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Lee, Lai Ming

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This is to certify that the above student's thesis has been examined by the following panel members and has received full approval for acceptance in partial fulfillment of the requirements for the degree of Doctor of Business Administration.

Chairman: Prof. Edward SNAPE
Dean, School of Business, HKBU

Internal Members: Dr. WAN Shui Ki
Associate Professor
Department of Economics, HKBU
(Designated by Programme Director of Doctor of Business Administration, HKBU)

Dr. TAN Weiqiang
Assistant Professor
Department of Finance & Decision Sciences, HKBU

External Members: Prof. Lewis Hon Keung TAM
Associate Professor
Department of Finance and Business Economics
University of Macau

Prof. LAM Kin
Professor Emeritus
Department of Finance & Decision Sciences, HKBU

In-attendance: Dr. Alexander FUNG
Senior Lecturer, Department of Finance & Decision Sciences, HKBU [Principal Supervisor]

Prof. Joseph FUNG
Professor, Department of Finance & Decision Sciences, HKBU [Co-supervisor]

Issued by Graduate School, HKBU

The Economics of Gold Price

LEE Lai Ming

A thesis submitted in partial fulfillment of the requirements

for the degree of

Doctor of Business Administration

Principal Supervisor: Dr. Alexander K W FUNG

Secondary Supervisor: Prof. Joseph K W FUNG

Hong Kong Baptist University

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DECLARATION

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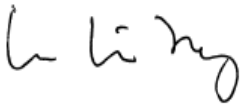

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ABSTRACT

The gold price has a widespread influence on industry practitioners and country reserve managers. The market view on the gold price is also an integral part of the hedging programmes of mining companies and jewellers. Similarly, many studies have explored the roles of gold as an alternative asset for tactical trading or portfolio diversification and as a strategic asset in country reserve. In this thesis, the understanding of the economics of gold's return is advanced by studying the effects of monetary policy stance, macroeconomic, and financial variables on the gold price.

Some empirical studies have investigated the determinants of the gold price by modelling its changes in relation to the changes in macroeconomic and financial variables; these studies have generated mixed results, depending on the variables and sample periods chosen. Their divergence may also suggest the omission of other critical driving factors for the gold price.

Monetary conditions are considered as one of the gold price drivers. Most studies on the relationship between monetary policy and the gold price have used US interest rates as an indicator of monetary policy stance; however, interest rates may not be representative of money supply shocks in the post-crisis period. In the past, central banks that adopted standard monetary policy would increase the money supply by lowering interest rates; the gold price thus reacts positively due to increased market liquidity. However, during the past 9 years, compared with standard monetary policy, "unconventional monetary policy" has applied even

greater influence on asset prices. In response to the lingering influence of the global financial crisis, the US Federal Reserve (US Fed) began implementing two unconventional monetary tools, namely forward guidance and quantitative easing (QE). QE is designed to be implemented when overnight interest rates are near zero and involves the US Fed buying long-term assets from commercial banks. This raises the money supply and asset prices and suppresses long-term yield. In the past few years, other major economies such as the United Kingdom, Eurozone, China, and Japan have also undertaken similar QE programmes. Therefore, whether and to what extent these unconventional monetary policy tools which are currently in effect may affect the gold price warrants examination.

The focuses and objectives of empirical studies have been varied; no studies have specifically examined the influence of international money supply. At the macro level, parameters have been heavily focused on data from the United States and European countries. Thus, previous studies may have been prone to a narrow focus on the United States or other factors. This thesis addresses these gaps in the literature.

In this study, an econometric analysis is performed to identify the determinants of the gold price. US dollar exchange rate is identified as the key variable for most of the sample period before the implementation of QE, among other factors. However, after the introduction of the unconventional monetary policy, international money supply became the most dominant factor. This study reveals that at times when there are drivers in force that would lead to a change in inflation or inflation expectation, the store of value property of gold is triggered

and these price determinants dominate; as in the case of international money supply in the post-crisis period.

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CHAPTER 1: INTRODUCTION

1.1 What determines the gold price?

Demand for gold is mainly derived from its function of money and aesthetic appeal. Gold has been a medium of exchange and a store of value for centuries, because it features the characteristics of money such as scarcity, storability, durability, and liquidity. In recent years, demand from the jewellery sector has surged; China and India, where possessing gold jewellery has cultural significance and is often associated with rituals and celebrations, are the two most important markets.

Gold has also evolved as an investment asset, and demand from this area has grown overtime, mainly because of its homogeneity and store of value property. Investment in gold can be made in both physical and paper markets through direct ownership of physical gold such as coins and bars or through indirect ownership with exchange-traded funds (ETFs) and other structured products. Investment needs in gold are further enhanced by its diversification role in a portfolio because its returns are independent of other assets.

Central banks' actions can affect the gold price mainly through their monetary policy and the gold holdings in their foreign exchange reserves. After the 2008 financial crisis, central banks, including the US Federal Reserve (US

Fed), Bank of Japan (BOJ), Bank of England (BOE), European Central Bank (ECB)[1], and recently People's Bank of China (PBOC), have implemented phases of quantitative easing (QE) to increase the money supply through open debt purchase with the intention of boosting economic growth. The excess liquidity enters the financial system, it leads to inflationary pressure, and investors flock to real assets such as gold to safeguard their wealth. During the third phase of QE in 2011, the gold price reached a record high at USD1,895.

Gold is also an important reserve asset for central banks. It provides numerous benefits to foreign exchange reserves, and central banks' gold holdings have been increasing in recent years. In addition to the liquidity that the gold market offers to investors even during crisis periods, gold can serve as a diversifier or hedging tool in reserve managers' portfolios. Some central banks buy gold because it is a real physical asset that is free from counterparty default risk.

These diverse demands from different sectors underpin a sustained demand for gold in the different stages of economic cycles.

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[1] The ECB was established in 1998. Its initial objective was to manage the economic and monetary transition of European Union integration. At present, the ECB is the central bank of Eurozone, and its tasks include administering foreign exchange operations and monetary policy for the area and managing country reserves for the European System of Central Banks.

