THE IMPACT OF INFLATION ON THE INVESTMENT RETURNS OF GOLD COMMODITY MARKETS IN THE UNITED STATES

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摘 要

研究資產投資價值或報酬率之對抗通貨膨脹，傳統衡量尺度是比較投資資產獲益報酬率與通貨膨脹率二者之高低，若投資資產報酬率高於通貨膨脹率，則可謂該項資產具有對抗通貨膨脹之效果，反之則不然。近來，多數財務學者則主張衡量投資資產的對抗通貨膨脹效果，應檢視資產報酬率與通貨膨脹的一對一對稱反應，並且探測其反應程度，從而評估其對抗通貨膨脹之效率。本文是以美國黃金期貨市場之投資爲研究對象，同時測試黃金期貨報酬率對抗預期與非預期之通貨膨脹率，觀察兩種比率的反應效果。實證結果顯示，黃金期貨的投資收益並不具有完全對抗預期與非預期通貨膨脹的效果。

1. INTRODUCTION

This paper examines the hedging performance of commodity futures against inflation. The impact of both the expected component of inflation and the unexpected component of inflation on asset returns from futures trading is related to the hedging capacity of commodity futures against inflation. The asset returns can be defined as the holding-period returns on both the futures market and the spot market.

The empirical case emphasizes gold metal market in the united states not only because this real asset is recognized as an efficient investment to hedge against inflation, but also because it is storable, nonseasonal and do not deteriorate. The store value of metal futures can reflect the time dimensional cost such as storage cost and financial expense caused by inflation and interest rates.

To see the historical returns of commodity futures with respect to inflation, Bodie and Rosansky (1980) and Bodie (1983) examined the nature of the risk and return in commodity futures as a real investment and the correlation coefficients between the returns on commodity futures and general inflation rates. Their studies provide two major results: first, the result of comparing the mean and standard deviation of rates of return on various assets and the economic series in their studies is that the mean of nominal, real and excess returns[1] on commodity futures with Treasury bills[2] is larger than the mean of common stock and any other financial asset returns in three different areas. Second, the correlation coefficients between commodity futures and the rate of inflation proxied by the consumer price index in the studies mentioned above shows that they are positive and commodity futures have served as a partial hedge against inflation.

As the return versus risk of commodity futures is analyzed, the preliminary indication is that commodity futures provide some part of the financial hedge against inflation. It must be emphasized that although the returns on commodity futures are, on the average higher than the mean inflation rates, this is not sufficient for commodity futures to be considered an effective hedge against inflation. The quality of an inflation hedging asset is, for the most part, determined by the extent to which the returns on the particular asset move systematically with the inflation rate (current or lagged). Precisely, the inflation hedging value of a particular asset is determined by the magnitude and volatility of the inflation rate relative to changes in the value of that asset.

Furthermore, decomposing inflation rates into the expected component and the unexpected component of inflation has been the major trend in studying the impact of relative price levels on returns from financial assets. The expected inflation rates are defined as the form of inflation from the expectation of the market's participants. They are the "market's" predicted rates of inflation and represent a consensus prediction of inflation. The unexpected inflation rates are defined as the deviations of actual inflation rates from expected inflation rates. The difference between the expected component of inflation rates and the unexpected component of inflation rates is that the former is limited on the predictability of actual inflation rates and the latter can be described as the unexpectable or "unpredictable" part of actual inflation rate. This consists of the forecasting errors that are caused by the forecasting errors that are caused by the forecasting ability of economists.

In short, the ideas of examining the impact of expected and unexpected inflation of the investment performance from any asset is the main theme of Fama and Schwert's (1977) theory of hedging against inflation. The hedging performance against inflation, thereby, is separated as hedging performance against expected inflation and unexpected inflation by examining the directly response of returns from a futures contract to both two inflation components.

Many empirical studies have investigated the relationship between asset returns and inflation. With regard to financial assets, they examine the impact of inflation of stock returns, government and corporate bond prices or returns, interest rates and monetary supply variables.

Some of the studies have shown the properties of stocks as hedges against expected and unexpected inflation. Long (1974), Lintner (1975), Nelson (1976), Fama and Schwert (1977), Fama (1982), Fama and Gibbons (1982) and Geske and Roll (1983) investigated inflation-security return relationship. They have found that the nominal and real rates of return on securities have been negatively correlated with both the expected and unexpected inflation rates. Solnik and Gultekin (1983) provide the evidence of a stock returns-inflation relationship in international cases for the postwar period. Their results, except for the case of Canada, are consistent with previous works.

Interestingly, Schwert (1981) found the result that stock prices seem to react negatively to the announcement of unexpected inflation in the Consumer Price Index (CPI). Baesel and Globerman (1976) found that unanticipated inflation is an important explanatory variable for stock price movements. However, their results do not support the thesis of a wealth transfer from creditors to debtors due to unanticipated inflation.

