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Can Gold Investments Provide a Good Hedge Against Inflation? An Empirical Analysis

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ABSTRACT

It is widely accepted that inflation erodes purchasing power of retirement savings, redistributes wealth from lenders to borrowers, and threatens private investors' long-term objectives. Thus, there is a high demand on diversifying investors portfolio for both individuals and institutions in order to hedge against inflation. This paper aims to examine the effectiveness of gold investments to hedge against consumer inflation risks in the United States (US). Using monthly data from April, 1986 to June, 2016, that covers more than 30 years, unit root testing approach robust for finite samples, the Johansen multivariate cointegration test procedure and vector error correction model have been employed to examine the long-run relationship between gold return and consumer inflation in the US. The key finding suggests that gold investments in the US provide an effective hedge against inflation for investors who are willing to keep their investments for long-run. However, it does not provide any hedge if investors hold it for only short-term.

Keywords: Hedge, Investments, Gold Prices, Inflation, Cointegration
JEL Classifications: C22, C52, G15, Q02

1. INTRODUCTION

Since inflation is considered as a leading macroeconomic indicator, recent fluctuations in the United States (US) economy have intensively raised the concerns of both consumers and investors of possible inflation. Basically, dramatic increase in the monetary supply to combat the global recession, continued rise in the demand for scarce raw materials in the emerging markets, and a growing level of imported inflation apparently, have shown a serious uphold to inflation pressure in the near future (Anderson, 2011). To manage inflation risk, investors prefer to diversify their investment portfolio by including more options that counter for potential price inflation and thus provide a good hedge against inflation. Bodie (1976) has explained that a security is an inflation hedge if it eliminates or at least reduces the possibility that the real return on the security will fall below some specified floor value such as zero. Empirically, inflation hedging states that an asset is an inflation hedge if its real return is independent of the rate of inflation, implying a positive correlation between the nominal return of the hedging asset and inflation. A correlation of 1 is called a perfect hedge because price increases are perfectly compensated by corresponding asset returns. If an asset does not provide a perfect hedge, a stable positive return-inflation relation can still make the asset valuable.

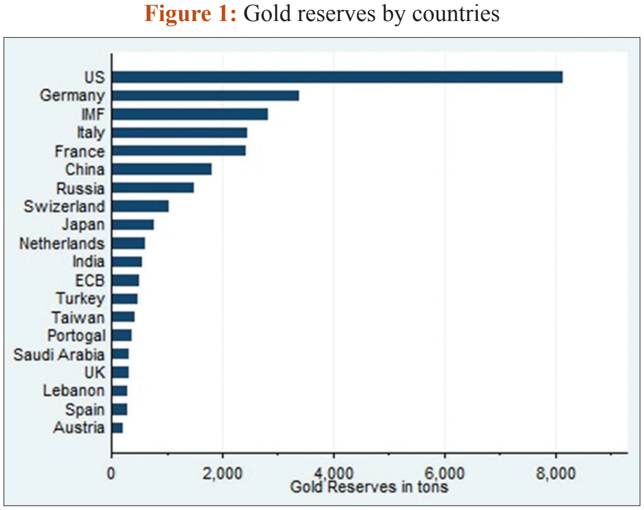
Investors shed the light on gold, which plays a vital role in macroeconomic world not only as a precious metal with significant portfolio diversification properties, but also as an industrial component, jewelry, investment asset, reserve asset and a monetary asset (Ciner, 2001). Gold is a unique highly liquid asset, as it can be readily bought or sold 24 h a day, in large denominations and at narrow spreads. Hillier et al. (2006) has highlighted that the total annual production of gold is cleared by the London Bullion Market Association every 2.5 days. Central banks and international financial institutions hold a large proportion of the above-ground stocks of gold in their reserve for a number of reasons including: Diversification, maintaining its purchasing power and liquidity, providing more security during crisis, maintaining values, and providing income-gold leasing (Ciner, 2001; Davidson et al., 2003; Hillier et al., 2006; Kaufmann and Winters, 1989). As inflation usually influences commodities that are linked to economic cycle, gold is placed uniquely compared to other commodities. Indeed, only 10% of gold's demand comes from industrial uses and the rest being jewelry and investment demand. Therefore, it has received much attention not only from investors, but also from traders, policy-makers and producers.