1.1.1 Demand for physical gold

Table 1 provides a breakdown of gold demand during recent years. Since 2010, the annual demand for gold has been more than 4,000 tonnes. This demand has been generated from four primary areas: technical applications, investment, central banks, and jewellery being the predominant source.

Demand for physical gold from the jewellery sector has been stable for centuries because jewellery is one of the earliest functions of this metal. The durable, aesthetic, and malleable properties of gold as well as its scarcity make it a perfect material for jewellery. A number of factors contribute to the demand for gold from the jewellery sector, including design trends, the gold price, desirability, and income levels as well as cultural and socioeconomic influences. At the end of 2016, the jewellery sector accounted for 47 per cent of the demand for physical gold; of this demand, approximately 60 per cent originated from India and China. The desire to own gold jewellery is deeply rooted in these cultures, because gold is a symbol of prosperity and luck and is often presented as gifts in celebrations and festivals.

Investment accounts for the second largest demand for physical gold. Between 2004 and 2011, demand for gold for investment has increased from only 478 tonnes to a record 1,730 tonnes. Coins, bars, medals, imitation coins, ETFs, and related products make up the identifiable retail investment. The emergence of gold as an investment is due to various reasons. Gold's homogeneity, durability, and ostentation value make it a universal denomination of wealth and a store of

value that maintains purchasing power. Many studies also demonstrate that gold can reduce the volatility of an investment portfolio. At the verge of the outbreak of financial crisis, retail gold investment increased from 697.1 tonnes in 2007 to 1,242.9 tonnes in 2008.

The launch of gold ETFs in 2003 also contributed to the investment demands for physical gold. Gold ETFs were well received for various reasons. First, the bid-ask spreads of gold bar and coin trades are relatively wide because of the small trading volumes, whereas gold ETFs are traded at a narrower bid-ask spread that is facilitated by the higher volumes resulted from pooling. Second, investors considered gold ETFs comparable to real gold investment alternative, because they are backed by physical gold, yet the storage costs of ETFs are substantially lower than those of physical gold due to economies of scale. Third, because institutional investors are often forbidden from holding physical assets by the investment guidelines of their institutions, therefore gold ETFs are a good alternative to them.

The trading convenience offered by ETF instruments and the lower all-in costs associated with economies of scale have resulted in a twofold structural change in gold demand. First, investment demand for gold has increased because gold ETFs appeal to the investors who had formerly been deterred by the complicated process of physical gold trading[2]. Moreover, gold ETF providers

[2] The trading of physical gold bars and coins is usually costly and time-consuming; investors must make such trades through dealers.

must purchase an equivalent quantity of physical gold outright in the open market for every new unit of gold ETF they issue.

Figure 1 illustrates the relationship between the gold price trend and gold ETF holdings since their inception in 2003. The demand derived from gold ETFs increased steadily until 2013 when the trend reversed; this reversal was solely due to the sell-off triggered by the unwinding activities of gold ETF issuers in order to meet investors' redemption.

Demand from the technical sector arises from areas such as biochemical applications and electronic devices. Gold also has pharmaceutical applications, and has been used in medicine and dentistry. However, recent technological advances have enabled gold to be replaced by other materials; hence, usage for industrial purposes has declined in real terms. For example, from 2015 to 2016, the total gold demand from the technology sector decreased from 332 to 322.5 tonnes. Nevertheless, with advances in nanotechnology, more catalytic applications for gold in the healthcare industry will be developed in the future. Because of its catalytic properties, gold is also used in other high technology industries such as the chemical and automobile industries; it could be an alternative material for catalytic converters.

1.1.2 Demand for gold as a financial asset

Gold has emerged from a monetary asset to a financial asset after the demise of the Bretton Woods system in the 1970s. Currently, individual and institutional investors can both participate in the gold market, and the investment demand comprises indirect ownership through ETFs, which offer direct exposure to the gold price, and the direct ownership of coins and bars. Other gold-linked products include paper gold, derivatives, and structured instruments, for which payoffs are associated with the gold price but no gold ownership is required. These different gold products are intended to satisfy diverse investment objectives.

The main drivers of investment demand in gold stem from its properties as a store of value, portfolio diversifier, and safe haven. Gold is a universal denomination of wealth because it features many characteristics of money such as scarcity, storability, durability, homogeneity, and liquidity. Although gold is no longer used as currency in modern economies, these qualities make it a desirable vehicle for store of value and hence a financial asset. Despite fluctuation in the gold price during the past few centuries, gold has always reverted to its historical purchasing power parity for exchangeable products, which indicates that the store of value property enables it to preserve wealth during inflationary periods.

Gold has also emerged as a diversifier or hedge in an investment portfolio. Gold is considered a risky asset on its own as its price is quite volatile. However, because the economic factors that determine the gold price differ from those of

other assets, the returns on gold are independent from other assets such as stock and bonds, which tend to co-move together. This suggests that gold has a negative or weak correlation with other asset classes and can be incorporated into a portfolio for diversification purpose.

The diversification benefit under stressed market conditions is known as the safe haven property, and it is an additional attribute for gold as a financial asset. During the past few decades, financial markets have grown substantially, and so as the variety of financial instruments has increased, along which the connections between markets have also strengthened. The 2008 financial crisis demonstrated the contagious nature of disasters, which had given rise of volatility and correlation among all asset classes; and the subsequent spillover effect of market shocks triggered widespread global turbulence. In general, other asset classes can act as a hedge or diversifier, but they fail to protect against loss in times of extreme market stress. The increased interdependence among markets necessitates holding safe haven assets because investors respond differently under typical and stressed market conditions.

During past crises, the gold market has remained highly liquid because of its breadth and depth, even when other financial markets were under severe liquidity strains. Thus, the safe haven property of gold enhanced the stability and resiliency of portfolios during the financial crisis is therefore evident; the gold price rose from about USD710 in 2008 to about USD1,895 in 2011.

Other factors have also contributed to the evolution of gold as a financial asset. Gold holdings may generate income for investors from the gold loan market even though gold does not pay dividends. However, similar to physical holdings of other tangible assets or commodities, gold is free of default (or counterparty) risk, whereas investors are subject to default risk of issuers when holding debt instruments or equities.