Fama (1975), Fama and Schwert (1977), Fama (1982) and Fama and Gibbons (1982) proide explicit evidence that U.S. government Treasury bills and bonds can be used as complete hedges against expected inflation, but that their returns are negatively related to unexpected inflation. Furthermore, a reconciliation of interest rate theory and inflationary expectations has been investigated. Sargent (1969), Roll (1972), Summer (1978), Fama (1980) and Fama (1982) ensured a positive relationship between the nominal interest rates and expected inflation, except for Ball's result (1965). The evidence provided by Mundell (1963), Tobin (1965), Fama (1982) and Solnik (1983) has shown that there is a negative relationship between the expected real rate of interest and anticipated inflation. Fama (1980) (1982) also found a positive relationship between general inflation rates and money supply variables such as the growth rate of demand deposit and growth rates of the monetary base.

The empirical works that investigate the impact of inflation on real asset returns examine (1) the influence on real activities, (2) the influence on relative price changes and (3) the influence on commodity trading. The most convincing evidence for the theory and tests explaining the relationship between inflation and real activities has been provided by Fama and Schwert (1977), Fama and Gibbons (1982) and Fama (1982). The real activities are represented by growth rates of GNP, growth rates of industrial production and growth rates of capital expenditures. The result shows that inflation is negatively related to growth rates of real activity. The theoretical and empirical origins of stagflation are thus explained. Moreover, Fama and Schwert (1977) observed the evidence that both expected and unexpected inflation have a significant positive relationship with real estate returns and an insignificant result with labor income.

The connection between inflation and the variability of relative price or the components of the consumer price index has been revealed by many studies. Vining and Elwertwski (1976), Parks (1970) and Cukierman and Watchtel (1982) showed that expected inflation and unexpected inflation have significant effects on the variance of changes in relative prices.

Several recent studies examine the hedging properties against inflation of trading commodities. All but Chua and Woodward (1981) used different models from Fama and Schwert's approach. They alone studied the impact of expected inflation on gold. But they discussed only the cash prices for gold without considering the value of futures contracts. Other studies, Tassel (1979), Kolluri (1980), Feldstein (1980), Bodie and Rosansky (1980), and Bodie (1983), missed the effect of unanticipated inflation of returns by using simple statistical correlation analysis. Some of them only considered commodity cash trading with respect to general inflation.

The literature review has indicated that the theory of heding against inflation cam be employed for testing the effectiveness of any asset's return in protecting real value against both expected and unexpected inflation. This paper used the regressive methodology that Fama and Schwert developed in both metal futures and metal cash markets. The advantage of using this methodology is that the explanatory model is especially capable of investigating the hedging capacity against both expected inflation and unexpected inflation.

2. DATA AND DEFINITIONS

2.1 Time Interval

Obviously, a time series analysis examining hedging theory requires the same time interval for the complete inflation data and commodity futures trading data. The research time period is from January 1975, until December 1983, for gold. The research time interval for gold is limited by its first trading day.

The maturity structures used in gold futures was changed in September 1977. That is to say, the longest maturity contracts of gold was extended from 12 months up to 18 months or longer in September 1977. Not surprisingly, the market economy and trading activities in gold metal can be different in two subperiods, based on the dividing month of market changes. Therefore, this paper will divide two subperiods within the research time interval for gold.

Finally, the contract durations is an important factor in this study. In order to illustrate how inflationary expectations affect the value of near futures contracts and the value of distant futures contracts, we will examine how the returns or contract value based on various contract durations directly responds to those inflationary variables. Hence, the paper will use both spot prices and futures prices with various maturity durations of metal traded of the commodity Exchange Inc. in New York (COMEX). The COMEX market is the largest trading market of gold in the Unite States.

2.2 Expected Inflation and Unexpected Inflation

2.2.1 A Model for Expected Inflation and Unexpected Inflation

To use the model proposed by Fama and Schwert in testing asset as hedges against expected and unexpected inflation, we need an empirical measure of the expected inflation rate, based on data available at time t-1. This paper employs an interest rate model suggested by Fama and Gibbons (1982), with assumes that the expected real rate of interest varies each month. First the return is estimated in a time series model with a first order moving average process. The real return can be expressed as an exponentially-weighted average of past real returns:[3]

$$TB_{t-1}-INF_t = (1-\Theta)(TB_{t-2}-INF_{t-1}) + \Theta(1-\Theta)(TB_{t-3}-INF_{t-2}) + \Theta^2(1-\Theta)(TB_{t-4}-INF_{t-3}) + \dots + e_t. \quad (2.1)$$

Where TB_{t-1} means the monthly interest rate which is approximated by the Treasury bill rate at time t-1, INF_t is the actual inflation rate at time t. Θ is the moving average parameter, and it will be less than 1. Using the term Er_t as the estimate of the expected real rate of interest for month t from equation (2.1), the implied expected inflation rate $EINF_t$ is:[4]

$$EINF_t = TB_{t-1} - Er_t, \tag{2.2}$$

and the unexpected inflation rate for month t can be written as:

$$UINF_t = INF_t - EINF_t. \tag{2.3}$$

2.2.2 Statistical Properties of Inflation Data

The Bureau of Labor's Producer Price Index (PPI) is used for estimating contemporaneous inflation rates and proxying expected inflation.[5] The rate of inflation (INF_t) is defined as the natural logarithm of the ratio of the values of the PPI at t and t-1. Observed INF_t will be used to get estimates of the expected inflation rate and the unexpected inflation rate. When $EINF_t$ and $INF_t - EINF_t$ are predicted by the interest rate model, we use TB_{t-1} as the one month interest rate observed at the end of month t-1. The Treasury bill rates are obtained from the quote sheets of Salomon Brothers.

