2016 were used for gold price and the general price level, with the latter captured by the retail price index (RPI). Data for both these variables were retrieved from Measuring Worth. The gold price data is downloaded from: https://www.measuringworth.com/gold/, while the RPI is derived from: https://www.measuringworth.com/ukearncpi/. Data were transformed by taking natural logarithms, and have been plotted in Figure 1.

Figure 1. Data Plots





We start by examining the individual series, and the first thing we do is to investigate the order of integration of the series from a fractional viewpoint. This is of interest noting that standard nonstationary unit root tests have very low power if the true data follows a fractional process (see, e.g., Diebold and Rudebusch, 1991; Lee and Schmidt, Hassler and Wolters, etc.). We consider the following model:

$$y_t = \beta_0 + \beta_1 t + x_t, \qquad (1 - L)^d x_t = u_t, \qquad t = 1, 2, \ldots \tag{2}$$

where y_t is the observed time series; β_0 and β_1 are unknown coefficients referring respectively to the intercept and a linear time trend, and x_t is supposed to be I(d) where d is also unknown and estimated from the data. We use a parametric approach based on the Whittle function in the frequency domain (Dhalhaus, 1989; Robinson, 1994), assuming that the error term u_t is white noise and autocorrelated. In the latter case, we use the non-parametric approach of Bloomfield (1973), which seems to be quite convenient in the context of fractional integration.

Table 1: Univariate results for the full sample (1257 – 2016)

i) No autocorrelation			
	No trends	An intercept	A linear trend
GOLD	0.98 (0.95, 1.01)	0.99 (0.95, 1.02)	**0.99 (0.95, 1.02)**
RPI	1.01 (0.97, 1.07)	1.03 (0.99, 1.08)	**1.03 (0.99, 1.08)**
ii) with autocorrelation			
	No trends	An intercept	A linear trend
GOLD	1.06 (1.01, 1.12)	1.06 (1.00, 1.12)	**1.06 (1.00, 1.13)**
RPI	0.95 (0.90, 1.02)	0.95 (0.91, 1.00)	**0.94 (0.92, 1.00)**

In bold the selected models according to the deterministic terms.

We present the results for the three standard cases of i) no deterministic terms, ii) an intercept, and iii) an intercept with a linear trend, and the results as presented in Table 1, (based on the t-values of the estimated coefficients) suggest that the time trend is required in all cases. Focusing on the estimates of the differencing parameters, we observe that all the estimated values are close to 1, and the I(1) hypothesis cannot be rejected in any single case.

Next we examine the possibility of the two variables to be (fractionally) cointegrated and the results (reported in Tables 2 and 3) shows that they are, with an estimated value of d for the parent series slightly above 1 (1.124).[1]

[1] To check for the robustness of our results, we also estimated a trivariate model by including silver prices starting in 1687, given data availability of silver prices from Measuring Worth. We observed that our results

Table 2: Testing fractional cointegration (1257 – 2016)

d	1.124	
Rank Test	Log-Likelihood	LR statistic
0	-12961.067	293.646
1	**-12817.800**	**7.113**
2	-12814.244	------

Table 3: Results in terms of the FVECM (1257 – 2016)

$$\Delta^{1.124}\left(\begin{bmatrix} gold \\ rpi \end{bmatrix} - \begin{pmatrix} -0.123 \\ -1.940 \end{pmatrix}\right) = L_{1.124}\begin{bmatrix} -0.000 \\ 230438.511 \end{bmatrix}\upsilon_t + \Gamma\Delta^{1.124}L_{1.124}(X_t - \mu) + \varepsilon_t.$$

Next we want to examine if this relationship has been stable across the sample period and for this purpose we examine different sub-periods by means of checking first if there are structural breaks using the Bai and Perron (2003) tests of multiple structural breaks. The breaks take place at 1545, 1696 and 1903, in an equation relating gold prices and the price level, based on the powerful *UDMax* and *WDMax* test statistics based on 1 to *M* globally determined breaks and allowing for error distributions to differ across the breaks. Similar breaks are obtained using Gil-Alana (2008)'s method, specifically designed for the case of fractional integration.

continued to be qualitatively and quantitatively similar. Complete details of these results are available upon request from the authors.

Table 4: Results for gold and prices with three breaks (1545, 1696 and 1903)