1.1.3 Gold as a reserve asset for central banks

Central banks have several motivations to increase their asset allocations in gold. First, gold is one of the few permissible reserve assets under the investment guidelines of central banks. Second, the size of gold market offers the liquidity for the central banks to liquidate gold holdings at times of crisis when other financial markets face a liquidity drain. Third, the negative correlation between gold and the US dollar makes it an effective US dollar hedge in country reserves; more than 50 per cent of the reserve assets currently held by central banks worldwide are denominated in US dollars. Moreover, gold is a universally accepted asset that people and markets have great confidence in.

Figure 2 illustrates the gold holdings of central banks worldwide. Figure 3 shows gold holdings as a percentage of total reserves worldwide. As gold has emerged as an important reserve constituent in recent years, central banks' attitudes towards gold holdings have also changed, as reflected by their official

sale and purchase activities. For example, from 2004 to 2008, central banks were net gold sellers, selling an average of approximately 400 tonnes per annum. However, since 2011, the central banks have become net buyers, purchasing approximately 400 tonnes of gold per annum. In 2016, central banks acquired 383.6 tonnes of gold.

Major European central banks entered into the first Central Bank Gold Agreement (CBGA) in 1999. At that time, central banks held approximately 33,000 tonnes of gold, equivalent to approximately a quarter of the total mined gold volume, indicating that central banks had considerable influence on the gold market. In the early 1990s, some of the Western European central banks that possessed substantial gold holdings participated in market activities such as lending gold and issuing gold derivative instruments in addition to their on-going gold sale. The gold price was in a prolonged period of drought at that time. The market perceived that such uncoordinated central bank actions were the driving force destabilising the gold price. Therefore, major European central banks signed the CBGA1[3] to regulate the volume of gold that could be disposed of by the signatories. These central banks agreed to limit sales of official gold holdings to 2,000 tonnes in aggregate within the 5-year contract period; the CBGA1 also provided terms to limit central banks' gold derivative activities. The gold holdings of the CBGA1 signatories constituted approximately 45 per cent of

[3] These 15 European central banks included those of the then 11 Eurozone countries, the United Kingdom, Sweden, and Switzerland as well as the ECB.

international gold reserves, and the non-signatories with substantial gold stocks also indicated their intention to sell gold in a similar coordinated manner. Such transparency eliminated the price-pressure uncertainties brought by official sales, and the gold price reacted positively with a spike from USD255 to USD325 per troy ounce in the days following the CBGA1 announcement. Thereafter three further CBGAs (the CBGA2, CBGA3, and CBGA4) were signed in 2004, 2009, and 2014, respectively. The CBGAs have been beneficial to all market participants including gold mining companies, investors, fabricators, consumers, and central banks, as they have enhanced the stability of the gold market. Figure 4 illustrates the CBGA-based sales by central banks since 1999.

In the CBGA2, which was effective from 2004, the signatories reaffirmed that gold would maintain an important status in global reserves; they were limited to selling 2,500 tonnes in total between 2004 and 2009.

Subsequently the CBGA3 was signed in 2009 and covered the period between 2009 and 2014. In the CBGA3, the maximum aggregate of gold that the central banks agreed to sell was capped at 2,000 tonnes during the contract period.

In 2014, the ECB and other central banks announced the CBGA4, which is still currently in force. The signatories indicated that they have no plans to sell significant amounts of gold, reflecting the change in central banks' official gold sale and purchase behaviour.

1.1.4 International monetary conditions

1.1.4.1 Money supply and asset prices

In addition to allocating assets to gold in their country reserves, central banks can affect the gold price through their monetary policy stance. Although the gold standard was abolished many years ago, governments worldwide still maintain gold reserves against money issued; therefore, gold holdings represent an implicit gold standard and are a function of the total money supply.

In general, money supply refers to the total amount of money in circulation in a country's economy, and it can be effectively controlled by the country's government through conventional monetary policies[4]. Money supply has an intertwined and dynamic relationship with gold: central banks could depress the gold price when they sell gold holdings because of an increase in the gold supply in the market; this would simultaneously reduce the money supply by taking the domestic currency from the sale out of circulation, which could further

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[4] Open market operation, discount rate, and reserve requirements are the three monetary tools that central banks use when implementing monetary policy; these tools all affect the money supply.

Adjustments to the discount rate and open market operation are the most commonly used tools under conventional monetary policy. The discount rate is the interest rate at which the commercial banks are charged by the central banks for short-term loans. Such lending by central banks represents a backup liquidity for the market. Central banks that adopt expansionary policies would lower the discount rate, and they would raise the discount rate under contractionary policies. Because changes in the discount rate influence other interest rates in the market, this would influence the cost of lending and consumer spending activities, which would eventually affect the money supply. Open market operation involves buying and selling government securities.

suppress the gold price by reducing the inflation expectation. Conversely, money supply can be increased either by economic growth or through central banks' monetary tools such as cutting interest rates. Therefore, positive relationship may exist between the gold price and money supply in either case; both economic growth and easing monetary tool may result in inflationary pressures because they increase the money supply for extended periods of time. If economic growth is the cause of increases in the money supply, the wealth effect would increase the demand for luxurious consumer goods such as gold jewellery. In another scenario, if expansionary monetary tools were implemented, investors would be prompted to safeguard the value of their investments against inflationary pressures by holding real assets.

During the past 9 years, however, "unconventional monetary policies" have influenced asset prices even more than traditional monetary policies. Central banks employ unconventional monetary policy tools when conventional tools become ineffective. Under slow economic conditions, central banks usually use conventional tools such as daily open market operations, which involve the purchase and sale of short-term government securities[5], to adjust the amount of money in the banking system. Central banks also set the overnight interest rate target[6].

[5] For example, 3-month Treasury bills are a typical short-term government security.

[6] The interest rate for one-day interbank loans.

