US MACROECONOMIC DETERMINANTS FOR MOVEMENT OF GOLD FIX

By
ANANYA SEEMUANG

An Independent Study
Submitted in partial fulfillment of the requirements
for the Degree of

MASTER OF SCIENCE IN FINANCIAL ECONOMICS

MARTIN DE TOURS SCHOOL OF MANAGEMENT AND ECONOMICS
Assumption University
Bangkok, Thailand

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ASSUMPTION UNIVERSITY

This Study by: Ms .Ananya Seemuang

Entitled: "Global Gold Price Model and Its Relationship with Dynamic macroeconomic Indicators in the United States"

has been approved as meeting the independent study requirement for the:

DEGREE OF MASTER OF SCIENCE IN FINANCIAL ECONOMICS

Dr. Wiyada Nittayagasetwat, Chairperson

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Date of Defense July 22, 2012

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Declaration of Authorship Form

I, **ANANYA SEEMUANG**
declare that this independent study and the work presented in it are my own and has been generated by me as the result of my own original research.

US MACROECNOMIC DETERMINANTS FOR MOVEMENT OF GOLD FIX

I confirm that:

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3. Where I have consulted the published work of others, this is always clearly attributed;

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ADVISOR'S STATEMENT

I confirm that this independent study has been carried out under my supervision and it represents the original work of the candidate.

Signed:

Dr. Suppanunta Romprasert, Advisor

Date:

6 - 11 - 12

ACKNOWLEDGEMENT

I feel deeply grateful to my advisor, Dr. Suppanunta Romprasert, whose advice with encouragement and consistence over two years has been valuable to the success of my research study. I also would like to thank my beloved mom, Mrs. Suchinda Seemuang, for her suggestions and being vital inspiration for my research.

Ananya Seemuang

July 2012

ABSTRACT

The present research principally aims to investigate macroeconomic factors significantly affect to the movement of gold value, and to explore how factors correlate with it. The movement of gold value was represented by Percentage change of London PM gold fix. Its causality were explored through five macroeconomic factors :- inflation rate, percentage growth of money expansion , percentage growth rate of real GDP, real interest rate change, and percentage change of US dollar index. The justified answers were sought by an analysis of Ordinary Least Square method and correlation analysis.

The result of research significantly found that while inflation rate is rising and US dollar index is expected to depreciate, gold value moves in a positive way which infers that macroeconomic factors significantly affected to the movement of gold value.

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I, Dr. Suppanunta Romprasert, have proofread this independent study entitled US MACROECNOMIC DETERMINANTS FOR MOVEMENT OF GOLD FIX and hereby certify that the verbiage, spelling and format is commensurate with the quality of internationally acceptable writing standards for a master degree in financial economics.

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6-11-12

CHAPTER I

GENERALITIES OF THE STUDY

1.1 Introduction to the Study

Inflation is a consequence of the products price increment that causes reduction in value of the money (Schwert, 1981). After the financial crisis in 2007 had revealed by IMF(2010), various governments and investors worried about inflation which was resulted from global imbalance of money flow. According to a study of IMF (2010), the sub-prime crisis slowed down the global economy's growth. US stock index dropped affected from uncertainty in economy as well as corporate revenue also declined from consumer's demand reduction. The reduction also affected real gross domestic product of the United States (US real GDP) and dropped its dollar value that caused people prefer to save more than to spend. In that period, the Federal Reserve and the US central bank tired to stimulate economic and consumers' spending with the policy of reducing interest rate. Simultaneously, they launched the program of money quantitative expansion to stimulate such economic status of the US. Since then, it might accelerate the increasing of inflation rate.

Several studies of IMF (2010) showed that, consumer demand, US real GDP, money supply, real interest rate, and value of money are linked to inflation fear. Furthermore, some studies on linkage between inflation and gold by Harmston (1998) and Dempster (2009) also mentioned that, quantity of money flow in the system and inflation linked to gold and one attribute of gold is an inflation hedge. During mid 2007 to 2009, a period of sub-prime crisis; value of gold still remained its value. Especially in 2008, the gold price hit above USD 1,000/ounce, while bond's yield and world stock market indices fluctuated and finally dropped rapidly. As stated in the above paragraph, people became aware of inflationary after the time of subprime crisis and comprise of a statement which Harmston (1998) and Dempster (2009) stated that gold acts as an inflation hedge. The above reasons inspire to this study of how those dynamic macroeconomic indicators link to an increasing in the value of gold.

During the first phase of the crisis in September to December 2007, the stock market faced in recession when it plunged in mid 2007. An explicit critical situation since then revealed. Later to a collapse of US's economy, US dollar devalued as an uncertainty of the

country's economy. A study of an inflation issue by Artigas (2010) presented that inflationary was being concerned after the US government had injected money paper to the business cycle.

The worst situation had not stopped in that year but still remained until 2009 and expanded across the world. Such advanced countries like US and UK started to reduce their policy interest rates. Then, EU countries and Japan followed reducing their policy interest rates while; emerging and developing countries maintained their interest rates higher than the advanced ones. Interest gap then existed. IMF (2010) suggested the interest rate gap caused foreign investors to search out a higher return in emerging markets. Until the second half of year 2008; many countries, especially emerging and developing countries realized the surge of fund flow and a declining demand from the recent crisis. They began to ease their monetary conditions by reducing their policy interest rate as well.

Arezki & Ismail (2010) and IMF (2010) also proved reduction of policy interest rates made the goods' price increasing. Although, this policy worked well to react against the money surge in previous crisis (IMF, 2010), it accelerated inflation to the economy cycle. Surge of foreign fund flow also made some concerns of bubble price and asset speculation. An acceleration of the inflation pace made some worries to many investors and even the policy makers around the world.

1.2 Statement of the Problem

What will happen if American investors fail to manage their portfolios as a result of plunge in their assets' value and global imbalance? Domino effects to the other industries and/ or to the rest of the world may occur as the US is the world largest economy. Since there is an arising concern of inflation as well as unstable global economy which Harmston (1998) cited that; gold acts as an inflation hedge as well as the last resort of asset allocation, then, the question comes up whether should we invest gold. Appropriated time to collect gold into investors' portfolio shall be determined by which macroeconomic determinants.

1.3 Research Objectives

This research mainly aims to explore relationship on the movement of gold value and dynamic macroeconomic variables, specifically in the United States. There are five macroeconomic variables used in this research. Those comprise of inflation rate of the United States, US real GDP, value of US dollar, money supply level 2 of the United States ("US

M2") and real interest rate in the US. The study will be discussed through production of various proxies. For example, percentage change of London PM Gold fix, as a proxy of movement of gold value would be dependent variable in this study. Other proxies would be then described in scope of the study section.

1.4 Research Questions

Following research questions are to be discussed:

1. Do inflation rate, percentage growth of money expansion (money supply), percentage growth rate of real GDP, real interest rate change, and percentage change of US dollar index would significantly determined the movement of gold fix?
2. Do those macroeconomics indicators move in the same or opposite direction with the movement of gold value?

1.5 Scope of the Study

Percentage change of London PM gold fix acts as dependent variable while dynamic macroeconomic indicators are the predictors. The determinants consist of US real gross domestic product (US real GDP), value of US dollar, inflation rate of the United States, money supply level 2 of the United States and real interest rate of the United States.

Besides percentage change of London PM gold fix, a proxy of value of gold in this study; dynamic macroeconomic indicators would be represented by various proxies as well. Quarterly US inflation rate acted as a proxy of inflation factor. Percentage change of US dollar index is a proxy of US dollar value. Quarterly percentage change of money supply level 2 is a proxy of the US M2. Quarterly growth rate of US real GDP is a proxy of US real GDP and real change in interest rate of three-month certificate deposit as a proxy of real interest rate of the US.