Table 1 shows the summary statistics of the variables relevant for the expected inflation and unexpected inflation measures. This table contains the mean, standard deviation and sample autocorrelation of the actual inflation rate, actual real rate of return, unexpected real rate of return and the unexpected inflation rate. Table 2 indicates the statistical properties of the regression of monthly inflation rates on estimated expected inflation rates. This table includes the standard deviation, the t ratio of the regression coefficients, the residual standard error and the sample autocorrelation of the residual. Given the evidence in these two tables, INF_t may be mean nonstationary, the R^2 values reported above may not be meaningful. Since the residual autocorrelations are close to zero, however, the residual standard error S(e) is meaningful.

2.3 Commodity Price Series and the Investment Performance on Futures Trading

2.3.1 Commodity Price Series

To obtain commodity futures and sport price series, this paper assumes that every month has at least six different futures contracts. These are one-month, two-

TABLE 1

Summary Statistics for Unexpected Inflation Measures, 1952-1983[a]

Variables(X)	N	$\bar{X}$	S(X)	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_{12}
$INF_t(PPI)$	385	0.00317	0.00676	0.27	0.35	0.29	0.19	0.31	0.35
INF_t-INF_{t-1}	384	0.00001	0.00416	-0.55	0.09	0.02	-0.15	0.04	0.12
$r_t=TB_{t-1}-INF_t$	385	0.00093	0.00642	0.17	0.24	0.18	0.07	0.21	0.27
r_t-r_{t-1}	384	0.00001	0.00827	-0.54	0.08	0.03	-0.16	0.05	0.13
e_t	384	0.00007	0.00605	-0.04	0.06	-0.02	-0.15	0.04	0.17
$UINF_t$	384	-0.00007	0.00605	-0.04	0.06	-0.02	-0.15	0.04	0.17

a $INF_t(PPI)$ is the inflation rate proxied by the producer price index for month t; TB_{t-1} is the one-month Treasury bill for month t observed at the end of month t-1; r_t is the actual real rate of interest for month t; e_t is the estimated unexpected real return (the negative of the unexpected inflation rate) from the naive interest rate model which allows the expected real return component of the interest rate to follow a random walk. $UINF_t$ is the estimated unexpected inflation rate from the naive interest rate model which estimated the expected real return from the time series model. N is the sample size, $\bar{X}$ and S(X) are the sample mean and standard deviation of the variable, and ρ_τ is the sample autocorrelation at lag τ.

TABLE 2

The Regression of Monthly Inflation Rates on Estimated Expected Inflation Rates, 1952-1983[a]

α	β	$t(\alpha)$	$t(\beta)$	R^2	S(e)	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_{12}
0.0007	0.7630	1.82	0.22	0.22	0.006	-0.03	0.07	-0.01	-0.14	-0.05	0.17
(0.0004)	(0.0732)										

a INF_t is the inflation rate for month t, $EINF_t$ is the expected inflation rate for month t estimated from the naive interest rate model in which the expected real return is estimated from a time series model with the first order moving average process. R^2 is the coefficient of determination. S(e) is the residual standard error (adjusted for degrees of freedom), and ρ_τ is the residual autocorrelation at lag τ. The numbers in parenthesis below the estimated regression coefficients are standard errors.

month, three-month, six-month, nine-month, and one-year contracts or longer. For one-month contracts, we need a current futures price F(t,t+1) and the spot price S(t), where t+1 is the delivery data. Since not every month has a current futures price for only a one-month maturity, we will use the Dow-Jones futures index method[6] to get a "hypothesized" one-month maturity futures price for that "missing" month. Similarly, if a month does not have a futures price with a three-month matuity or a six-month maturity, we can easily used the same method to figure out a three-month "hypothesized" futures price or a six-month "hypothesized" futures price for that particular month. Consequently, we would be able to calculate returns for different maturith contracts for each month.

The source of futures price information is available in many places such as The Wall Street Journal, commodity research bureau, inc., etc. After obtaining complete commodity futures and spot price series, we are able to calculate two important investment performance measurements. These are: the returns on a cash holding and the returns on a futures contract. For any month t, each performance measurement will be investigated on the basis of various contract durations.

2.3.2 The Holding-Period Returns on a Cash Holding

In this section, we shall not only discuss the meaning of the return on a cash position, but also discuss the mathematical expresions for it. Let S(t) be the cash price of a commodity at trading day t which means the price the commodity can be bought or sold at for immediate delivery on day t. F(t,T) represents the futures price at time t with the maturity date T. The futures price of a commodity is the price at which one can agree to buy or sell it at a given time in the future. Wher t = T the futures price is supposed to be equivalent to the cash price at T. The expressions of F(T,T) or F(t,t) are called maturity futures price. Thus, we can express the return of a cash holding as the ratio of cash price changes which is

$$RS = [S(t_2) - S(t_1)] / S(t_1). \qquad (2.4)$$

2.3.3 The Holding-Period Returns on Futures Contracts

There are many measures of the holding-period return on an investment in commodity futures. Dusak (1973), Black (1976), Yeaney (1979), Sharpe (1981), and Bodie and Rosansky (1982) have discussed the concept and calculations of the holding-period return on a futures contract. The differences and complications of this measurement among their methods are due to the different assertions they make. The main factor that influences the return calculation in futures contracts is whether or not commodity margin can be treated as an investment base in commodity futures.