1.1.4.2 Unconventional monetary policy

In 2009, the overnight US federal funds interest rate target[7] still remained at 0 to 0.25 per cent one year after the outbreak of the global financial crisis. Nominal interest rates were effectively bound to 0 per cent, yet banks had to maintain a safe reserve level to preserve the soundness of the banking system. If interest rates remain near 0 per cent for a period of time, the economy may fall into a liquidity trap; under such conditions, banks have no incentive to issue loans and people have no incentive to make investments, thus restricting economic recovery. The US Fed thus began implementing two unconventional monetary tools—forward guidance[8] and QE. QE is a monetary tool designed to be implemented when the overnight interest rates are close to 0 per cent and involves buying long-term assets[9] from the commercial banks. QE raises the prices of financial assets and suppresses long-term yield; banks receive proceeds in the form of deposits from asset sale. Through such operation, the market long-term interest rates are maintained at a low level and the money supply is simultaneously increased, thus fuelling market liquidity, making it easier and cheaper for businesses to raise capital.

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[7] The Federal Open Market Committee (FOMC) sets the overnight interest rate target.

[8] Forward guidance means the way central banks communicate to the financial institutions and the market about their future actions. With forward guidance, central banks aim to clear out uncertainty and provide transparency to the market and public.

[9] Including 30-year Treasury bonds and other non-government issued securities.

In response to the lingering effects of the global financial crisis, the United States, the United Kingdom, the Eurozone, Japan, China and various other countries have launched QE programmes or similar policies in the past 9 years.

The US Fed has implemented three rounds of QE since November 2008, namely QE1, QE2 and QE3[10]. At the end of QE programme in 2014, the US Fed held approximately USD4.5 trillion of financial assets on its balance sheet, equivalent to injecting the same amount of money supply into the economy. Other central banks proceeded with similar actions; the BOE had purchased approximately GBP375 billion in assets during March 2009 to July 2012, and the ECB bought approximately EUR60 billion in assets during May 2009. To put the numbers into perspective, the US Fed's asset holdings during QE were worth 20 per cent of Gross Domestic Product (GDP) of the United States, whereas the ECB's assets were equivalent to 30 per cent of the total GDP of member countries.

Because of the slow economic recovery in Europe, the ECB has expanded the size of its asset purchase programme, announcing EUR60 billion worth of asset purchases per month from member countries from March 2015; this was later increased to EUR80 billion. The programme was planned to last until

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[10] Before the financial crisis, the US Fed had about USD800 billion of Treasury notes on its balance sheet. It started buying assets in late 2008, and accumulated USD2.1 trillion of assets by June 2010. The US Fed later announced QE2 and bought USD600 billion of government securities in mid 2011. QE3 was announced in the third quarter of 2012, and the US Fed started a USD40 billion monthly bond purchasing program, and later increased the monthly purchase amount to USD80 billion. The US Fed began tapering at end of 2013, and bond buying was ceased in October 2014 after the assets on its balance sheet reached USD4.5 trillion.

September 2016 and reach at least EUR1.1 trillion, and the ECB signalled the programme would continue.

As for Japan, the BOJ expanded its asset purchase programme by JPY5 trillion, reaching a total of JPY55 trillion in October 2011. The BOJ further expanded the programme to JPY70 trillion per year in 2013 and JPY80 trillion per year in 2014. Because of the enormous size of the programme, the money supply was expected to double.

In China, the world's second largest economy, a stimulus package of CNY4 trillion was implemented in 2009, largely financed through the expansion of credit. In the past 2 years, the PBOC has continued to employ quantitative tools such as various kinds of lending facilities and short-term liquidity operations; it added CNY1.9 trillion of liquidity to the financial system in 2014 and 2015 and a further CNY4 trillion in 2016.

Figure 5 displays the international money supply of major economies as well as the gold price.

1.2 History of gold in monetary system

1.2.1 Gold standard: a fixed money supply regime

Gold has played an indispensable role in economic and monetary systems throughout history. It has also been traded over-the-counter on exchanges since the seventeenth century. Since the nineteenth century, gold was the foundation of the gold standard exchange rate mechanism and subsequently the Bretton Woods system. When the Bretton Woods system eventually collapsed in the 1970s, a free-float gold market was formally established after two and a half centuries.

During the gold standard period, central banks had two principle functions in the monetary system. First, the central banks maintained fixed exchange rates by ensuring the convertibility of fiat currency into gold at the fixed parity. Second, the banks facilitated the adjustment of the balance of payments between different countries.

Under the gold standard, countries pegged their currencies to a specified amount of gold. The exchange rates were fixed, because each currency's value was fixed in terms of gold, and most countries set a ratio of gold to total currency issued. Therefore, the amount of fiat money in circulation was limited by the central banks' gold reserves, and international balance of payment differences were settled in gold. In theory, the adjustment of the balance of payments was intended to be self-correcting: a country in deficit would experience an outflow of gold, leading to a decrease in the money supply and a corresponding reduction in

consumer prices. Thus, the competitiveness of the currency in the international market would be enhanced and the balance of payment deficits would eventually be corrected. Countries with a surplus would experience the reverse process.

Although the gold standard was managed according to this principle, in reality the process was more complex. For instance, central banks were able to accelerate the adjustment of the balance of payments through monetary tools such as the discount rate, which in turn would influence the market interest rates.

Between the 1870s and the beginning of World War I in 1914, many countries adopted the gold standard. Originally, only the United Kingdom, Portugal, and Germany used the gold standard. Germany's participation and the opportunity to access London's financial markets attracted other countries to the gold standard. By the start of the twentieth century, almost all countries, except some in Asia and Central America, had adopted the gold standard until the outset of World War I.

During World War I, as countries resorted to expansionary monetary policies to finance the war and rebuilding, the gold standard collapsed. Only the United States remained on the standard at that time. Although many countries intended to implement the gold standard, the economic reality made it infeasible. The lack of new major gold mines was a primary concern, because it meant that there was insufficient gold to underpin the standard. In response, some central banks instituted a "gold exchange standard", whereby the central banks increased the proportion of British pounds and US dollars in their reserves in addition to

acquiring gold stock. On this basis, most countries effectively returned to a temporary gold standard during the 1920s.