The data covers the first quarter of 1973 to the modest time period of this research able to cover in which fell in the second quarter of 2011. All data series are collected in quarterly basis.

1.6 Significance of the Study

Recently, there is a concern of asset's price bubble resulting from capital flows into Emerging and Developing (EMD) countries. Financial assets' price in such advanced country

like US dropped sharply. The result of this paper will benefit to investors toward their portfolios' strategy. These strategies contribute them either to consider the appropriated proportion to invest their suitable assets or just lead them for an effective hedging strategy.

It is not only useful for American investors, but also helpful to general investors who are interested to invest either in the stocks listed in New York Stock Exchange or who are interested to invest in the US government bonds. Mostly, those investors are financial institutions, fund manager, and foreign state agencies. In addition, the knowledge from this study would be absolutely applicable for those investors whose point of views are not sure in an economic situation and are willing to invest in real assets as gold. Besides, it may help other researchers to find out some benefit information for their works. For example, instead of using the gold fixing as dependent variable, researcher may apply other commodities or other indices, such as oil, T-Bill yield or stock market indices, to be used as dependent variables.

1.7 Limitations of the Research

Main focus of this research is on USA's economy. The information available is publicly and reachable. However, macroeconomic indicators normally announce in different periods. The closest data collecting is in term of quarterly basis.

1.8 Definition of Terms

London PM gold fix or gold fix as a proxy for global gold price is the gold price that is traded in London Market. Gold fix is settled twice (one at 10.30 a.m. and another at 03.00 p.m.) of each business day by five members of The London Gold Market Fixing Ltd. It is widely used as a benchmark for pricing the gold as the products and other form of contract (i.e. derivatives). The gold fix price is dominated in US Dollar, Pound Sterling and Euro.

Inflation rate is an important economic measurement. It is equivalent to the percentage rate of increase in the price index per period. The price index here measures the average level of prices for some specified set of goods and services. Consumer Purchasing Index or CPI is the most well known index for the price level measurement. Quarterly percentage change in CPI-Urban acts as a proxy of inflation rate for this study. Bureau of Labor Statistics defines CPI-Urban that as dollar expenditure values by urban wage earners and clerical workers, professional, managerial, and technical workers, the self-employed, short-term workers, the unemployed, retirees and others outside the labor force.

Money supply is the whole amount of any form of monies, for example; bill-notes, coins, deposits, and loans which of those are in particular country's economy (Abel, Bernake & Croushore, 2008). It can be categorized into M0, M1, M2 and M3. Money supply can also quantify amount of money flowing in the economy. In this research, M2 comprises of petty cash, time deposits, current and saving accounts, and non-institutional money market funds.

US dollar is an American currency and it is widely used in commodity trading.

Real interest rate is nominal interest rate deflated by inflation rate to reflect the real cost of capital borrowers and the real rate of return for lenders (Diewer, 2001). In this research, interest rate of 3-month certificate of deposits (CDs) deflate by inflation rate was applied as a proxy of real interest rate in the US. The CDs are promissory notes issued by the Bank where restrict the note holders to withdraw those CDs at maturity date which is stated in the notes. The note holders shall generally earn interest rate in return at respective maturity date.

Real Gross Domestic Product (RGDP) is derived from percentage change of billions of dollars- seasonally adjusted at annual rates. US real GDP is the real gross domestic product in the US. It is the output of goods and services produced by labor and property located in the United States (Abel, Bernake & Croushore, 2008). In this research real GDP are calculated by using expenditure approach and the data series derived from Bureau of Economic Analyst, USA Department of Commerce's calculation.

Arbitrage Pricing Theory (APT) is one type of an asset pricing model former by Roll and Ross (1980). It is used for asset price prediction that is linear by multi-independent variables.

CHAPTER II

REVIEW OF RELATED LITERATURE

As mentioned briefly in the previous chapter, global imbalances and inflationary fear caused inconfident to the investors on their financial assets investment. This research aims to explore and declare the movement of percentage change of London PM gold fix which is influenced by some changes of macroeconomic variables. The present chapter provides the readers with information essential to understand this research. In this chapter will briefly discuss and preview how and what the previous researchers have discovered about value of gold and macroeconomic indicators. Related theory to define the determinant to percentage change of London PM gold fix is also focused. The review is classified into three main issues as follows:

2.1 Literature related to dependent variable
2.2 Literature related to independent variables
2.3 Arbitrage Pricing Theory

Each of the topics will be elaborated in the following sections.

2.1 Literature Related to Dependent Variable

Percentage change of London PM gold fix, a proxy of return of gold will be used as dependent variable for this research. Many literatures supported that gold has some crucial attributes that different from other commodities, are to be discussed in this section.

Dubey, Geanakoplos & Shubik (2003) and Lowrence (2003) said that gold is independently, unique and indestructible. Gold has maintained its real purchasing power especially in the time of great depression (Dubey et al., 2003). A study on the volatility of gold by Wozniak (2008) on twenty years historical data stated that real rate of return of gold value is inflexible to economic situation comparing to other commodities such as oil and metal. Demspter (2009) also found that during inflationary, the movement New York spot gold price independently moved from commodity index, real estate investment index and US treasury inflation-protected security index (TIPS). Empirical study by Lowrence's (2003) conducted the gold price from other financial assets mainstreams and found that movement in macroeconomic indicators have a much stronger impact on other commodities than they do on gold. Randson (2005a) and Randson (2005b) confirmed as well that gold is a better inflation indicator than oil price and other financial assets.

Time series and excess risks of return, a theory by (Sharpe, 1964) were derived for exploration by Jeffe (1989) on an average return of portfolios in which average return of portfolios would be increase when adding gold and gold stocks into portfolios. Gold is perceived as a better store of value than paper money in times of crisis (Harmston, 1998).

Even Jeffe (1989), Harmston (1998), Randson (2005a), Randson (2005b), confirmed investment in gold is a good strategy under financial crisis, Saidi & Scacciavillani (2010) found a sudden dropped in gold price after union the Euro in 1999. At that time, central bank

of United Kingdom and central bank of Switzerland released some gold from their international reserve to maintain their appropriate proportion of the Euro international reserve as a whole. Concern and expectation of gold price reduction occurred since then.

2.2 Literature Related to Independent Variables

2.2.1 Inflation rate

Diewert (1999) and Pollak (1980) mentioned about inflation that, inflation or cost of living index or consumption deflator is measured by Consumer Price Index (CPI). CPI for All Urban Consumers (CPI-U), a proxy of inflation in this research, is one of multi macroeconomic variables describing percentage change of London PM gold fix. Inflation rate is a measure of an average change between any two time periods of prices of consumer goods and services spent by all household in the US. Gillingham (1974) defined an annualized percentage change of inflation(PC_{annual}) as;

$$PC_{annual} = \left[(IX_{t+m}/IX_t)^{12/m} - 1\right] * 100,$$

where IX_{t+m} represented the index m month after month t and IX_t represented as the index in month t.

A study of (Dubey et al., 2003) about the attribute of the gold is a store in its value. Whenever there is an expectation of inflation, people will turn to hold more gold. Gold has been counted as Inflation Hedge (Harmston, 1998). Numerous papers talking about investing in gold had been issued so far. Harmston (1998), Ranson (2005a), Ranson (2005b), Levin & Wright (2006) and Dempster (2009) argued gold is a well diversified portfolio when there is a fear of inflation. Their studies found the correlation between the gold price and inflation. Also, Levin & Wright (2006) found that gold and inflation move together in long-run.