If interest-earning securities can be posted to meet margin requirements, it is clear that no investment is involved in an open commodity position. The individual's funds are invested but in Treasury bills. On the other hand, if only cash is allowed, the required margin may be considered the investment needed to support the open commodity positions. Taking the margin required as an investment base, this will be small relative to the values of such positions, and even small relative to the possible gains and losses from them. This has led many to argue that commodity futures are "highly levered" and extremely risky investments and has led to several different methods in calculating returns. Other important factors, like commission charges and taxes, also influence the return on a futures contract. However for simplicity the assumption of no transaction costs and no taxes has been made.

The following discussion about the measurement of return on a futures contract will emphasize the case of a speculator who takes a long position in futures. Since a short position in futures is the other side of a long position, together they constitute a zero sum game with a positive-negative relationship in their outcomes.

Dusak and Black argue that there is no rate of return on a futures contract because no initial capital investment has been involved in the opening position. They suggest that the dollar return which is the unrealized gains or losses on open positions will be the best way to measure speculative profit on a futures contract. The actual profit of a long position in futures is termed as PR. The one period return of PR is

$$PR = F(t_2, T) - F(t_1, T). \tag{2.5}$$

When $t_2 = T$, the maturity date, the expression of PR becomes

$$PR = S(T) - F(t_1, T). \tag{2.6}$$

If the required margin can only be cash and is set up to be K Percent of open positions, it can be referred to as the investment base for supporting the futures positions. Also, the levered futures contract will not earn any interest return on its margin requirement. Bodie and Rosansky (1980) and Yeaney (1979) have provided the measurement of holding-period returns on this case of levered futures contracts without earning any interest. This return will be equal to the percentage change in futures prices times the reciprocal of K percent.

$$R = [F(t_2, T) - F(t_1, T)] / K\, F(t_1, T). \tag{2.7}$$

The time interval between t_1 and t_2 can be one, two, three months or longer. Wher $t_2 = T$, the maturity date, the expression of R becomes

$$R = [F(t,T) - F(t_1,T)]/K\,F(t_1,T)$$

or $$R = [S(T) - F(t_1,T)]/K\,F(t_1,T). \qquad (2.8)$$

When K = 100 percent, the full margin requirement of a futures contract implies an unlevered contract, its margin will just be equivalent to the percentage change in futures prices. This relationship is shown as

$$R = [F(t_2,T) - F(t_1,T)]/F(t_1,T). \qquad (2.9)$$

When $t_2 = T$ is the maturity date, the R becomes

$$R = [S(T) - F(t_1,T)]/F(t_1,T). \qquad (2.10)$$

The final case assumes that margin requirements can be posted as a "performance bond" and earn interest from Treasury bills. Sharpe and Bodie and Rosanksy have derived this measurement for a futures contract placed K percent margin requirements with earning the rate r from Treasury bills. The long position holding-period return on a futures contract can be obtained as follows:

$$R' = r + [F(t_2,T) - F(t_1,T)]/K\,F(t_1,T). \qquad (2.11)$$

Where R′ is the actual holding-period return on the position from time t_1 to t_2. When $t_2 = T$ is the maturity date, the R′ is equal to

$$R' = r + [F(T,T) - F(t_1,T)]/K\,F(t_1,T)$$

or $$R' = r + [S(T) - F(t_1,T)]/K\,F(t_1,T). \qquad (2.12)$$

When K = 100%, it is a special case of the unlevered futures contract where the margins will earn interest. Then the holding period return on a long futures position initiated at time t and closed out just prior to delivery at time T is:

$$R' = r + [S(T) - F(t_1,T)]/F(t_1,T). \qquad (2.13)$$

Sharpe's methods concern the speculator holding the futures position to maturity like equations (2.10) (2.12). Hence the revenue at the closing out date should be priced at spot prices. On the other hand, Bodie and Rosansky's equations such as (2.9) (2.11) do not necessarily require the futures position to be held until the delivery date T. Their measures can be employed when a speculator determines that the futures position if favorable to him or her and wants to close it out at any time

TABLE 3

Summary Statistics for Investment Performance Variables in the Gold Market, 1975-1983[a]

The Performance Variables(X)	N	X	S(X)	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6
RS (Cash Market Return)	108	0.0100	0.0830	0.03	0.01	-0.02	-0.24	0.20	-0.09
R1 (1-Month Contract Futures Return)	108	0.0110	0.0800	0.05	-0.02	-0.02	0.19	0.20	-0.14
R2 (2-Month Contract Futures Return)	108	0.0030	0.0834	0.11	-0.04	-0.00	0.17	0.23	-0.12
R3 (3-Month Contract Futures Return)	108	0.0024	0.0831	0.11	-0.04	-0.00	0.17	0.23	-0.11
R6 (6-Month Contract Futures Return)	108	0.0023	0.0838	0.13	-0.03	-0.00	0.16	0.24	-0.11
R9 (9-Month Contract Futures Return)	108	0.0022	0.0851	0.15	-0.03	-0.01	0.16	0.24	-0.10
R12 (12-Month Contract Futures Return)	108	0.0026	0.0859	0.15	-0.03	-0.02	0.17	0.23	-0.10
R15 (15-Month Contract Futures Return)[b]	75	0.0083	0.0964	0.14	-0.04	-0.02	0.17	0.22	-0.12
R18 (18-Month Contract Futures Return)[b]	75	0.0084	0.0978	0.14	-0.04	-0.02	0.16	0.21	-0.12

a The definition of the investment performance variables in futures trading is explained in the text and table 2. N means the number of observations. X and S(X) are the monthly mean and standard deviation of the performance variable. ρ_τ is the sample autocorrelation at lag τ.

b Data are available from September 1977 to December 1983.

within the T−t interval.