In the mid 1920s, various deficit countries experienced an outflow of gold, which weakened people's confidence in the respective currencies, with the United Kingdom being the most notable example. This caused a run on the pound, and the United Kingdom was forced off the gold standard. As the global economy worsened, other countries abandoned the gold standard to pursue inflationary policies in order to devalue their currencies to restore competiveness. Throughout 1933 and 1934, the United States gradually raised the parity to USD35 from the fixed price of USD20.64 per ounce that had been maintained for decades.

From a historical perspective, the gold standard contributed to a long period of price stability, increased capital flows and trade, and eventually enhanced global economic development. However, the gold standard has also been blamed for deepening the deflationary pressures and economic slump during the 1930s due to the central banks' inability to increase the money supply when adhering strictly to the gold standard.

1.2.2 The Bretton Woods: a fixed money supply system with a twist

The international market demanded stability after the interwar period, and the consensus was to establish a more flexible fixed exchange rate system. In

1944, at a conference held in Bretton Woods, the United States, delegates agreed that currencies would be pegged to the US dollar, and the US dollar would be fixed to gold at the parity of USD35 per ounce. Under the Bretton Woods system, capital controls were permitted to provide governments with greater flexibility.

The global economic growth was satisfactory in the early stage of the Bretton Woods system. However, in the 1960s, low but persistent global inflation made the parity of USD35 per ounce too low in relation to the real gold price, and the ongoing trade deficit in United States depleted its gold reserve. However, surplus countries resisted appreciation against the US dollar to achieve the required adjustment in the exchange rate mechanism. Moreover, capital controls were less effective, and investors' loss of confidence in the system caused capital flight and speculation against currencies perceived as weak.

In 1961, to prevent a rise in the gold price, the central banks of eight countries pooled their gold reserves to defend the peg of USD35 per ounce, and this was successful for some time. However, in 1968, a two-tier gold market emerged in which private transactions were conducted in a free-float market, but the international monetary system still used the official parity for international settlements. Moreover, in the meantime, the deficit in the United States worsened and other central banks started to refuse to use the US dollar for settlement. In 1971, the situation had become so untenable that the US government announced it would cease converting the US dollar into gold for other countries, thus ending the Bretton Woods era. Thereafter, gold has been traded freely.

1.3 Structure and operation of the gold market

The gold market comprises paper and physical markets. In the physical gold market, gold bullion is transacted between market agents. By contrast, in the paper gold market, rather than trading physical gold, claims to gold stocks are traded; therefore sellers must be prepared to satisfy claims to deliver gold. These two markets are closely linked and the prices are actively arbitraged; the paper gold price is mostly in line with the physical gold price, which in turn is affected by fundamental changes in supply and demand.

1.3.1 Physical gold market

Gold is not perishable, and, in contrast to other goods, it is not consumed. In fact, analysts believe that most of the gold that has been unearthed still exists in circulation and at least 80 per cent of that can be accounted for. World Gold Council has estimated that the total above ground gold is approximately 187,200 tonnes.

In addition to existing stocks, new gold supply adds more than 4,000 tonnes to the market each year. Mine production usually accounts for approximately two thirds of the supply stock, with the other third coming from recycled gold recovered from fabricated products such as jewellery. Although the official sector has also been a supply source in the past, however, central banks

are currently net buyers and have not contributed to market supply since 2010. Table 2 shows the total production of gold in recent history.

The annual demand for gold has exceeded 4,000 tonnes in recent years. Table 1 shows the historical breakdown of physical gold demand. The main source of demand is the jewellery industry, and through the years it has accounted for approximately half of the total demand. Investment is the second largest component of the demand for gold, accounting for approximately 20 to 30 per cent of total demand from 2008 to 2016. Investment in physical gold is usually made in the form of coins, bars, ETFs, or related products. Gold bullion is the most common form of physically traded gold, but gold coins and jewellery are also frequently traded. Gold bullion refers to gold that is forged into bars and authenticated by a recognized refinery stamp. Gold demand derived from the industrial sector fluctuates with global GDP and the prospects in related industries; it accounted for approximately 7 per cent of gold demand in 2016.

The physical gold market is a type of spot market. The participants in the physical gold market are mainly gold mining companies, refiners, central banks, investors, and fabricators. Forward contracts are frequently used for hedging physical positions.

1.3.2 Paper gold instruments

The main disadvantages of investing in and holding bullion gold are the storage and security costs incurred and the lack of yield from gold holdings. Therefore, many gold investors choose to hold paper gold instruments with which they have the right to claim a specified quantity of gold from the counterparty. In general, the paper gold instruments are transacted for investment, speculation, and hedging purposes without the actual delivery of physical gold. For example, according to the data from COMEX[11], the actual delivery of gold has been approximately one to two per cent of total future contract value in the past. Nevertheless, transactions of paper gold instruments form an integral part of the gold market.

By contrast, default and counterparty risks are the two main disadvantages of paper gold instruments. Investors are exposed to such risks when the counterparties purport these instruments are physical gold when in fact they are not.

There are many forms of paper gold instruments in the market. In a gold futures contract, the seller and buyer undertake to deliver or receive from the other party a specified amount of gold on a specific date for which the contract is defined.

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[11] COMEX is a commodities exchange which facilitates metals trading. It is also a subsidiary of New York Mercantile Exchange.

A gold option is a unilateral contingent contract, which enables the buyer to either sell or buy physical gold at a strike price; the seller is obliged to perform the transaction on demand.

A gold ETF is a financial instrument that aims to track the gold price. Gold ETFs issued by different providers have different structures as stipulated in their prospectuses; they are usually backed by physical gold.

Other types of spot paper gold instruments are also available. Investors may choose to obtain a gold certificate issued by gold dealers or gold brokers instead of taking delivery of physical gold. A gold certificate is equivalent to a title proof of the physical gold being kept in the dealers' vaults. The operation of the gold certificates is similar to that of the bank notes in the early stage of a monetary system; holders of gold certificates can exchange gold on demand or sell the certificates at market price to cash in. Depository orders are paper gold instruments that are similar to gold certificates.