With a glance on the statistics of gold reserves shown in Figure 1 below, it is clear that the US is still on the top of countries that hold gold where the International Monetary Fund comes on the third position. Although India is the greatest country that demanding for gold, it comes on the 11^{th} position as a holder for gold reserves. Central banks keep on holding passive stocks of gold regardless the patterns of the real prices (Aizenman and Inoue, 2013), which indeed contributed to the stability of gold supply, on one hand, while on the other hand, the demand for gold has witnessed a rapid change in response to global economic episodes. Thus, gold prices have witness a high volatility in the short-run as explained by Aggarwal (1992).

From the above discussion, analyzing the nature of the relationship between gold investments and inflation rate to investigate whether or not gold has the ability to hedge against inflation in both short and long run is still in need, especially that the literature findings are inconsistent yet. Accordingly, this paper is not only representing an attempt to re-examine the long run relationship between both gold investments and inflation rate in the US, but also uses a data-set that includes all the recent boom and busts for the last 30 years. In addition, the asset return equation proposed by Fisher (1930) is employed into an error correction model (ECM) developed by Johansen (1988); Johansen and Juselius (1990) to find out the dynamic of short-run relationship. The key findings suggest that gold investments are far from being a short-term hedge against inflation. However, it provides an imperfect hedge against inflation only for investors willing to keep gold investments for relatively longer period, which is in line with the findings of Beckmann and Czudaj (2013), Capie et al. (2005) and Shahbaz et al. (2014).

In what follows, a literature review is provided in Section 2. Section 3 describes the theoretical framework, where data is analyzed in Section 4. Methodology is discussed in Section 5 and finally, concluding remarks and policy implications are provided in Section 6.

Figure 1: Gold reserves by countries



2. LITERATURE REVIEW

Inflation hedge of gold has attracted many researchers in literature to investigate the ability of gold investments hedging against inflation. Basically, methods that investigate long-run relationship between gold return and ex-post inflation (Adrangi et al., 2003; Baillie, 1989; Ghosh et al., 2004; Hoang, 2012; Lawrence, 2003; Mahdavi and Zhou, 1997); McCown and Zimmerman, 2006; Narayan et al., 2010; Pecchenino, 1992; Wang et al., 2011; Worthington and Pahlavani, 2007), short-run relationship between gold return and ex-post inflation rate (Ghosh et al., 2004; Hoang, 2012; Laurent, 1994; Taylor, 1998; Wang et al., 2011), and relationship between gold return and expected inflation (Bhardwaj et al., 2011; Blose, 2010; Christie-David et al. 2000), have been widely applied. However, results with regards to the ability of gold to hedge against inflation are still contradicting. For instance, Jaffe (1989) has estimated gold returns on contemporaneous anticipated inflation using yield of 1 month treasury bill and surprisingly found that the relationship is negative. On the other hand, empirical results for return on gold and unanticipated inflation show a significant positive relation. Jaffe (1989), subsequently, conclude that a short time interval within a 17-year period is the reason why gold is not a good hedge against inflation.

Under the shed of the above discussion, results of historical studies with regards to the effectiveness of gold as a hedge against inflation are contradicting. Thus, there is a demand for analyzing the nature of the relationship between gold investments and inflation rate to investigate whether or not gold has the ability to hedge against inflation in both short and long run. To do so, this paper is contributing to the literature by two main folds. First, we provide an attempt to re-examine the long run relationship between both gold investments and inflation rate in the US using a data-set that includes all the recent boom and busts for the last 30 years. Second, the asset return equation proposed by Fisher (1930) is employed into an ECM developed by Johansen (1988); Johansen and Juselius (1990) to find out the dynamic of short-run relationship.

3. THEORETICAL FRAMEWORK

Fisher (1930) notes that the nominal return on an asset can be expressed as the sum of expected real return and expected inflation rate as shown below:

$$R_t=[E_{t-1}(r_t)]+[E_{t-1}(\pi_t)]+\epsilon_t \quad (1)$$

Where R_t is the nominal return, $[E_{t-1}(r_t)]$ is the expected real return, $[E_{t-1}(\pi_t)]$ is the expected rate of inflation, and ϵ_t is the error term. On the basis of Equation 1 above, Fisher (1930) has emphasized that both monetary and real side of the economy are completely independent. Accordingly, he has suggested that the expected real return in Equation 1 is influenced by including real factors such as: Investor time preferences, risk and productivity of capital. This indeed promote the idea that recommend relying on the independence of the expected real return and expected inflation rate. Following from the rational expectations, the expected $[E_{t-1}(\pi_t)]$ and actual π_t inflation rate, and the expected nominal $[E_{t-1}(r_t)]$