Even Lowrence (2003) under the Vector Auto Regressive (VAR) model found a positive correlation between gold price and inflation but, his investigation found insignificant relationship between the real rate of return of gold price and inflation rate under Ordinary Least Square (OLS) method. This outcome was consistent with a study of Jaffe (1989). Jaffe (1989) examined movement of gold value using Capital Asset Pricing Model (CAPM). He suggested that gold is not a good inflation hedge as his significant outcomes suggested that the beta of gold is nearly zero.

2.2.2 Percentage Growth Rate of M2

M2 was applied as one determinants of real rate of return of gold in a study by Lowence (2003). The money supply is important to economists for understanding how policies will affect interest rates. It is a tool of monetary policies for the policy makers. IMF (2010) suggested that huge volume of money supply injects to the economic system especially in the US revealing the fear of inflation and fear of inflation will indicate the monetary policy of the government. IMF (2010) found strongly positive link between money supply and asset prices. Artigas (2010) also studied on the linkage of money supply to inflation and hence the effect to the gold price as huge amount of money supply flowing in

the economic system will make booming of asset price, especially gold, and increasing of such asset's price will be a signal of inflationary.

Lowerence (2003) found real rate return on gold did not significantly related to money supply.

2.2.3 Percentage change of US Dollar index

One role of US dollar is accumulation of wealth. Every government and financial institution holds US dollar as a major reserve currency. A study of (IMF, 2010) found US dollar tends to be depreciating continually since Bretton Woods system which is a system of fixed exchange rate has been aborted. Capie, Mills & Wood (2004) suggested even before or after the Bretton Wood system, the gold value has been linked with the dollar value. An abortion of the Bretton Woods system in 1971, exchange rates of US dollar floated and US dollar has become varies upon economic situation and some macroeconomic indicators since then (Loretan, 2005).

Hence, investors looked for currencies which they could rely on as an asset hedge against investor's portfolios (Dempster, 2009). However, as Ranson (2005b) explained investment by relying only on US dollar is somehow danger as US dollar's move in accordance with the situation of the US. Since Ranson (2005b) found changes in US dollar value and effect to the gold value changes, he suggested an alternative way to hedge investor's portfolios by investment in gold.

Proportion of gold reserve by each central bank is arising while holding US dollar is reducing (Saidi & Scacciavillani, 2010) due to gold has been proved itself as the store of value asset (Dempster , 2009). Though its price fluctuates sometimes, its real purchasing power has not been declined (Harmston, 1998).

Recently, sub-prime crisis affects the confidence of US economy; value of US dollar thus keeps continually declining. Every single of a country's currency evolved with gold. Dempster (2008) and Capie et al., 2004 also suggested that; since gold moves in the opposite direction to US dollar, whenever individuals lose some confidence in the nation's currency, they will move their desires to hold the gold instead.

However, a study of Lowrence (2003) found movement of US dollar does not change the gold value significantly.

2.2.4 US Real GDP Percentage of Growth

The study by (Abel, Bernake, & Croushore, 2008) stated about real GDP that, it is one primary indicator used to examine the health of a country's economy or it could be said as the size of the economy indicator.

GDP is a major impact to every business sector, from household sector to the large corporations and governments sector (Abel et al., 2008). Most investors concern of negative GDP growth and it is one of the factors that the economists use to determine whether an

economy is in a recession. Growing in economic was one main factor effects to a sudden increase in gold price. India and China have rapid and high economic growth rates level. Both of them are the nations where consume high proportion of gold in the world. Demand of gold for ornament industry in India and China was approximated 51% of global demand in 2010. In 2010, the world demand of gold for jewelry and technology increased from 2009 by 17% and 12% respectively but the demand for investment reduced from previous year by 2% (Saidi & Scacciavillani, 2010). World Gold Council (2011) suggested the gold price will not increase as much as expected from an increasing concern in budget deficit of the US government and declining demand of gold for ornament and industrial production sectors.

Real GDP growth usually has a significant effect on the stock market but found none significant impact directly on value of gold. However, demand boom encourages an increasing rate of real GDP and sometimes arouse inflation (IMF, 2010) in which Dempster (2009) concluded gold as a strategic inflation hedge.

Lowrence (2003) found insignificant relationship between growth rate of US real GDP and real rate return of gold and later conclusion by Dempster (2008) that US recession has no impact to the gold price movement.

2.2.5 Real Interest Rate

Hirshleifer (1969) stated about the real interest rate that it is an inflation adjustment rate that aims to remove the effects of inflation to reflect the real cost of funds to the borrower, and the real rate of return to the lender. In term of an investment, it would be calculated as the amount by which the nominal interest rate is higher than the inflation rate. Therefore, real interest rate is the important fact to be concerned.

The results of recession recently arising from subprime crisis have an impact to various countries need to reconsider their monetary policies. One of such effective tools to fight with the recession period is the reduction in policy interest rate, especially, in advanced countries like USA, UK and Japan[1] (IMF, 2010).

The long-term government bonds, long-term corporate bonds and Treasury bill (T-bill) yield as proxies of real interest rate, were also tested to estimate their relationship with bullion gold price and gold stock prices[2] (Jaffe, 1989). Only yield on one-month T-bill was significantly negatively related to monthly return on gold price. Lowrence (2003) showed a negative correlation of -0.17 of the three-month real interest rate to the gold price movement.

However, Lowrence (2003) also found insignificant relationship between the gold price movement and short term real interest rate.

[1] After Subprime crisis, USA, UK and JAPAN announced its policy interest rate to be nearly zero.

[2] An index of gold stocks traded on the Toronto Stock Exchange and record of "ASA" which is a mutual fund composed primarily of South African gold-mining stock were used as proxies of gold stock.

Table 1: Correlation of macroeconomics variables and value of gold in previous studies

Variables	Positive	Negative	Not significant
Inflation	Harmston (1998), Ranson (2005a), Ranson (2005b), Levin & Wright (2006), and Dempster (2009)		Lowrence (2003), Jaffe (1989)
Money Supply	Artigas (2010), IMF (2010)		Lowrence (2003)
US dollar		Harmston (1998), Capie et al., 2004, Dempster (2008) Demspter (2009)	Lowrence (2003)
Real GDP			Lowrence (2003), Demspter (2008)
Real interest rate		Jaffe (1989)	Lowrence (2003)

2.3 Arbitrage Pricing Theory

Despite the factors related to gold, the theory that this research used to find out the determinants of changes in London PM gold fix is also previewed.

Rather than the simple equilibrium model to predict the excess return of dependent variable by using one factor (market risk) called Capital Asset Pricing Model (CAPM), a theory by (Sharpe, 1964), the Arbitrage Pricing Theory (APT) is used to explore the relationship of multiple variables. Burmeister, Roll & Ross (2003) included macroeconomic factors to control the portfolio's risks. Chen, Roll & Ross (1986), Fama & French (1992), Flannery & Protopapadakis (2002), Kyereboah-Coleman & Agyire-Tettey (2008) and Mohammad, Hussain, & Ali (2009) suggested that there are several primary sources of risk which affect the stock returns. Those risks comprising of an investor confidence, interest rates, inflation, real business activity and a market index. APT is an instrument used to analyze the asset price (Roll & Ross, 1980). One of APT's characteristics is that, it allows more than one factor describe the model. In other words, APT is used as the same fashion as multi-factor model.