There are other ways investors can purchase gold without safekeeping physical gold themselves through other means. Some large banks offer bullion or gold accumulation accounts, which operate like an ordinary bank account but are denominated in allocated or unallocated gold. Allocated gold represents outright ownership for the investors and is stored in the bullion vault of the bank under a custodian agreement between the two parties. Unallocated gold, however, is not equivalent to a tangible asset for the investors and banks usually use the proceeds received from the transactions for other purposes. Unallocated gold is similar to

the cash deposited into a bank account, and the bank is essentially borrowing money from a depositor to make loans. Holders of unallocated gold accounts would become creditors to the bank if it becomes insolvent, as practically the account holders are assuming counterparty risk rather than safekeeping gold in their accounts. Most banks currently offer unallocated gold accounts marketed as "paper gold" accounts.

1.3.3 Gold market operation

Gold trading transactions are mainly conducted over-the-counter (OTC). Gold is traded globally and trades take place around the clock, supported by different regional gold exchanges in different time zones. In addition to the bullion gold market, futures, options, and swaps are also traded on the gold derivatives market. These activities augment investors' liquidity.

In terms of geographic location, Switzerland has become a main storage centre and the largest entrepôt for new gold. New York is an important physical gold centre with large domestic supply and demand volumes, and it dominates the paper gold instruments market. Hong Kong is the third largest trading market for physical gold, reflecting the growing prominence of the Asian market. The fixing price of the London market is the most representative because it is the most prominent and liquid market. Fixing price ensures an international benchmark that can be used as a reference by market participants. Most markets quote both local

and London prices.

Since the mid 1980s, the London gold market has been supervised by the BOE and the London Bullion Market Association (LBMA). The LBMA was formed in the 1980s and comprises 52 ordinary members who are mostly brokers and banks. The organisation has established guidelines and best practices to support market development, and is also responsible for price fixing. During the price setting process, the chairman of the LBMA attempts to match the positions of the participating dealers. Before the price is fixed, the price is adjusted continuously until all dealers reach an agreement. Because the dealers communicate the net positions of their books during the process, the actual volume of gold transacted at the fixed price cannot be determined. Nevertheless, the breadth of the London market and the fixed price facilitate a liquid environment in which traders around the world can place orders.

The LBMA estimated that physical gold worth an average of approximately USD21 billion was transferred between the accounts per day in 2015. However, because the physical gold market comprises only a fraction of the total gold market and many trades are not captured because they are netted within the bullion banks' own books, this figure is a conservative estimate. For instance, all the daily transactions between two bullion dealers are recorded as one entry in their books. Therefore, the actual trading volume is substantially higher. The LBMA estimates that the daily OTC trading volume is at least USD67 billion.

1.3.4 Historical gold price

Despite the prominent status of gold in the history of monetary systems, a free floating gold market did not emerge until the late 1960s when the two-tier gold market was established. At that time, transactions between central banks were still conducted at the official price of USD35 per ounce, whereas investors and industry practitioners participated in the private free market. In 1971, the United States terminated the official conversion of US dollar to gold, marking the start of a truly free market for gold. The gold price surged to USD43.98 in 1971 and remained volatile and strong due to the shortage of supply and the United States' large trade deficit. The gold price reached a record high of USD127 in 1973 due to the continued depreciation of the US dollar. Between 1973 and 1979, because of events such as an unstable supply stream, gold sales by the official sector, and strong demand from industry, the gold price remained strong and volatile, trading between USD103.5 and USD167.95. Later in 1979, gold reached another record price of USD850 mainly due to political uncertainty in the Middle East.

However, the gold price fell continuously during 1981 and it entered a prolonged period of sideways trading, remaining in the trading range of USD252.8 and USD599.25 from 1982 to 2005. From 1997 to 2003, the gold market was particularly lacklustre: investors were net sellers and gold producers were net dehedgers. The strengthening US dollar, official sector gold sales, and concerns over an economic slowdown were the main causes of the price dampening.

After years of range trading, a notable upward trend began in 2003 with the gold price reaching USD416.25, supported by rising geopolitical risk and strong investment demand caused by the growing concern over the US trade deficit and its likely negative consequences for the US dollar. In the following 2 years, investment demand remained the main driver, and the market prepared for a price hike as investors substantially increased their gold ETF holdings. The gold price rally continued throughout 2006 and 2007, mainly for similar reasons such as the weak US dollar, rising inflation, and growing political concern.

During 2007 and 2008, with the rising turmoil in the credit market and the onset of the global financial crisis, investors flocked to gold for its safe haven property, which caused the price to rise. In 2011, the gold price reached an all-time high of USD1,895. This strong performance was due to investors' continued interest in a safe haven, growing inflation expectations caused by the QE programme in the United States, the deteriorating outlook of the US dollar resulting from rising national debt, and a change in the reserve management approaches of central banks as developed countries slowed gold sales and developing countries accumulated gold.

In 2013 and 2014, the upward trend of the gold price reversed when the United States announced the tapering of its bond-buying programme. The gold price fell sharply during 2013 because of market expectation that the tapering would continue as the economy improved. The gold price eventually stabilised in the first half of 2014, as the market factored in the US Fed's actions, and gold traded between USD1,200 and USD1,450 for most of this period. However, in

the second half of 2015, the strong US dollar and an expected rise in interest rates, resulting from economic recovery in the US, caused a heavy sell-off of all commodities. The gold price had dropped below the USD1,100 level by the end of 2015. Nevertheless, in 2016, the QE programmes implemented by central banks worldwide lifted asset prices. Figure 6 shows the gold price history from 1968 to 2016.

1.4 Management implications of understanding the economics of the gold price

1.4.1 Implications for industry practitioners

Most corporations nowadays employ techniques to hedge their exposure to foreign exchange rates, interest rates, and commodity prices. For firms in the jewellery sector and the gold mining industry, hedging exposure to the gold price is crucial for many aspects of their operations. Empirical studies have shown that the operation and business of gold mining firms are affected by movements in the gold price.

As for the valuation of the gold mining firms, it is mostly dependent on the value of their mines, which in turn is solely determined by the gold price. The gold price also is the key determinant for operational decisions. For instance, if the gold price is low relative to the extraction cost, the companies can either hedge the gold price or scale back their operation to reduce capital expenditure

and overheads. However, because of the capital-intensive and inelastic nature of gold mining, any change in operations or expansion plans requires complex and deliberate long-term planning.