and actual return (r_t) may vary by a stationary zero mean forecast error. These respectively can be expressed as:

$$\pi_t=[E_{t-1}(\pi_t)]+\delta_{1t} \quad (2)$$

$$r_t=[E_{t-1}(r_t)]+\delta_{2t} \quad (3)$$

Where δ_{1t} and δ_{2t} represent stationary zero mean forecast errors. By putting Equations 2 and 3 into Equation 1, it can be written as; $R_t=r_t+\pi_t+v$, where $v=\delta_{1t}-\delta_{2t}$.

4. DATA ANALYSIS

This study uses the US data to investigate the effectiveness of investing in gold against inflation. It uses monthly data on gold investment proxied by gold prices (Gold) and inflation measured by consumer price index (CPI), for the US between April 1968 and June 2016. The data are collected from FRED database for CPI, where it represents the CPI for all urban consumers: All Items, index 1982-1984=100, and seasonally adjusted. Gold prices are collected from the ICE Benchmark Administration Limited (IBA) on the basis of US dollars. All data are expressed in natural logarithms to proceed with our empirical investigation. Figures 2 and 3 plot gold prices (Gold) and CPI at level and first-differenced forms, respectively, for the period from April 1968 till June 2016. Figure 2 show that the lowest 1 oz gold price occurred in December 2005 at $492.80 USD, where the highest spot price was $1,905.10 USD per troy ounce on September 2011. The price of gold has increased from a level of US$ 250 per troy ounce to an all-time high of US $ 1,900 in August 2011, before falling substantially to around US $ 1,200 at the end of June 2013. By the end of 2015, prices had fallen to almost $1,061, which is attributed to the fact that the dollar had strengthened by 25% since 2014. After Great Britain voted to leave the European Union in year 2016, gold prices surged $100 an ounce in 6 h. They rose from $1,254.96 at 4 pm on June 23, the evening of the Brexit vote, to $1,347.12 at midnight[1].

Descriptive statistics shown in Table 1 provides means to describe the basic feature and structure of available data, so that meaningful inferences can be drawn from the results. The various descriptive statistical measures mean, median, maximum, minimum, standard deviation, skewness, and kurtosis have been used to identify and summarize the general trends of the data-set.

5. METHODOLOGY

The empirical methodology starts from Fisher's equation. Since the interest in this paper is to assess how gold investment varies in relation to changes in inflation. Thus, gold investment equation can be written as a function of inflation:

$$Gold_t=f(CPI_t)$$

1 It is widely accepted that investors bought gold as a hedge against a declining euro and British pound at that stage. For more information see http://www.wsj.com/articles/gold-soars-as-investors-seek-haven-following-brexit-1466745191.