Roll & Ross (1980) APT's process is performed under the assumption that the asset returns follow a multivariate normal distribution. Benefit of APT enables the researcher to describe the asset's contribution more general than using CAPM. This means the asset's price can be affected beyond one factor together with riskless asset. An empirical work by Roll & Ross (1980, 1984) fellow by an empirical study of Chen, Roll & Ross (1986) constructed APT given larger samples and a risk free asset generated the process. APT was thus, so far proved as a linear regression. APT formulation can be expanded to;

$$E_i - E_0 = \lambda_1 b_{i1} + \cdots + \lambda_k b_{ik}$$

Provided that, E_i is the expected return of stock market, E_o is the return on risk free asset, b_{ik} is the asset's sensitivity to the factor k, and λ_k is return on factor k. Homogeneous assumption is also required under APT method. This means that variance of the error term does not depend upon the value of E_i.

CHAPTER III

RESEARCH METHODLOGY

This research mainly aims to find out determinants of movement of London PM gold fix. This chapter will discuss on the different data acquired from different sources and will explain definitions of each variable. The research hypotheses and methodologies used for achieving objectives of this research will be also described.

Those methodologies to be discussed comprised of Ordinary Lease Square (OLS) and correlation analysis. OLS would be used to explore the factors contributing to the movement of the gold fixing. Another method is correlation analysis used to explore correlation between each observed predictors and dependent variables.

3.1 Research Hypotheses

This research will determine whether macro economic factors have effect to the change of gold price real rate of return. In each ordinary least square regression equation, the standard t-test and F-statistic test will be performed.

Ho: There is no difference in significantly determined the movement of macroeconomic factors and percentage change of gold fix.

Ha: There is a difference in significantly determined the movement of macroeconomic factors and percentage change of gold fix.

3.2 Construction of Variable Terms

Global gold price percentage rate of return is affected by various macroeconomic variables in the United States. Inflation rate, money supply, real GDP, US dollar, and real interest rate are used as independent variables. The period of this research covers the first quarter of 1973 the second quarter of 2011. Each of nominal data was appeared preceding 1973 except Nominal Major Currencies US Dollar Index which was first introduced in 1973 after the Bretton Woods System had been terminated in 1971. Data gathering were in quarterly basis by extracting value of each data series at end of each quarter.

The variables which derived from different sources are denominated in units of US$. To avoid such misspecification or means and variances of the data series systematically

change over time, all data series except real interest rate would be then converted in term of percentage of natural logarithm (Chen, Roll & Ross, 1986).

3.2.1 Percentage Change of London PM gold fix (GOLDP)

Nominal data of London PM gold fix is derived from Bloomberg data base. Percentage of return on the London PM gold fix data would be used as a proxy of movement of gold value. Nominal data retrieved in US$ per ounce and be constructed in to percentage change by converting into following natural logarithm term as follows:

$$GOLDP_t = \{\log_e(GOLD_t)/\log_e(GOLD_{t-1})\} * 100,$$

where *t* stands for period of time *t* and *t*-1 means the time period prior to time *t*.

3.2.2 Inflation rate (INFG)

Consumer Price Index or CPI is an effective economic indicator widely used to discover movement of gold value. It is also mostly used as a guide for making economic determinations as its components are used to adjust other economic data set for price change and to translate this data set into inflation-free dollars. CPI-U after logarithm process will be used as a proxy of inflation in this research. It includes expenditures by urban wage earners and clerical workers, professional, managerial, and technical workers, the self-employed, short-term workers, the unemployed, retirees and others not in the labor force.

To being suit with the data derived for this study, CPI-Urban (CPIU) would be determined as U.S. inflation rate by modification of an annualized inflation rate calculation by Gillingham (1974). This research, CPI-U is derived from Bureau of Labor Statistic, U.S. Department of Labor. Normally; CPI-Urban is just a price level, quarterly inflation rate (π_t) can be generally calculated as;

$$\pi_t = \left((CPIU_t/CPIU_{t-1}) - 1\right) * 100$$

given π_t represents the inflation rate as the percentage change in CPI quarter on quarter and *t* represents quarter *t*, *t-1* is the quarter after quarter *t*.

Raw CPI-U data would be applied in term of the first difference of the logarithm or return on CPI-U ($\Delta lnCPIU_t$), in this regards, it has been called "inflation rate". Inflation rate in % (INFG) represented by following formula:

$$\text{INFG}_t = \{ln(CPIU_t) - ln(CPIU_{t-1})\} * 100$$

3.2.3 Percentage Growth of US Dollar Index (USDG)

Unlike nominal major currencies dollar index announced by Federal Reserves, weight of each currency to the US dollar value will not be changed from time to time. In this research, the nominal US dollar index was retrieved from Bloomberg. Loretan (2005) expressed the US dollar index (I_t) as follows;

$$I_t = I_{t-1} \times \prod_{j=1}^{N(t)} \left(\frac{e_{j,t}}{e_{j,t-1}} \right)^{w_{j,t}}.$$

whereby I_{t-1} is the dollar index prior to time t, $e_{j\cdot t}$ and $e_{j\cdot t-1}$ are the price of US dollar exchange rate relative to foreign currency j at times t and time t-1, $w_{j\cdot t}$ is the weight of currency j in the index at time t, $N(t)$ is the number of foreign currencies in the index at time t, given that $\sum_j w_{j\cdot t}$ equals to one. The US dollar index is the value of the US dollar which is set at a base value of 100, weighted with major currencies at 57.60%, 13.60%, 11.90%, 9.10%, 4.20%, and 3.60% to Euro, Japanese Yen, Pound Sterling, Canadian dollar, Swedish Krona, and Swiss Franc, respectively. So, the US dollar index ($USDX_t$) is constructed by:

$$\begin{aligned} USDX_t = I_{t-1} &\times \left((EURUSD_t/EURUSD_{t-1})^{-0.576}\right) \times \left((USDJPY_t/USDJPY_{t-1})^{0.136}\right) \\ &\times \left((GBPUSD_t/GBPUSD_{t-1})^{-0.119}\right) \times \left((USDCAD_t/USDCAD_{t-1})^{0.091}\right) \\ &\times \left((USDSEK_t/USDSEK_{t-1})^{0.042}\right) \times \left((USDCHF_t/USDCHF_{t-1})^{0.036}\right) \end{aligned}$$

Apart from inflation, the variables which derived from different sources are denominated in different units. To avoid such misspecification and to perform Dicker-Fuller Test , this could be solved by convert them into % natural logarithm form as Chen, Roll and Ross performed natural logarithm for Industrial Production as an economic factor in their study in 1986. US Dollar Index Percentage Growth Rate (USDG) at time t computes as:

$$USDG_t = \{ln(USDX_t) - ln(USDX_{t-1})\} * 100$$

3.2.4. M2 Percentage of Growth (M2G)

M2 data series derived from The Federal Reserve of the Central Bank of United States. As explained previously in Chapter 2, M2 comprises all physical monies, current accounts, small time deposits less than US$100,000 and saving accounts in the United States. Unit represented in US$. For data series' stationary, this term would be converted in to

percentage of natural logarithm. Percentage growth of M2 at time t ($M2_t$) would be computed as;

$$M2G_t = \{ln(M2_t) - ln(M2_{t-1})\} * 100$$

3.2.5 Percentage Growth Rate of Real GDP (RGDPG)

In this research, real GDP data derived from Bureau of Economic Analyst, US Department of Commerce. The data represented as seasonally adjusted at annual rates in Billions of chained (2005) dollars under an expenditure approach. Real GDP (denoted as *Y*) is a composition of Consumption (*C*), Investment (*I*), Government Spending (*G*) and Net Exports (*X-M*) or $Y = C + I + G + (X - M)$, where *X* refers to exports and *M* refers to imports. Like other variables, real GDP shall be converted into logarithm term. The term of percentage growth rate of real GDP ($RGDPG_t$) shall represent as;