The investment performance variables will be based on the equation (2.10) which means that a futures contract is an unlevered contract and the posting margin with this futures contract will not earn interest. Moreover, this paper assumes a buy and hold strategy whereby contracts were entered into a monthly, quarterly, semi-annual intervals or longer, held for a specific time interval and then liquidated. There are two reasons to support the returns variable from equation (2.10). First, the returns variables are different in whether the deposit marging can earn interest. The statistical evidence show that they should have the same analytical result. This is because running the inflationary variables on these two dependent variables which show difference in a constant term r will obtain the similar regression output in R^2, t ratio and Durbin Watson statistics. Second, assuming the buy and hold strategy to measure investment returns provides a stable measurement about the investment performance.

Finally, the summary statistics of the major investment performance variables (Rs and R) are presented in Table 3 for gold metal. Each variable is described by the mean, standard deviation and sample autocorrelation with lag 1 to lag 6.

3. MODELS AND HYPOTHESES

3.1 The Impact of both Expected Inflation and Unexpected Inflation on the Performance of Futures Trading

The theory of hedging against inflation provides two major types of regression models (3.1) and (3.2). In these two equations, the dependent variable R_{jt} means the holding-period return on a commodity futures contract with a specific percentage margin and a holding-period to maturity date.

$$R_{jt} = \alpha_i + \beta_i E(INF_t | \Phi_{t-1}) + e_{jt} \tag{3.1}$$

and $$R_{jt} = \alpha_i + \beta_{1j} E(INF_t | \Phi_{t-1}) + \beta_{2j}[INF_t - (EINF_t | \Phi_{t-1})] + e_{jt}, \tag{3.2}$$

where j means an individual commodity. In this study, j represents gold.

The variables $E(INF_t | \Phi_{t-1})$ and $(INF_t - E(INF_t | \Phi_{t-1})$ mean the expected component of inflation and the unexpected component of inflation based on time t-1 market information set Φ_{t-1}. The efficient market hypothesis implies that this market information set is identical to the true information which market equilibrium appraises. The intercept term α_t is approximately equal to the real rate of return on a futures contract. β_{1j} and β_{2j} indicate the degree of hedging against the expected and the unexpected inflation rate for each individual commodity. The residual terms e_{jt} show a normal distribution with zero mean and constant variance.

In terms of regressive models, equations (3.1) and (3.2) may be rewritten as either a simple linear regression or a multiple regression model:

$$R_{jt} = \alpha_j + \beta_i E(INF_t) + e_{jt} \tag{3.3}$$

and $$R_{jt} = \alpha_i + \beta_{1j} E(INF_t) + \beta_{2j}(INF_t - EINF_t) + e_{jt}. \tag{3.4}$$

The model of equation (3.3) is for testing the Fisher effect in the returns on commodity futures. The model of equation (3.4) indicates the testing of hedging capacity against expected and unexpected inflation in commodity futures. The testing hypotheses of equation (3.3) and (3.4) can be written as

$$H_{1N} : \beta_i \text{ or } \beta_{1j} = 1 \quad \text{or} \quad H_{1A} : \beta_i \text{ or } \beta_{1j} \neq 1. \tag{3.5}$$

The hypothesis checks the Fisher effect, implying that expected inflation will fully reflect the return or profit variables; H_{1N} means the null hypothesis and H_{1A} represents the alternative hypothesis.

For testing any positive relationship between expected inflation and futures performance variables, the testing hypotheses follow:

$$H_{1N}: \beta_i \text{ or } \beta_{1j} > 0 \text{ or } H_{2A}: \beta_i \text{ or } \beta_{1j} \leqslant 0 \tag{3.6}$$

and $$H_{2N}: \beta_i \text{ or } \beta_{1j} \geqslant 1 \text{ or } H_{2A}: \beta_i \text{ or } \beta_{1j} < 1. \tag{3.7}$$

If one of the metals offers some protection against expected inflation (or unexpected inflation) for investors, one would expect the estimated slope coefficient β_i (or β_{1j}) in the above model to be positive and statisticant; that is, increases in expected inflation (or unexpected inflation) lead to contemporaneous increases in the return on the metal. A statistically significant value of β_{1j} between 0 and 1 would indicate that a metal is only a partial hedge against expected inflation, whereas values of β_{1j} greater than or equal to +1 would indicate that the metal is a complete hedge against expected inflation.