i) No autocorrelation			
	No trends	An intercept	A linear trend
GOLD (1257 – 1544)	0.88 (0.81, 0.97)	0.91 (0.83, 1.01)	**0.91 (0.83, 1.01)**
GOLD (1545 – 1695)	1.03 (0.92, 1.18)	0.96 (0.85, 1.12)	**0.97 (0.87, 1.12)**
GOLD (1696 – 1902)	0.76 (0.69, 0.86)	0.13 (0.05, 0.23)	**0.12 (0.04, 0.22)**
GOLD (1903 – 2016)	1.02 (0.88, 1.23)	1.10 (0.97, 1.31)	**1.10 (0.96, 1.33)**
RPI (1257 – 1544)	0.90 (0.82, 0.99)	0.61 (0.50, 0.75)	**0.61 (0.50, 0.75)**
RPI (1545 – 1695)	0.95 (0.83, 1.11)	0.78 (0.64, 1.06)	**0.81 (0.68, 1.05)**
RPI (1696 – 1902)	1.03 (0.92, 1.21)	**1.03 (0.92, 1.22)**	1.03 (0.92, 1.22)
RPI (1903 – 2016)	1.57 (1.41, 1.79)	**1.68 (1.51, 1.92)**	1.68 (1.51, 1.92)
ii) with autocorrelation			
	No trends	An intercept	A linear trend
GOLD (1257 – 1544)	0.89 (0.77, 1.09)	0.91 (0.78, 1.12)	**0.93 (0.78, 1.12)**
GOLD (1545 – 1695)	0.91 (0.74, 1.15)	0.98 (0.82, 1.23)	**0.98 (0.80, 1.23)**
GOLD (1696 – 1902)	0.99 (0.81, 1.33)	**0.14 (-0.01, 0.35)**	0.16 (0.00, 0.36)
GOLD (1903 – 2016)	0.78 (0.66, 1.01)	0.86 (0.75, 1.08)	**0.79 (0.58, 1.11)**
RPI (1257 – 1544)	0.81 (0.71, 0.95)	0.30 (0.21, 0.42)	**0.29 (0.18, 0.44)**
RPI (1545 – 1695)	0.81 (0.66, 1.03)	0.52 (0.46, 0.59)	**0.46 (0.36, 0.60)**
RPI (1696 – 1902)	0.74 (0.66, 0.85)	0.72 (0.63, 0.84)	**0.72 (0.62, 0.84)**
RPI (1903 – 2016)	1.21 (1.01, 1.55)	1.19 (1.00, 1.50)	**1.20 (1.00, 1.50)**

Table 4 reproduces the results in Table 1 but for each one of the subsamples again for the two cases of uncorrelated (Table 4i) and autocorrelated (Table 4ii). Focusing on the autocorrelated ones, which seem to be more realistic based on its non-parametric nature and the diagnostic tests carried out on the uncorrelated case, we observe that for gold, the I(1) hypothesis cannot be rejected for the first two subsamples and for the fourth one. However, in the third one (from 1696 to 1902) this hypothesis is decisively rejected in favour of smaller orders of integration and the I(0) case cannot be rejected for this subsample. For price level, a different picture emerges and mean reversion (i.e., statistical evidence in favour of $d < 1$) is obtained for the first three subsamples, and the I(1) hypothesis cannot be rejected only in the last subsample (1903 – 2016). This is very relevant, since it implies that the two series only display the same degree of integration during last subsample, and this is a necessary condition for cointegration in the bivariate case.

Table 5: Testing fractional cointegration (1903 – 2016)

d	1.322	
Rank Test	Log-Likelihood	LR statistic
0	233.399	13.759
1	**239.791**	**0.976**
2	240.279	------

Table 6: Results in terms of the FVECM (1903 – 2016)

$$\Delta^{1.322}\left(\begin{bmatrix}\text{gold}\\ \text{prices}\end{bmatrix}-\begin{pmatrix}1.291\\ 0.188\end{pmatrix}\right)=L_{1.322}\begin{bmatrix}-0.121\\ 0.019\end{bmatrix}\upsilon_t+\Gamma\Delta^{1.322}L_{1.322}(X_t-\mu)+\varepsilon_t$$

Tables 5 and 6 focus on the fractional cointegration test and the FVECM for the last subsample (1903 - 2016), and the results show evidence of cointegration between the two variables with a common differencing parameter of 1.322, much higher than when looking at the whole sample, and consistent with the univariate results in Table 4.

5. Conclusions

In this study, we investigate whether gold acts as a hedge against inflation using the UK data from 1257 to 2016. Our analysis is based on the fractional integration and cointegration framework. The fractional integration test shows that gold and the general price level exhibit different orders of integration at different sub-periods. However, both series display the same degree of integration, I(1), during the last subsample (1903-2016). With respect to cointegration, we find the existence of cointegration between gold and price level using the full sample, but this is exclusively due to the data from the last century consistent with the fractional integration results. Therefore, gold has an inflation hedging ability.

These findings have important implications for policy makers, investors, financial analysts and academics. This paper makes additional contribution among academics in better understanding the inflation hedging ability of gold based on new application of the fractional integration approach. It has demonstrated that although the long-run price of gold and inflation move together, this is stronger in the recent period. From the investors' perspective, the findings provide a guide for portfolio asset allocation decision. Specifically, incorporating gold in one's investment portfolio would help investors to reduce losses arising from inflation. The capital resources stored in gold may be mobilised by monetary policy authorities via introduction of more investment channels in the economy. While investment in gold is a good instrument for hedging investors against inflation, large hoarding of gold should be discouraged by monetary authorities since this may lead to loss of confidence in the fiat money as well as limit the opportunity of investing in other assets thereby reducing the volume of financial resources that would contribute to economic growth and development.

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