$$RGDPG_t = \{ln(RGDP_t) - ln(RGDP_{t-1})\} * 100$$

3.2.6 Percentage Change of Real Interest Rate (RINTX)

Interest rate for the three-month certificated of deposit is used as a proxy of interest rate. However, each data are presented in term of nominal. In order to remove the price effect from a data series, the data series will then been adjusted to be real by deflate with inflation rate(π). CPI is applied to be used for multi-purposes. Two main functions of CPI are to be used as a consumption deflator and as a measure of inflation (Diewert, 1999 and Pollak, 1980). So, to track the data series independently from the price movement over time, nominal three-month certificated of deposit rate would be then considered as percentage change of real interest rate *($RINTX_t$)* by deflate with log of particular return at time *t* on CPIU ($INFG_t$). $RINTX_t$ computed as follows:

$$RINTX_t = \{(CDs_t - INFG_t)/ (CDs_{t-1} - INFG_{t-1})\}\text{-}1$$

CDs_t is interest rate of three-month Certificate of Deposits at quarter ended *t*. CDs_{t-1} is interest rate of three-month Certificate of Deposits at end of quarter prior to quarter *t*. This proxy of interest rate derived from The Federal Reserve of the Central Bank of United States

3.3 Data Series Stationarity Test

Process to transform nominal data into useful information and method to describe the validity of data series will be described in this section.

Augmented Dickey-Fuller

Data series or value of variables (X_{mt}) will be efficient when they are stationary. In other words; their lags have no unit root or their parameters such as means and variances, do not systematically change over time. Stationarity is used in the time series analysis in which raw data are often converted to become stationary.

Dicker-Fuller Test is used to test whether there is any unit root in an autoregressive model. A simple autoregressive model is $y_t = \rho y_{t-1} + u_t$ where y_t is data at time t, ρ is the coefficient of lag of the data and u_t is a residual term.

First step for the testing is transformation of data series by using lags, first difference, logarithms and growth rate. If first lag of return on the variables m at period t (X_{mt}) is X_{mt-1} and the first difference of X_{mt} is the change between period t-1 and t ($\Delta X_{mt} = X_{mt} - X_{mt-1}$), the first difference of the logarithm in percentage can be then, constructed as:

$$\Delta lnX_{mt} = \{ln(X_{mt}) - ln(X_{mt-1})\} * 100 \qquad \text{---- (1)}$$

After the log process to estimated the percentage change of data series (ΔlnX_{mt}), its mean will equal to $\tilde{\mu}_t$. An Augmented Dicker-Fuller Test was applied to this study to test stationary of the data series. This method is as same as the Dicker-Fuller Test but it can removes autocovariance ($\gamma_{t(j)}$) effect by testing if jointly distribution exists between the percentage change of the data series at time t ($\Delta ln\, X_{mt}$) and its lags until j period ($\Delta ln\, X_{mt-j}$). Once the mean of ΔlnX_{mt} equals to μ_t,

autocovariance $\gamma_{mt(j)} = E[((\Delta lnX_{mt}) - \tilde{\mu}_t)((\Delta lnX_{mt-j}) - \tilde{\mu}_{t-1}]$

$$= Cov[(\Delta lnX_{mt}), (\Delta lnX_{mt-j})]$$

The joint distribution of $\Delta ln\, X_{mt}$ and its lag is stationary when there is no unit root or when the joint distribution reject null hypothesis. An alternative hypothesis has been set up to test such stationary as:

$H_o : \gamma_{mt(j)} = 0$ and

$H_a : \gamma_{mt(j)} \neq 0.$

3.4 Correlation of variable terms

How individual variable correlates to each other would be also explored. Pearson correlation is as a tool to explore such correlations. The formula derived from covariance between two variables relative with standard deviation of each two variables. Correlation coefficient ($\rho_{m,n}$) between two variables can be written as:

$$\rho_{m,n} = \frac{\sum_{j=1}^{153}[(X_{mj}-\bar{\mu}_m)(X_{nj}-\bar{\mu}_n)]/_j}{\{[(\sum_{j=1}^{153} X_{mj}-\bar{\mu}_m)/j][(\sum_{j=1}^{153} X_n-\bar{\mu}_n)/j]\}}$$

The term ($\sum_{j=1}^{153}[(X_{mj}-\bar{\mu}_m)(X_{nj}-\bar{\mu}_n)]/_j$) stands for covariance between different two observed data series ($\sigma_{m,n}$). Denominator is the product of standard deviation of variable m and n ($\sigma_m * \sigma_n$). For example, correlation between return on global gold price and inflation rate defines as follows:

Correlation Coefficient of GOLDP and INFG $(\rho_{m,n}) = \frac{\sigma_{GOLDP,INFG}}{\sigma_{GOLDP} * \sigma_{INFG}}$

Then, substitute m and n by two different observed data terms. The results shall be between -1 and 1.

3.5 Determinants of Percentage Change of London PM Gold Fix by Arbitrage Pricing Theory

This paper intends to explore macroeconomics indicators as determinants of the movement of gold value. VAR method was used to study the correlation of the gold price (Lowrence, 2003). Ordinary Least Square (OLS) Method will be applied in order to determine the effective factors jointly impact to the movement of the gold value. In this paper, under the OLS, the global gold price model is defined as:

Equation of Percentage Change of London PM Gold Fix;

$$\overline{GOLDP} = E_{GOLDP} + (b_{GOLDP,INFG} \cdot \check{\delta}_{INFG}) + (b_{GOLDP,M2G} \cdot \check{\delta}_{M2G}) + (b_{GOLDP,RGDPG} \cdot \check{\delta}_{RGDPG}) + (b_{GOLDP,RINTX} \cdot \check{\delta}_{RINTX}) + (b_{GOLDP,USDG} \cdot \check{\delta}_{USDG}) + \varepsilon_t$$

where; $\overline{GOLDP}$ is predicted average percentage change on London PM gold fix (XAU/USD) at quarter t ended,

E_{GOLDP} is the expected value of percentage change on London PM gold fix if all factor indices are equal to zero,

$b_{GOLDP,INFG}$ is the sensitivity or called coefficient of percentage change on London PM gold fix and inflation rate of quarter t,

$\check{\delta}_{INFG}$ is the value of inflation rate at predicted quarter,

$b_{GOLDP,M2G}$ is the sensitivity of percentage change on London PM gold fix to percentage growth rate of M2,

$\check{\delta}_{M2G}$ is the percentage growth of M2, a proxy of quantity of money expansion at predicted quarter,

$b_{GOLDP,RGDPG}$ is coefficient of real growth rate of GDP impact to percentage change on London PM gold fix,

$\check{\delta}_{RGDPG}$ is the value of percentage growth rate of real GDP at end of predicted quarter,

$b_{GOLDP,RINTX}$ is coefficient of real interest rate effect to percentage change on London PM gold fix,

$\check{\delta}_{RINTX}$ is value of percentage change of real interest rate at end of quarter t,

$b_{GOLDP,USDG}$ is coefficient value of the movement between percentage change on London PM gold fix and percentage change of US dollar index,

$\check{\delta}_{USDG}$ is the value of percentage change of USD index at end of predicted quarter t, and

ε_t is a random error term of this function where $\mu_{\varepsilon t}$ equals to zero and variance equals to $\sigma^2_{\varepsilon t}$. It has been called as "residual term" in this research.

Result by Ordinary Least Square Method will be presented in following chapter.