Similarly, examining the impact of unexpected inflation on the examined variables, the testing hypotheses are:

$$H_{3N}: \beta_{2N} > 0 \quad \text{or} \quad H_{3A}: \beta_{2j} \leqslant 0. \tag{3.8}$$

and $$H_{3N}: \beta_{2j} \geqslant 1 \quad \text{or} \quad H_{3A}: \beta_{2j} < 1. \tag{3.9}$$

When the evidence shows the result that β_{2j} is positive, this implies that the impact of unexpected inflation on futures outcomes is positive. The magnitude of β_{2j} indicates the hedging degree against unexpected inflation for the outcome variables.

4. EMPIRICAL RESULTS

In the discussion of the empirical relationship between inflation and gold metal returns, an important regression model is developed. This model is the regressions of futures performance variables on both expected and unexpected inflation for testing the inflation hedging properties of gold metal.

Monthly data are used for running regressions of performance variables against expected and unexpected inflation, the testing hypotheses under this regression model expects the value of regression estimates to be positive or negative. A significant positive value of the regression estimate β_1 indicates that these particular asset returns have a partial hedging value against expected inflation. If the regression estimate β_1 is significantly equal or greater than one, then the asset returns provide a comlete hedge against expected inflation. Similarly, the value of the β_2 estimate indicates the hedging properties against unexpected inflation of the asset's return.

4.1 The Returns on Spot Market Holdings (RS)

The monthly rate of return on the cash market (RS) is determined by the price differences between the cash prices of two consecutive months, divided by the cash price of the previous one. The returns on spot market holdings are the returns on a spot position without any hedging or speculation in the futures. This performance variable indicates that investors are only concerned with the trading profit from the certain and current spot price in the gold cash commodity market.

Table 4 shows how the cash returns hedge against both expected and unexpected inflation in gold market. The evidence shows that gold has a significantly negative effect from expected inflation at the level of 10% during January 1975 to August 1977. During the second period, with 76 months from September 1977 to December 1983, the gold returns have an insignificant positive relationship with both expected and unexpected inflation. This is to say that gold is examined for a shorter period, and for the 1977-1983 period, it does not seem to perform as well.

TABLE 4

Regressions of the Returns on the Gold Cash Market on Expected and Unexpected Inflation.

$$RS_t = \alpha_0 + \beta_1 \, EINF_t + \beta_2 \, (INF_t - EINF_t) + e_t$$

Performance Variable	Regression Coefficients								
	α_0	β_1	β_2	$t(\alpha_0)$	$t(\beta_1)$	$t(\beta_2)$	R^2	F	DW[a]
Time period 1 (1/1975–8/1977)									
RS	0.048 (0.030)	-9.157 (5.118)	0.208 (1.854)	1.62	-1.79*	0.11	0.142	2.40	1.83
Time period 2 (9/1977–12/1983)									
RS	0.008 (0.020)	1.637 (2.501)	3.286 (2.230)	0.43	0.65	1.47	0.029	1.10	2.10

Note: Standard deviations of regression estimates are shown in parentheses.

** indicates coefficients statistically different from 0 at the 5% level.

* indicates coefficients statistically different from 0 at the 10% level.

a DW is the Durbin Watson Coefficient. When it indicates autocorrelation, the equation is reestimated with a Durbin Watson procedure, and the results of that estimate are also given.

In testing the Fisher hypothesis, the β_1 regression estimate that represents the reaction of the nominal return to inflationary expectations must be identical to one at the required significance level. To examine if the β_1 value is equal to one with statistical testing, the t ratio allows a judgment as to whether the β_1 regression estimate is significantly equal to one. The hypothesis the $\beta_1 = 1$ can be tested in the case of cash returns from any commodity cash holding. The results from Tables 4 indicates that the regression estimate of β_1 of each metal is not identical to 1 at the required significance level. This implies that the evidence of cash returns in gold metal is inconsistent with the Fisher hypothesis.

In summary, the cash returns in gold metal did not provide good hedging performances against both expected inflation and unexpected inflation based on monthly data.

4.2 The Rates of Returns on a Futures Contract (R)

This performance variable is measured by the ratio of monthly futures price differences with the same contract maturity and with assuming a buy and hold strategy. The statistical evidence from Table 5 indicates that gold has rates of return that provide a partical hedge against unexpected inflation (at the 10% significance level) only for the fifteen- and eighteen-month contracts during the second time period.

One can test the Fisher hypothesis by examining whether or not the nominal rates of return on futures with a specific contract maturity adjust fully to expected inflation. An estimated value of β_1 shows the reaction of the nominal rates of return to expected inflation. The results from Table 5 do not imply that the nominal returns on commodity futures, with respect to gold metal, is consistent with the Fisher hypothesis because none of the β_1 estimate values is significantly equal to one. In other words, the nominal rates of returns from futures contracts in gold metal markets do not fully react to inflationary expectations. In summary, gold futures' rates of return do not have a good hedging value against both expected and unexpected inflation from January 1975 to December 1983.