Furthermore, the gold mining industry is a prominent sector, in 2016 it contributes approximately USD171.6 billion to the world economy. Other non-mining firms, especially those involved in the use, supply, or production of gold, are indirectly influenced by gold price trends through the economic activities of mining companies. Therefore, gold price trends have substantial managerial implications for such firms.

Gold mining companies usually hedge the gold price by selling gold at a predetermined price to lock-in profit with forward contracts. In theory, regardless of the future gold price, a company can guarantee its future revenue with a hedge arrangement to protect itself from potential declines in the gold price. Similarly, if gold mining companies anticipate a rise in the gold price, they either unwind the hedging position or decide not to hedge to take advantage of the potential price rise. The wide variety of gold hedging tools available in the market enables gold mining firms to customize their gold price exposure. For example, American Barrick Resources Corporation employs a combination of bullion loans, forward contracts, spot deferred contracts, gold options, gold warrants, and tailored gold-linked equity financings.

Whether to hedge, and to what extent or at what gold price the company should hedge against its exposure, are crucial managerial decisions for such firms.

Managers adjust their hedging positions according to changes in the gold price and the conditions of the gold market. Many corporate executives consider the market view on the gold price as an integral part of a hedging programme. A poor hedging strategy could threaten a mining firm's survival if a gold price unfavourable to the company's position persists for a period of time.

1.4.2 Implications for the finance industry

Although gold has often been considered as a stabilising control in a portfolio, recent empirical evidence has demonstrated that the prices of many assets move in tandem during recent crises due to the increased connectedness between various asset markets and geographic locations. Because gold has now emerged as a financial asset, the diversification and hedging functions of gold in a portfolio are undermined during times of turbulence. Therefore, it does matter to all asset management industry practitioners and investors as to whether gold is still an appealing option to provide safe haven benefit in enhancing the stability and resiliency of the portfolios at times when it is needed most.

1.4.3 Implications for governments and central banks

Government policy perspective

The relationships between exchange rate policy, monetary policy, and foreign exchange reserves are dynamic and complex. The foreign exchange reserve (or country reserve) is a portfolio consisted of high quality investments held by the central bank of a country that is intended for meeting various obligations such as domestic currency issued and international payments. Hence, the foreign exchange reserve can be viewed as an international investment position and 'savings' of a country. Yet, the domestic currency issued is the largest liability of a country; in other words, the main purpose of the foreign exchange reserve is to support the value of the domestic currencies.

The classic exchange market and monetary systems were tied to the gold price. Under the gold standard, countries pegged their currencies to a specific amount of gold. Therefore, gold was the sole constituent of foreign exchange reserves, and the international payments were settled using gold. Under such arrangements, currency exchange rates between countries were fixed, and the broad money supply was limited by the size of the gold holdings in a country's foreign exchange reserves. During the Bretton Woods era, foreign exchange reserves consisted predominantly of US dollar holdings, which functioned as a reserve currency. Current foreign exchange reserves typically include gold, bonds, foreign currencies, special drawing rights, and IMF reserve positions. Gold remains an indispensable asset for foreign exchange reserves in many economies.

For example, gold constitutes 74 and 68 per cent of the reserves of the United States and Germany, respectively.

Following the dismantling of the Bretton Woods system, most countries have accumulated sizable reserves. Governments have several motivations for doing so. First, during periods of high volatility, the foreign exchange reserve can be used to intervene in the currency market and stabilise the exchange rate of a domestic currency by buying the domestic currency and selling foreign currencies from the reserves in the open market. Hence, a country without an adequate foreign exchange reserve to defend the value of a weak currency, a financial crisis or currency devaluation is inevitable.

Additionally, the state of a country's reserves represents its ability to deal with unforeseen international capital movements, counter unexpected market shocks, and meet external obligations. To assess the financial soundness and strength of a country's domestic currency, ratios relating to its foreign exchange reserve are frequently used by the market as indicators that signal vulnerability. For example, foreign exchange reserve as a percentage of broad money supply is a commonly used measurement. A strong foreign exchange reserve increases the credibility of a country and bolsters the confidence of international investors and creditors.

In summary, the state of a country's reserves can affect its macroeconomic environment in two ways. First, the strength of the domestic currency depends on the people's confidence in the ability of the reserve's capability in backing the

currency. Second, foreign exchange interventions involve buying and selling domestic currency, which can directly affect monetary policy by altering of amount of domestic money in circulation.

Because gold constitutes a substantial portion of foreign exchange reserves, its price movement affects the values and states of the reserves. Thus, the economics of the gold price is relevant to the government officials responsible for determining monetary and foreign exchange policies.

Central bank reserve managers' perspective

Strategic asset allocation of ordinary portfolio usually defines the proportion of assets weighting solely for risk-adjusted returns maximization. In practice, the asset allocation of the reserves differs substantially from this. In addition to meeting the central banks' objectives, reserve managers must accommodate constraints imposed by the investment guidelines of the reserves and yet consider the tactical position of their central banks.

For foreign exchange reserves, risk management and market liquidity take precedence over returns; hence, reserve managers' attitudes towards different monetary and interest rate environments differs somewhat from that of investors fundamentally, and their decisions are further complicated by liquidity requirements because of the size of the reserves. Therefore, reserve assets must be readily sold when markets are stressed. Many financial markets simultaneously

face acute liquidity strains in times of crisis. The gold market has remained highly liquid in many crises due to its breadth and depth, even when other asset markets experience liquidity strains. Therefore, the investment guidelines of central banks often restrict asset allocation to several key assets, such as major currencies or sovereign debt; gold is one of the few permissible assets for foreign exchange reserves. Thus, the economics of the gold price has implications for reserve managers from the perspective of asset management.

1.5 Research objectives

This thesis examines the driving factors of the returns on gold and sheds light on the dynamic relationships between the gold price, monetary stance, and macroeconomic and financial variables. In addition, the thesis explores the time-varying nature of the composition of gold price determinants under different economic conditions.