CHAPTER IV

PRESENTATION AND CRITICAL DISCUSSION OF RESULTS

As previously mentioned on this research, the main purpose of this research is to study the relationship between gold value and five dynamic macroeconomic factors in the United States. The determinants of movement of gold fix were constructed through exploration of five macroeconomic factors as presented in chapter III. The present chapter presents the results of research, which demonstrate the answers to the following research questions:

1. Do inflation rate, percentage growth of money expansion (money supply), percentage growth rate of real GDP, real interest rate change, and percentage change of US dollar index significantly determine the movement of gold fix?
2. Do those macroeconomic indicators move in the same or opposite direction with the movement of gold value?

In accordance with the research questions above, data series stationarity testing and analysis of Ordinary Least Square is used to test whether the data series and the information are reliable and which one significantly impacts to the movement of gold fix. Beside, the correlation analysis presents the correlative movement directions of variables with the percentage change of gold price and with each other. The results are presented in the following sections.

4.1 Data Series Stationarity Testing

As mentioned previously in Chapter 3, the joint distribution percentage change of particular data series and its lag is stationary when there is no unit root. Table 2 showed the statistic result from Augmented Dickey-Fuller test.

Table 2: Augmented Dickey-Fuller test statistic (see also: Appendix A)

Variable	t-stat value	One tail Probability (p-value)
GOLDP	-11.7320	0.0000
INFG	-3.8232	0.0179
USDG	-9.7315	0.0000
M2G	-7.1413	0.0000
RGDPG	-8.2068	0.0000
RINTX	-11.2383	0.0000

Under autoregressive model, the t-stat of percentage change of London PM gold fixing, inflation rate, percentage change of US dollar index, percentage change of money supply level 2, growth rate of US real GDP, and real interest rate change are -11.7320 (p-value = 0.0000), -3.8232 (p-value = 0.0179), -9.7315 (p-value = 0.0000), -7.1413 (p-value = 0.0000), -8.2068 (p-value = 0.0000) and -11.2383 (p-value = 0.0000); respectively. Their p-values of constant and drift are less than 5% significant level, hence; reject null hypothesis where covariance of each variables with their lags are different from zero at 95% confident interval. The results revealed that, all variables have no unit root. In another word, all data series are stationary. The information used in this research is reliable and it does not conflict with OLS assumptions.

4.2 Correlation Analysis

As Table 3 presented below, only inflation rate has a positive correlation with percentage change of London PM gold fix. Meanwhile, growth rate of US real GDP, changes in real interest rate, percentage growth rate of M2, and percentage of change of US dollar index have negative correlation with percentage change of London PM gold price fix. Inflation rate and percentage change of US dollar index have the strongest positive and negative correlation of 0.1980 and -0.3905, respectively.

Table 3: Correlation Matrix

	INFG	M2G	RGDPG	RINTX	USDG
GOLDP	0.1980	-0.0013	-0.0953	-0.0456	-0.3905
INFG		0.0401	0.0261	0.0299	-0.0304
M2G			-0.0754	0.1587	0.1332
RGDPG				-0.0139	-0.0087
RINTX					0.0990

The result also shows that, only percentage of US dollar growth moves in the opposite direction with inflation rate, meanwhile, the rest of variables move in the same direction with inflation rate. Percentage change of money supply is the strongest positively correlated with inflation rate at 0.0401. This may imply that when there is a larger quantity of money supply inject into economy, it stimulates the rate of inflation. As a consequence, the central bank has a necessity to increase real interest rate in order to slow down the increasing of inflationary.

This action will also stimulate people's saving as well as decelerate their lending and borrowing.

Even change of real interest rate positively correlated with inflation rate and percentage change of money supply, it moves in the opposite direction with growth rate of US real GDP. The growth rate of US real GDP negatively correlated with the percentage change of US dollar index as well, but it slightly negative co-move to the change of real interest rate and percentage of US dollar index at -0.0139 and -0.0087, respectively. Furthermore, according to table 3 showed above, expansion of money flow in the United States reflects an appreciation in US dollar index as well.

4.3 Ordinary Least Square (OLS) Analysis on Equation of Gold Value Movement

As explained previously in Chapter 3, regression of percentage change of London PM gold price fix is explained its fit by Ordinary Least Square. An estimation results in following equation:

Estimated Regression:

GOLDP = 0.7561 + 2.0268*INFG - 1.3738*USDG -0.0321*RINTX + 0.4123*M2G -1.1643*RGDPG

(0.6721) (0.0121) (0.0000) (0.7875) (0.6110) (0.1745)

Recall that; GOLDP is percentage change of London PM gold price fix, INFG is an inflation rate, USDG is US dollar index growth rate, RINTX is change of real interest rate, M2G is percentage change of M2 and RGDPG is real GDP growth rate. Each coefficient of each factor could be clarified as follow:

1) Holding unchanged in percentage change of M2, unchanged in real interest rate, no growth in real GDP and no growth of US dollar, 1 % increasing in inflation rate results in 2.03% returning in global gold price.
2) If US dollar index falls by 1%, it increases in percentage change of London PM gold fixing by 1.37%. Given coefficient of the rest variables equal to zero.
3) 1% reduction in real interest rate will yield 0.03% returning on global gold price, holding the rest equal to zero.
4) A percentage increase in M2 results in 0.41% increasing in percentage change of London PM gold price fix, given the rest constant.

5) If the constant rate of inflation rate, M2 growth rate, real interest rate and US dollar growth are zero, one percentage growth of US real GDP decreases the gold price fix by 1.16%.

According to Appendix B, inflation rate, M2 growth rate, real GDP growth rate, real interest rate, and percentage change of US dollar are moderate predictors to explain the global gold price return. Measurement of the model fit (R^2) equals to 20% which is in line with an adjusted R^2 of 0.17%. This means that, the above regression is a moderate regression to explain the whole population. Even 20% indicate measure of fit of the regression, though an average mistake size made by the above regression is 8.83%. In addition, probability of F-Statistic (F-prob = 0.000004) which tested the joint hypothesis of whole population is nearly zero. Therefore, at least one of the population coefficients is not zero.

Beside, by regression of each independent variable on the other ones showed that, an equation of the percentage change of London PM gold price fixing has no perfect multi co linearity. Their R^2 results are weak to explain that each of them relies on each other.

Furthermore, t-stat results also shows that; p-value of percentage change of M2, US real GDP growth rate, and change in real interest rate, all fell to reject the null hypothesis (p-value > 0.05) at 95% confidence interval. F-test coincides to the t-test of each particular factor at 5% significant level that is the F-test of whole population reject null hypothesis at 5% significant level. On the other hand, it means that only inflation rate and US dollar growth rate are the factors to explain the percentage change of gold fixing significantly. Meanwhile, percentage change of US dollar index is negatively affects percentage change of gold fix; inflation rate is also a good factor to explain the positively impact to the percentage change of London PM gold fix at 5% significant level.

However, heteroskedasticity of the residuals and misspecification problem for an above estimated regression still persist. Testing under the White Heteroskedasitcity, the result appeared that, p-value of F-test rejects the null hypothesis at 95% confidence interval. Seventeen percent measure of fit ensures that, there are omitted variables in the regression. Even there is no autocorrelation problem exist, but heteroskedasticity of residual terms do. Not only omitted variables problem, but non linearity of the function also exists in regression 2 (see: Appendix B).

In conclusion, the answers to all research questions are obtained from correlation analysis and OLS method. The analysis from both methods reveals a satisfactory result. Beyond the analysis, the relationship between movement of gold value and macroeconomic variables, all data terms used in this research are stationary. The data series are reliable including in the study.