5. SUMMARY AND CONCLUSION

5.1 Summary

Commodity futures, especially precious metals like gold have been known as

TABLE 5
Regressions of the Rates of Returns on Futures Contracts on Expected and Unexpected Inflation in Gold

$$R_t = \alpha_0 + \beta_1 \text{ EINF}_t + \beta_2 (\text{INF}_t - \text{EINF}_t) + e_t$$

Performance Variable	Regression Coefficients								
	α_0	β_1	β_2	$t(\alpha_0)$	$t(\beta_1)$	$t(\beta_2)$	R^2	F	DW[a]
Time Period 1 (1/1975–8/1977)									
R1	0.027	-5.328	-0.056	0.87	-1.01	-0.03	0.045	0.69	1.80
	(0.030)	(5.287)	(1.916)						
R2	0.031	-6.617	0.148	0.96	-1.17	0.07	0.067	1.03	1.72
	(0.032)	(5.633)	(2.041)						
R3	0.032	-6.872	0.143	0.96	-1.20	0.07	0.069	1.08	1.71
	(0.033)	(5.713)	(2.070)						
R6	0.031	-6.944	0.347	0.94	-1.20	0.17	0.075	1.17	1.66
	(0.033)	(5.790)	(2.099)						
R9	0.031	-6.910	0.508	0.92	-1.18	0.24	0.077	1.22	1.63
	(0.034)	(5.878)	(2.130)						
R12	0.032	-7.156	0.662	0.95	-1.21	0.31	0.086	1.36	1.62
	(0.034)	(5.930)	(2.148)						
Time Period 2 (9/1977–12/1983)									
R1	0.015	0.539	2.367	0.80	0.22	1.10	0.016	0.61	2.04
	(0.019)	(2.418)	(2.156)						
R2	0.002	1.144	2.690	0.09	0.45	1.20	0.019	0.72	1.92
	(0.020)	(2.520)	(2.240)						
R3	0.003	0.955	2.779	0.15	0.23	1.25	0.021	0.78	1.91
	(0.019)	(2.495)	(2.224)						
R6	0.002	1.151	3.067	0.10	0.46	1.37	0.025	0.94	1.89
	(0.020)	(2.508)	(2.236)						
R9	0.001	1.406	3.443	0.03	0.55	1.52	0.031	1.16	1.88
	(0.020)	(2.535)	(2.260)						
R12	0.001	1.465	3.590	0.06	0.57	1.58	0.033	1.24	1.89
	(0.020)	(2.556)	(2.278)						
R15	0.000	1.670	3.860	0.00	0.65	1.69*	0.038	1.43	1.88
	(0.020)	(2.571)	(2.292)						
R18	-0.0008	1.821	4.155	-0.04	0.70	1.79*	0.043	1.61	1.87
	(0.020)	(2.607)	(2.320)						

Note: Standard deviations of regression estimates are shown in parentheses.
** indicates coefficients statistically different from 0 at the 5% level.
* indicates coefficients statistically different from 0 at the 10% level.

a DW is the Durbin Watson Coefficient. When it indicates autocorrelation, the equation is reestimated with a Durbin Watson procedure, and the results of that estimate are also given.

the real assets that possess the store value to protect investment wealth during periods of high rates of inflation. However, relatively few studies investigate the hedging value of commodity futures as a real asset against both expected and unexpected inflation.

If one believes that real asset markets are efficient processors of information, the nominal returns on real assets should reflect the inflationary expectation measured by the concensus forecasting of public investors. The predicted rates of inflation measured by the difference between nominal and 'real' yields on treasury bills should be among the best measures available. Fama and Gibbon's interest rate model appropriately follows this methodology to decompose inflation into expected inflation and unexpected inflation. Their model indicates that the expected real rates of return follow a random walk.

The theory of hedging against inflation, which is based on the Fisher equation, is developed by Fama and Schwert. This theory is used for examining the impact of both the expected component of inflation and unexpected component of inflation on any asset return. To study the hedging performance against expected and unexpected inflation in commodity futures this paper uses gold metal. This paper then defines the investment performance measurements in futures trading based on the criteria as the rates of return on a cash holding and a futures contract.

The research time interval for gold is from January 1975 to August 1977 for the first time period and from September 1977 to December 1983 for the second time period. The evidence presented in Tables 3 shows the basic statistics of major investment performance variables in gold metal for the overall period. The relevant data about measuring the expected inflation rate and unexpected inflation rate is summaized in Tables 1 and 2. Moreover, the empirical evidence for the regressions on the investment performance of gold metal on expected and unexpected inflation are shown in Tables 4 to 5. The research in this paper leads to the following conclusions:

A. The hedging performance against expected inflation

None of the gold's rates of return on either cash holdings or futures contracts with different contract durations provides a complete hedge against expected inflation. These performance variables do not even provide a partial hedge against expected inflation.

B. The hedging performance against unexpected inflation

The returns for cash gold did not provide for any partial hedging performance against unexpected inflation during the overall period. Furthermover, during the whole time period, the rates of return on gold futures contracts neither provide any hedging performance against unexpected inflation.

C. Testing the Fisher hypothesis

The paper examines whether or not the nominal rates of return on cash and commodity futures fully reflect the level of expected inflation. The results indicate that the nominal rates of returns on cash and futures do not fully absorb the "new" level of expected inflation. This seems to be inconsistent with the Fisher hypothesis.

5.2 Implications of the Study

The cash returns and the rates of returns on futures contracts in gold do not show a good hedging performance against both expected and unexpected inflation. Precisely, gold has not provided the real protecting value in hedging against inflation since its first public trading in the United States in 1975. This result is consistent with recent price actions, suggesting that gold prices do not correlate well with inflation rates over the short run. The rate of inflation has moved steadily upward in the most of time periods during the research time interval, while the price of gold has fluctuated over a broad range.