Figure 2: Top countries with largest gold reserves

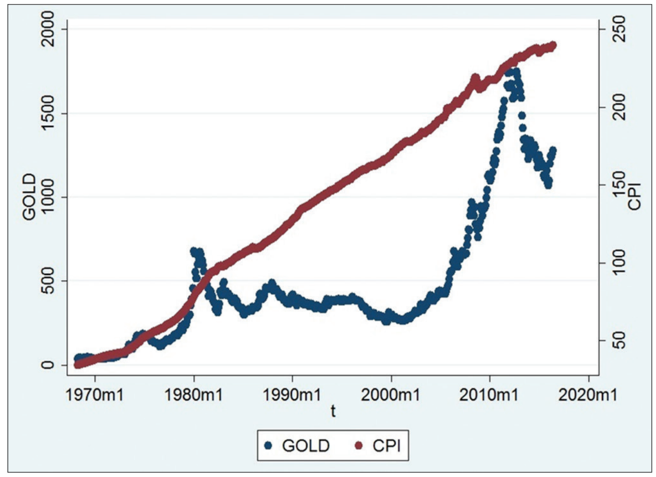


Figure 3: Plot of monthly gold prices and consumer price index

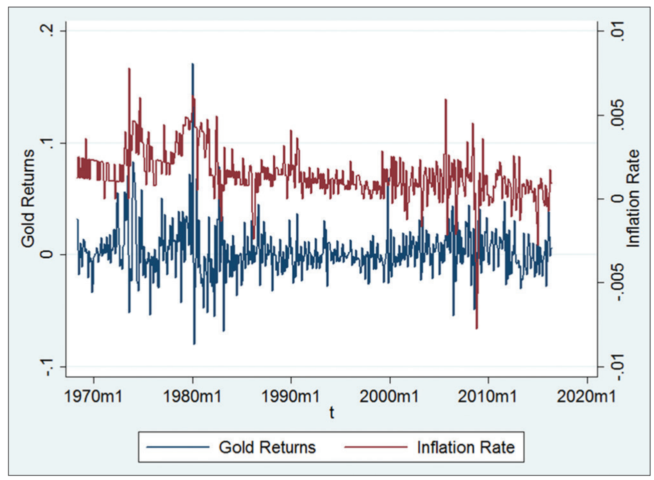


Table 1: Descriptive statistics: Monthly data

Variable	Gold	CPI
Mean	2.52	2.07
SD	0.41	0.25
Skewness	−0.66 (0.000)	−0.68 (0.000)
Kurtosis (excess)	0.39 (0.050)	−0.76 (0.000)
Jarque-Bera	45.21 (0.000)	59.15 (0.000)

Where $Gold_t$ is the gold investment proxied by gold prices in US\$/ounce and CPI_t denotes the CPI. Most studies on the inflation hedging attributes of gold have followed the methodology of Fama and Schwert (1977). Accordingly, to determine if gold is a hedge against inflation:

$$\ln Gold_t=\alpha_1+\alpha_2 \ln CPI_t+\epsilon_t \quad (4)$$

Where variables maintain their definitions except for ϵ_t error term which is assumed to be independent and identically normally distributed (iid). Since variables are in logarithmic form, the coefficients represent their respective elasticities.

Thus, α_2 which is the coefficient of CPI measures how responsive gold price is to changes in general price levels ceteris paribus. The intuition is that if investment in gold rises in response to increases in inflation, then,

$$\alpha_2 = \frac{\partial \ln Gold_t}{\partial \ln CPI_t} > 0$$

Otherwise $\alpha_2 < 0$. By being unitary or fairly elastic, a unit percentage increase in inflation would increase gold prices by 1 or more than the proportionate increase in consumer prices. Thus, the empirical analysis tests for the existence of a long-term relationship among the suggested variables, while the vector error-correction model captures both short-run dynamics and long-run relationship between the variables. Basically, if two or more economic variables witness a systematic co-movement over the long run, then these variables are cointegrated as explained by Engle and Granger (1987). Engle and Granger (1987) propose that if X and Y are both non-stationary, one would expect that a linear combination of X and Y would be a random walk. However, the two variables may have the property that a particular combination of them Z=X−bY is stationary. Thus, if such a property holds true, then we say that X and Y are co-integrated. If X and Y each are non-stationary and co-integrated, then any standard Granger-causal inferences will be invalid and a more comprehensive test of causality based on an ECM, should be adopted (Erol and Yu, 1987). However, if X and Y are both non-stationary and the linear combination of the series of two variables is non-stationary, then standard Granger-causality test should be adopted (Toda and Phillips, 1993). Therefore, it is necessary to start this implication by testing for stationary of the variable, where non stationary series lead to spurious or nonsense inferences; the results obtained will be unreliable and inaccurate. Accordingly, the empirical analysis used in this study is performed in three steps starting form verifying the order of the integration of both variables. This has been tested using both the augmented Dickey and Fuller (1979, 1981) (ADF), and Kwiatkowski et al. (1992) (KPSS) tests. The difference between the ADF and the KPSS tests is that the formulation of the null hypothesis is different. ADF while on the other hand, KPSS assumes that the series to be investigated is stationary. This is because of the arguments surrounding stationary tests (Maddala and Kim, 1998), which may make comparing results from different alternative tests more likely to provide the opportunity to examine whether the preponderance of the evidence makes a convincing case for stationary or non-stationary. The ADF testing procedure to test the unit root hypothesis following:

$$\Delta y_t = \theta_0 + \gamma_0 t + \gamma_1 y_{t-1} + \sum_{i=0}^{p} \theta_i \Delta y_{t-1} + \varepsilon_t \tag{5}$$