Apart from percentage change of money supply, change in real interest rate, and growth rate of US real GDP; inflation rate and US dollar index percentage of growth are the only two variables that significantly impact to the movement of percentage change of London PM gold price fix. Inflation rate moves in the same direction with London PM gold price fix whereas US dollar moves in the opposite direction.

CHAPTER V
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the research study and gives some suggestions for further studies.

5.1 Summary of the Findings

The answer to the research questions are obtained from an analysis of Ordinary Least Square (OLS) method and correlation analysis. The analysis reveals a satisfactory result.

Under OLS, all data series has no unit root. F-test shows at least one of whole population used in this research significantly impact to the movement of gold fix. By t-test, inflation rate and percentage change of US dollar significantly affect the gold price at 95% confident interval. The movement of gold fix is positively impacted by inflation while it is negatively affected by percentage change of US dollar.

Correlation analysis is used to justify correlation of percentage change of gold fix with five macroeconomic variables. Inflation rate positively correlated to percentage of gold fix whereas percentage growth rate of US real GDP, change of real interest rate, percentage growth of money supply and US dollar percentage change all move in opposite direction with return of global gold price.

5.2 Discussion/Conclusions

Percentage change of US dollar index is the perfect factor to explain movement of gold fix. When the US dollar depreciates at 1% from previous quarter, gold price at present quarter increases by 1.3%. The global gold price with only US dollar percentage change accepts all Arbitrage Pricing Theory assumptions. No residual terms are omitted in this linear regression and the US dollar in this regression significant moves independently from the residual terms.

Value of gold goes well even value of money drops. In an ongoing euro crisis, to curb with mess sovereign debts in Euro zone; one possible outcome to cope such problem is printing out paper money for debt repayment. This solution is similar to what US had done several years ago. Such deleveraging effect, like heavily drop in global demand and

devaluation of the currency may happen. So far, gold is proved as an inflation hedge, investors should better collect gold as one asset in their portfolio to hedge such risks. While people's wallet size continually reduces, price of gold still keeps increasing in its value. Reasonable price of the gold can be predicted by the value of US dollar. Movement of gold value and percentage change of US dollar index have mirror effects to each other.

In Thailand, buying and selling price of a unit gold fund is determined by mark-to-market at the end of each day trade. Thai investors who are willing to invest in gold through gold fund, can decide to buy such fund when US dollar spot drops heavily. They can collect cheap gold for their investment by predetermination when dollar spot rate is weak.

5.3 Limitations and Recommendations for Future Research

The best exploration global gold price model may have some weak points. Includingly, the five factors of inflation rate, percentage growth of US dollar, percentage growth of money supply, percentage growth of US real GDP, and change of real interest rate to explore the movement of gold value are conflicted with the assumption of Arbitrage Pricing Theory. Regression under arbitrage model shows that some data series are omitted in the model. It can be further improved by adding more variable terms into the study. For example, further study may include crude oil price, main stock market index and other commodity products indices.

In addition, once this research data derived in quarterly basis, it is not suitable for gold spot investor, gold future investors and FX marketers. It is suggested that holding assets in longer tenor will be more risk than to hold in a shorter period of time. To be applicable for them, further researcher should ignore real GDP and the data series should be retrieve daily. Both long and short of gold contracts are available through gold spot and gold future markets. When dollar index appreciate, investors should short gold. Fund managers and marketers in financial institution will also have benefits from the result of this study due to they are the largest players in FX market. They can applied global gold price model to predict and determine US dollar spot rate.

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APPENDICES

APPENDIX A

Data Series Stationarity Test

GOLDP has no unit root

Null Hypothesis: GOLDP has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.73202	0.0000
Test critical values:	1% level	-4.019561	
	5% level	-3.439658	
	10% level	-3.144229	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GOLDP)
Method: Least Squares
Date: 09/22/12 Time: 14:26
Sample (adjusted): 1973Q2 2011Q1
Included observations: 152 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GOLDP(-1)	-0.928039	0.079103	-11.73202	0.0000
C	0.869918	1.550541	0.561041	0.5756
@TREND(1973Q1)	0.008436	0.017506	0.481897	0.6306

R-squared	0.480606	Mean dependent var	-0.177124
Adjusted R-squared	0.473634	S.D. dependent var	13.05259
S.E. of regression	9.469799	Akaike info criterion	7.353632
Sum squared resid	13361.89	Schwarz criterion	7.413314
Log likelihood	-555.8760	Hannan-Quinn criter.	7.377877
F-statistic	68.93625	Durbin-Watson stat	1.847973
Prob(F-statistic)	0.000000		

INFG has no unit root

Null Hypothesis: INFG1 has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 2 (Automatic - based on SIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.823198	0.0179
Test critical values:	1% level	-4.020396	
	5% level	-3.440059	
	10% level	-3.144465	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(INFG)
Method: Least Squares
Date: 09/22/12 Time: 14:27
Sample (adjusted): 1973Q4 2011Q1
Included observations: 150 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INFG(-1)	-0.380632	0.099559	-3.823198	0.0002
D(INFG(-1))	-0.341993	0.096844	-3.531365	0.0006
D(INFG(-2))	-0.287686	0.080102	-3.591517	0.0004
C	0.708002	0.229382	3.086557	0.0024
@TREND(1973Q1)	-0.004101	0.001741	-2.355525	0.0198

R-squared	0.383988	Mean dependent var	-0.011137
Adjusted R-squared	0.366994	S.D. dependent var	0.829146
S.E. of regression	0.659682	Akaike info criterion	2.038648
Sum squared resid	63.10120	Schwarz criterion	2.139003
Log likelihood	-147.8986	Hannan-Quinn criter.	2.079419
F-statistic	22.59625	Durbin-Watson stat	1.985141
Prob(F-statistic)	0.000000		

USDG has no unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.731511	0.0000
Test critical values:	1% level	-4.019561	
	5% level	-3.439658	
	10% level	-3.144229	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(USDG)
Method: Least Squares
Date: 09/22/12 Time: 14:30
Sample (adjusted): 1973Q2 2011Q1
Included observations: 152 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
USDG(-1)	-0.772940	0.079427	-9.731511	0.0000
C	1.430587	0.449642	3.181613	0.0018
@TREND(1973Q1)	-0.011257	0.004963	-2.268281	0.0247

R-squared	0.388763	Mean dependent var	-0.000852
Adjusted R-squared	0.380558	S.D. dependent var	3.336959
S.E. of regression	2.626341	Akaike info criterion	4.788600
Sum squared resid	1027.752	Schwarz criterion	4.848282
Log likelihood	-360.9336	Hannan-Quinn criter.	4.812845
F-statistic	47.38393	Durbin-Watson stat	1.976799
Prob(F-statistic)	0.000000		

M2G has no unit root

Null Hypothesis: M2G has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.141282	0.0000
Test critical values:	1% level	-4.019561	
	5% level	-3.439658	
	10% level	-3.144229	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(M2G)
Method: Least Squares
Date: 09/22/12 Time: 14:29
Sample (adjusted): 1973Q2 2011Q1
Included observations: 152 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
M2G(-1)	-0.513446	0.071898	-7.141282	0.0000
C	1.064640	0.195643	5.441735	0.0000
@TREND(1973Q1)	-0.003374	0.001486	-2.270716	0.0246

R-squared	0.255112	Mean dependent var	-0.001687
Adjusted R-squared	0.245114	S.D. dependent var	0.869600
S.E. of regression	0.755545	Akaike info criterion	2.296784
Sum squared resid	85.05632	Schwarz criterion	2.356466
Log likelihood	-171.5556	Hannan-Quinn criter.	2.321029
F-statistic	25.51504	Durbin-Watson stat	2.056861
Prob(F-statistic)	0.000000		