However, gold prices tend to fluctuate in response to a variety of considerations. This is not to say that inflation or expections of inflation cannot influence gold market action over the near term. Gold prices react to numerous fundamental, psychological and political influences. Therefore many factors could blunt momentarily what the logical price direction would be if inflation were the sole gold market price influence. Finally, the results in this paper have important implications for further studies, such as the following:

1. In the past seven years, the uncertainty of forecasting inflation rates has grown and finding the deterministic factors to proxy expected inflation is more difficult now. Recently, a new method was developed to obtain better inflation forecasts. Fama and Gibbons (1983) and Geseke and Roll (1983) found that expected inflation is negatively related to the expected real rate of interest. They found out that a systematic, risk-related bias in the estimates of the coefficients on both expected and unexpected inflation is generated by specification errors in inflation regressions. Hence, an adjustment for the true expected real rate of interest is necessary when decomposing expected and unexpected inflation. A further study following this procedure is to obtain better forecasts of inflation and relate these to

the hedging performance. This would produce meaningful insights in comparing the statistical differences among inflation hedging results based on different expected and unexpected inflation forecasts.

2. This study could be extended to cover international markets to compare how the hedging performance against inflation of precious metals is affected by different national experiences. It is clear that metal prices are essentially determined in a world market. We then are really measuring the inflation rate in each country versus the metal being studied.

TABLE 6

Correlation Matrix of Annual Rates of Return and Inflation, 1950-1983 (The metals case)[a]

	Inflation	
	CPI	PPI
A. Nominal Returns		
Gold Cash Market	.588	.765
Silver Cash Market	.405	.426
Copper Cash Market	.156	.351
Gold Futures Market	.590	.739
Silver Futures Market	.408	.394
Copper Futures Market	−.039	.086
B. Real Returns		
Gold Cash Market	.488	.705
Silver Cash Market	.333	.371
Copper Cash Market	−.075	.157
Gold Futures Market	.537	.699
Silver Futures Market	.374	.369
Copper Futures Market	−.170	−.027
C. Excess Returns		
Gold Cash Market	.516	.725
Silver Cash Market	.360	.398
Copper Cash Market	.009	.247
Gold Futures Market	.564	.726
Silver Futures Market	.392	.386
Copper Futures Market	−.125	.024

Data Sources: *The Wall Street Journal* and *Business Statistic Survey*.

a These four metals futures prices are represented by the prices of the nearest futures contracts posted on the last trading day each year. Gold futures prices are available from the last trading day in December 1974. Silver futures prices are available from the last trading day in June 1963. Copper futures prices are available from the last trading day in June 1953.

FOOTNOTES

1. The real rate of return is defined by:

$$(1+r_t) = (1+R_t)/(1+INF_t). \qquad (N.1)$$

where R_t is the nominal rate of return and INF_t is the rate of inflation as measured by the proportional change in the Consumer Price Index. The excess return is the difference between the nominal rate of return and the Treasury bill rate.

2. Commodity margins are the amount deposited by buyers and sellers of futures, to insure performance on contract commitments. They serve as a performance bond rather than a "down payment". The margin requirements serve as security deposits intended to guarantee that people with positions in commodity futures will, in fact, be able to fulfill their obligations. In practice, the initial margin, assessed when a position is first opened, is usually 5 to 10 percent of the contract. The maintenance margin requires the level of margin to be kept on deposit throughout the period a futures position remains "open", as a binder of performance on the contract. In general, the greater the value of a contract and the variability of its price, the larger will be the required margins. Usually, brokers require this margin requirrement to be cash and/or interest-earning cash equivalents (usually U.S. Treasury bills).
3. See, for example, Box and Jenkins (1976, Chapter 5).
4. Mathematically, the Fisher equation can be expressed as follow:

$$(1+R_t) = (1+r_t)(1+INF_t) \qquad (N.2)$$

$$= 1+r_t+INF_t+r_tINF_t$$

$$R_t = r_t+INF_t+r_tINF_t \qquad (N.3)$$

The r_tINF_t term is relatively so small that it can be Omitted. The new Fisher equation becomes the following equation

$$R_t = INF_t + r_t \qquad (N.4)$$

Fama and Gibbon (1982) suggest to use TB_{t-1} to proxy R_t.

5. The statistical correlation coefficients of commodities prices movements with respect to PPI or CPI have been examined in this paper. The evidence shows that commodities prices series (futures and spots) are more relevant to producer price Index (PPI) than Consumer Price Index (CPI). See Table 6.
6. The dow-Jones futures index method saves several "futures" of "missing" months by using two quotations for each futures commodity. For example: On July 1, October delivery is just three months off, but a month later it is only two months away. A three-month delivery should not, in a precise index, be compared with a two-month delivery. To overcome this problem, we just take the August 1 quotation for the October maturity plus the amount which is equal to an assigned weight times the price difference between October delivery and next year January delivery quoted on August 1. This weight must be equal to the proportion of the passing days to the full maturity days. Arithmetically, we can express this relationship as:

Futures price of August 1 (a three-month contract)
= August 1 quotation with October maturity + 30/90
(next year's January futures quotation on August 1
– October futures quotation). (N. 5)

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