Where y_t is the variable in period t; Δy_{t-1} the $y_{t-1} - y_{t-2}$; ε_t is the iid. disturbance with mean 0 and variance 1; t the linear time trend and p is the lag order. In order to test the null hypothesis for the presence of a unit root in y_t, we conducted the hypothesis testing that γ_1=0 in Equation 6. If γ_1 is significantly less than zero, the null hypothesis of a unit root is rejected. It is argued in literature that the ADF test lack of sensitivity to the heteroscedasticity and the autocorrelation of the residuals and may be inefficient on small samples. Thus, KPSS stationarity test is more effective for small samples when it chooses a lower lag truncation parameter.

In the second step, when all of the series are found to be integrated of the same order, the Johansen maximum likelihood Johansen and Juselius (1990) method is used to test the cointegration relationship between the variables.

This indeed prevent the loss of information subjected to converting a non-stationary into a stationary process. The model selection is guided by the Akaike information criterion (AIC), Schwarz's Bayesian information criterion (SBIC), and the Hannan and Quinn information criterion. Then, the existence of cointegration indicates that there is a long- run equilibrium relationship among both gold prices and CPI, and thereby, Granger causality exists among them in at least one direction (Johansen, 1992).

In the last step, if all of the variables are I(1) and cointegrated, the ECM is used to correct any disequilibrium in the cointegration relationship, that may have been captured by the error correction term, and to test for long-run and short-run causalities among the cointegrated variables as follow:

$$\Delta \ln Gold_t = \beta_0 + \beta_1 \varepsilon_{t-1} + \sum_{t=1}^{k} \theta\beta_{2i} \Delta \ln Gold_{t-i} + \sum_{t=1}^{k} \theta\beta_{3i} \Delta \ln CPI_{t-i} + u_{1t} \tag{6}$$

Where ε_{t-1} is the long-run relationship between gold investments and inflation as shown above, u_{1t} is the error term, and is a difference operator.

6. EMPIRICAL FINDINGS

6.1. Stationarity Test

It is clear from Table 2 that the null hypothesis of no unit roots for all the time series are rejected at their first differences since the ADF and KPSS test statistic values are less than the critical values at 1% levels of significance. Thus, the variables are stationary and

Table 2: Unit root test

Variable	ADF	KPSS	Lags
Level			
Gold	−1.868	12.82843**	4
CPI	−2.7	18.19720**	4
First difference			
Gold returns	−12.171***	0.268535	4
Inflation	−4.681***	0.689662**	4

Table entries are the results obtained from unit root tests. Tests are shown in the first row: Augmented Dickey and Fuller (1979) (ADF) and the stationary test by Kwiatkowski et al. (1992) (KPSS). Regression include an intercept and trend. The variables are specified in the first column: Gold price (GP), and CPI. All variables are in natural logarithms, while the lag length determined by Akaike Information Criteria and are in parentheses. **And *** indicate significance at the 10% and 5% level, respectively. The nulls for all test except for the KPSS test are unit root. CPI: Consumer price index

Table 3: Selection-order criteria

Lags	AIC	HQIC	SBIC
0	−0.371329	−0.36542	−0.3561
1	−15.4964	−15.4787	−15.451
2	−15.8222	−15.7927*	−15.465*
3	−15.8279	−15.7865	−15.721
4	−15.8378*	−15.7847	−15.701

AIC, HQIC and SBIC stand for Akaike, Hannan and Quinn and Schwarz's Bayesian information criteria, respectively. In the case of conflicting results, we use AIC results as suggested by Pesaran and Pesaran (1997). *Indicates significant at 5% level integrated of same order, i.e., I (1). All variables became stationary and do not contain unit root in first difference.

6.2. Determination of Lags

Table 3 reports lag-order selection statistics, which shows that the optimal lag length for the tested system is two. This indeed suggest that the empirical work should be proceeded using lags (2).