RGDPG has no unit root

Null Hypothesis: RGDPG has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.206824	0.0000
Test critical values:	1% level	-4.019561	
	5% level	-3.439658	
	10% level	-3.144229	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RGDPG)
Method: Least Squares
Date: 09/22/12 Time: 14:29

Sample (adjusted): 1973Q2 2011Q1
Included observations: 152 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RGDPG(-1)	-0.622152	0.075809	-8.206824	0.0000
C	0.479119	0.141000	3.398016	0.0009
@TREND(1973Q1)	-0.000989	0.001455	-0.679859	0.4976

R-squared	0.311310	Mean dependent var	-0.005393
Adjusted R-squared	0.302066	S.D. dependent var	0.938729
S.E. of regression	0.784237	Akaike info criterion	2.371329
Sum squared resid	91.63916	Schwarz criterion	2.431011
Log likelihood	-177.2210	Hannan-Quinn criter.	2.395574
F-statistic	33.67646	Durbin-Watson stat	2.074416
Prob(F-statistic)	0.000000		

RINTX has no unit root

Null Hypothesis: RINTX has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.23825	0.0000
Test critical values:	1% level	-4.019975	
	5% level	-3.439857	
	10% level	-3.144346	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RINTX)
Method: Least Squares
Date: 09/22/12 Time: 14:28
Sample (adjusted): 1973Q3 2011Q1
Included observations: 151 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RINTX(-1)	-1.257041	0.111854	-11.23825	0.0000
D(RINTX(-1))	0.268730	0.079463	3.381804	0.0009
C	0.389380	0.988986	0.393716	0.6944
@TREND(1973Q1)	-0.010467	0.011210	-0.933676	0.3520

R-squared	0.531796	Mean dependent var	-0.005243
Adjusted R-squared	0.522241	S.D. dependent var	8.655567
S.E. of regression	5.982736	Akaike info criterion	6.441766
Sum squared resid	5261.591	Schwarz criterion	6.521694
Log likelihood	-482.3533	Hannan-Quinn criter.	6.474237
F-statistic	55.65532	Durbin-Watson stat	2.009038
Prob(F-statistic)	0.000000		

APPENDIX B

Ordinary Least Square Method

Estimated Regression of Percentage change of London PM gold fix

Dependent Variable: GOLDP
Method: Least Squares
Date: 09/22/12 Time: 14:19
Sample: 1973Q1 2011Q1
Included observations: 153

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.756100	1.782862	0.424093	0.6721
INFG	2.026766	0.798042	2.539673	0.0121
USDG	-1.373790	0.264112	-5.201549	0.0000
M2G	0.412250	0.808748	0.509739	0.6110
RGDPG	-1.164344	0.853341	-1.364453	0.1745
RINTX	-0.032146	0.119051	-0.270021	0.7875

R-squared	0.199525	Mean dependent var	1.841223
Adjusted R-squared	0.172298	S.D. dependent var	9.712583
S.E. of regression	8.836325	Akaike info criterion	7.234045
Sum squared resid	11477.85	Schwarz criterion	7.352886
Log likelihood	-547.4045	Hannan-Quinn criter.	7.282320
F-statistic	7.328204	Durbin-Watson stat	2.051025
Prob(F-statistic)	0.000004		

White Heteroskedasticity Test:

F-statistic	5.736889	Prob. F(5,147)	0.0001
Obs*R-squared	24.98070	Prob. Chi-Square(5)	0.0001
Scaled explained SS	51.17116	Prob. Chi-Square(5)	0.0000

Dependent Variable: RESID^2
Method: Least Squares
Date: 09/22/12 Time: 14:21
Sample: 1973Q1 2011Q1
Included observations: 153

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	40.02234	19.40287	2.062702	0.0409
INFG^2	22.34599	4.309009	5.185876	0.0000
USDG^2	-0.065740	1.063390	-0.061821	0.9508
M2G^2	1.244542	3.258599	0.381925	0.7031
RGDPG^2	-10.72453	7.557291	-1.419097	0.1580
RINTX^2	-0.006314	0.027952	-0.225899	0.8216

R-squared	0.163273	Mean dependent var	75.01865
Adjusted R-squared	0.134812	S.D. dependent var	158.5596
S.E. of regression	147.4850	Akaike info criterion	12.86376
Sum squared resid	3197517.	Schwarz criterion	12.98260
Log likelihood	-978.0773	Hannan-Quinn criter.	12.91203
F-statistic	5.736889	Durbin-Watson stat	1.575987
Prob(F-statistic)	0.000072		

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.726405	Prob. F(2,145)	0.4854
Obs*R-squared	1.517757	Prob. Chi-Square(2)	0.4682

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 09/22/12 Time: 14:20
Sample: 1973Q1 2011Q1
Included observations: 153
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.056197	1.790632	0.031384	0.9750
INFG	0.105903	0.804412	0.131652	0.8954
USDG	-0.056091	0.269900	-0.207820	0.8357
M2G	-0.064069	0.812438	-0.078860	0.9373
RGDPG	-0.040119	0.859099	-0.046699	0.9628
RINTX	-0.003778	0.119943	-0.031500	0.9749
RESID(-1)	-0.063014	0.085554	-0.736545	0.4626
RESID(-2)	-0.084151	0.083758	-1.004690	0.3167

R-squared	0.009920	Mean dependent var	6.84E-16
Adjusted R-squared	-0.037877	S.D. dependent var	8.689775
S.E. of regression	8.852817	Akaike info criterion	7.250220
Sum squared resid	11363.99	Schwarz criterion	7.408674
Log likelihood	-546.6418	Hannan-Quinn criter.	7.314586
F-statistic	0.207544	Durbin-Watson stat	1.904786
Prob(F-statistic)	0.983318		

Ramsey RESET Test
Equation: UNTITLED
Specification: GOLDP C INFG USDG M2G RGDPG RINTX
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	1.862265	146	0.0646
F-statistic	3.468029	(1, 146)	0.0646
Likelihood ratio	3.591812	1	0.0581

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	266.3147	1	266.3147
Restricted SSR	11477.85	147	78.08064
Unrestricted SSR	11211.54	146	76.79137
Unrestricted SSR	11211.54	146	76.79137

LR test summary:

	Value	df
Restricted LogL	-547.4045	147
Unrestricted LogL	-545.6086	146

Unrestricted Test Equation:
Dependent Variable: GOLDP1

Method: Least Squares
Date: 09/22/12 Time: 14:21
Sample: 1973Q1 2011Q1
Included observations: 153

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.597990	1.911757	-0.312796	0.7549
INFG	1.766463	0.803675	2.197982	0.0295
USDG	-1.156689	0.286694	-4.034571	0.0001
M2G	0.260818	0.806155	0.323534	0.7468
RGDPG	-0.256745	0.976571	-0.262905	0.7930
RINTX	-0.012862	0.118518	-0.108520	0.9137
FITTED^2	0.051054	0.027415	1.862265	0.0646

R-squared	0.218098	Mean dependent var	1.841223
Adjusted R-squared	0.185965	S.D. dependent var	9.712583
S.E. of regression	8.763068	Akaike info criterion	7.223641
Sum squared resid	11211.54	Schwarz criterion	7.362289
Log likelihood	-545.6086	Hannan-Quinn criter.	7.279962
F-statistic	6.787371	Durbin-Watson stat	2.042527
Prob(F-statistic)	0.000002		