6.3. Cointegration Test and Vector ECM (VECM)

Based on π rank test developed by Johansen (1988), the results of testing for the number of cointegrating vectors are reported in Table 4, which derives two likelihood estimators named Eigen value and trace statistics test. The cointegration rank (r) can be formally tested with the trace and Eigen value statistics taking into accounts the 5% critical value of the test. Thus, results shown in Table 4 reveals that the trace statistic either rejects the null hypothesis of no co-integration among the variables or does not reject the null hypothesis that there is one co-integration relation between the variables. Start by testing a maximum rank of 0, if it is rejected, then repeat for next option where the maximum rank tested for 1. When a test is not rejected, then stop testing there and that value of r is the commonly-used estimate of the number of cointegrating relations. Here, r = 1 is not rejected at the 5% level (2.936 < 3.76). In other words, this trace test result does not reject the null hypothesis that these two variables are not cointegrated. The final number of cointegrated vectors with two lags is equal to one, i.e., rank (r) =1. Since, the rank is equal to 1 which is more than zero and less than the number of variables; the series are cointegrating among the variables. Nevertheless, we will proceed to estimate the ECM model to estimate the short-run dynamics.

Table 5 presents results of the long-run elasticities. There exists a positive relationship between gold prices and inflation where a

Table 4: Johansen test for cointegration

Maximum Rank	Parms	LL	Eigen value	Trace statistics	5% Critical value
0	6	4545.305		60.92	15.41
1	9	4574.301	0.096	2.936*	3.76
2	10	4575.769	0.005		

*means significancant at 5% level

Table 5: VECM estimation results

Cointegration equations	Cointegrating equation 1
Gold (−1)	1.000
π (−1)	0.481***
	[0.1029]
C	3.622**
	[0.1833]
Error correction	D (Gold)
Cointegrating equation (1)	−0.2923***
	[0.408]
D (Gold(−1))	0.6639***
	[0.0314]
D(π(−1))	0.0026
	[0.00224]
C	0.0011
	[0.0015]

**Means significant at 5% level. ***Means significant at 1% level, VECM: Vector error correction model

one percentage point increases in the latter significantly increases the former by 0.48%. The long-run elasticity is inelastic showing that gold prices rise in response to inflationary pressure but not as much as increases in inflation. Although gold cannot perfectly hedge against inflation, this finding nonetheless reveals the ability of gold to cushion investors against inflation in the long-run. Our findings are consistent Beckmann and Czudaj (2013), Capie et al. (2005) and Shahbaz et al. (2014) only in terms of direction but not on the relative strength of the coefficients. On the other hand, short-run results from the ECM show that the coefficient of inflation is insignificant suggesting that although inflation affects gold prices in the long-run, it's impact in the short-run is statistically not different from zero.

7. CONCLUDING REMARKS AND POLICY IMPLICATIONS

This paper contributes to the economic literature by investigating the validation of whether or not gold investment is a hedge against inflation in the short run as well as in the long run, in case of the US. Since the findings in literature are inconsistent yet, this paper re-examine the long run relationship between both gold investments and inflation rate in the US, but also uses a data-set that includes all the recent boom and busts for the last 30 years. In addition, the asset return equation proposed by Fisher (1930) is employed into an ECM developed by Johansen (1988); Johansen and Juselius (1990) to find out the dynamic of short-run relationship. The key findings suggest that gold investments are far from being a short-term hedge against inflation, however, it provides an imperfect hedge against inflation only for investors willing to keep gold investments for relatively longer period, which is in line with the findings of Beckmann and Czudaj (2013), Capie et al. (2005) and Shahbaz et al. (2014).

Although investments in gold do not provide a perfect hedge against inflation, investors are suggested to use gold for both diversifying their investment portfolios and protect against rising general price level. The main reason is that hike in inflation reduces the real value of money and people seek to invest in alternative investment avenues like gold to preserve the value of their assets and earn additional returns. This suggests that investment in gold can be used as a tool to decline inflation pressure to a sustainable level. However, the ability of gold to perform this function is only elusive in the short-run.

From an investor's point of view, the effectiveness of gold as an inflation hedge crucially depends on the time horizon. Over the very long-run, gold is useful as a partial hedge since a cointegrating relationship prevails. However, during some periods where no price adjustment is observed, gold is not able to shield a portfolio. This may be illustrated by a simple example of an investor who buys gold at the beginning of a period with no adjustment and sells at the end of the corresponding period.

An interesting topic for further research may be the possibility to apply daily data in such an analysis may contribute to further insights with respect to the importance of gold for portfolio investors over the very short run. Another appealing question is how does gold perform against other potential inflation hedges such as stocks, bonds, real estate, or other commodities in our framework.

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