Understanding the economics of the gold price has managerial implications for industry practitioners and reserve managers. Gold is an indispensable strategic asset in country reserves, and the gold price is a critical determinant of hedging strategies for mining firms and jewellers. O'Connor, Lucey, and Baur (2016) revealed that mining companies that make false forecasts of future gold price trends incur higher production costs.

Many empirical studies have examined the driving factors of the gold price, but they have generated mixed results. This divergence may indicate that these studies have omitted some critical determinants or that they were narrowly focused on certain geographical areas.

The implementation of unconventional monetary policies in major economies worldwide has changed the context of the gold market; similarly, the role of international demand for gold has structurally changed the demand fundamentals, but it has received the attention of few studies. Therefore, recent changes in international monetary stance warrant an empirical examination of the gold price. This thesis approaches the issues from two distinct but intertwined angles, namely gold's role in the international monetary system and its status as a financial asset. In this study, the influence of international market demand is investigated by studying the international money supply.

The remainder of this study is organised as follows: Chapter 2 reviews selected literature that have examined the relationship of the returns on gold with macroeconomic and financial variables as well as some relevant literature on the international monetary conditions; Chapter 3 describes the data and methodology employed; Chapter 4 presents empirical findings and analysis; and Chapter 5 presents conclusions.

CHAPTER 2: LITERATURE REVIEW

The renunciation of the Gold Standard and Bretton Woods system has not undermined the economic importance of the metal. There are a number of driving factors for gold value: the interplay between its physical demand and its significance as a financial asset. The following survey of literature focuses on how the interaction between these forces affect gold price.

The first segment of the review concentrates on researches that study the relationship between returns of gold and a number of macroeconomic variables such as interest rates, inflation rate, exchange rates and money supply. The second segment focuses on the role of gold in the market as a financial asset. The third segment of the literature reveals the relationship between the international monetary stance, unconventional monetary policy and asset prices. Table 20 contains a survey of literature summary.

2.1 Gold and money supply

Money supply may affect the gold price positively while impacts are channeled through either economic growth or easing monetary conditions. For case of economic growth, higher income would lead to higher demand for luxurious consumer goods, while in the latter case, investors would be prompted

to safeguard their wealth against inflationary pressures brought by the excess liquidity in the financial system by increasing holding of real assets.

Sherman (1982) examines the relationship between the returns of gold, and industrial demand and gross domestic demand, and finds that the demand for gold from the commercial sector is related to both the total real incomes of industrialized countries and the real price of gold. The inflation and inflationary expectations tend to cause the gold price movements, and effects of which are channeled through monetary aggregates growth rates.

Kitchen (1996) studies the effects of announced revisions of Federal deficit projections on financial variables in the United States and international markets between 1981 and 1994. The results show that the gold price reacts positively to the announcement of revised deficit projections, which the authors interpret as being due to increases in real interest rates and hence the inflation risk premium which was resulted from higher projected deficits.

Laurent (1994) examines empirically whether gold should play a more prominent role in monetary policy. He uses the data between January 1972 and November 1993 and finds that gold price is positively related to general price levels in the long term but not in the short term. Such finding means that gold prices are not highly sensitive to small changes in the inflation rate, and the author suggests that the complex nature of deciding whether to use gold or fiat money as store of value may be the reason for such price movement. The author argues that even the fiat money can be converted to gold with the reintroduction of gold

standard, long term stability in the purchasing power of money still cannot be attained, and there is better money system than gold standard.

Tandon and Urich (1987) empirically examine the impacts of macroeconomic news announcements by seven major industrial countries on gold price changes. Using data between 1977 and 1982, they find that the announcement of unanticipated money supply changes leads to significant positive impact on Eurodollar interest rates, and the gold price will rise if the increase in interest rates is resulted from inflationary expectations.

Bailey (1988) studies the effects of releases of money supply data on the volatility of asset prices by examining the relationship between unanticipated money supply news and the ex-ante volatility in the prices of different assets, including gold, using data over the sample period from 1982 to 1985. He finds that the gold price volatility rises with the unexpected growth of the money supply.

Hammoudeh, Yuan, McAleer and Thompson (2010) use dataset between 1999 and 2007 to examine the conditional volatility of gold market and find that monetary policy changes have a long term effect on volatility of gold price.

Batten, Ciner, and Lucey (2010) investigate the key macroeconomic variables that have an influence on the precious metals market volatility using time series data over the sample period from 1986 to 2006. The authors posit that the returns of precious metals are correlated to a set of macroeconomic determinants that account for the impacts of the monetary environment, financial

market and sentiment of business cycle. Specifically, the authors find that monetary variables such as Consumer Price Index (CPI) of the United States and money supply are consistently related to the price returns of gold, but not to other precious metals. They argue that gold price is sensitive to the actions of central banks is largely due to gold's status as a surrogate currency.

Sipkova and Sipko (2014) examine the drivers of gold price using monthly data over the period from August 1971 to August 2013. The sample includes data of gold mining stocks, COMEX futures, S&P Depository Receipts Gold shares ETF and macroeconomic variables, and the time horizon for each regression is constructed based on business cycles. The authors note that the US dollar exchange rate is the key driver in the past, however, their results reveal that at present the factors driving the gold prices are expected inflation, money supply expectations and investor speculation.

2.2 Gold and inflation

Inflation has all along been the focus of gold related academic research, which usually coexists with money supply. Many studies focus on how the positive correlation between gold price and inflation rate has evolved around the metal's store of value attribute.

Moore (1990) uses a range of inflation signals based on a leading inflation index and examines their relationships with the gold prices on the New York market since 1970. He finds that if investors followed these signals in trading gold, they would have earned an average return of about 18 per cent per annum between 1970 and 1988.

Fortune (1988) explains explicitly how inflation directly affects gold price in respect of maintaining purchasing power. He uses quarterly data over the period from third quarter of 1973 to second quarter of 1980 to test his model. Fortune argues that gold price should be positively related to expected future price level and finds evidences that are consistent with the model's prediction. He explains that savers try to preserve their purchasing power by converting cash into gold when inflation is eminent. Conversely, higher expected interest rate induces investors to convert gold to cash as they expect to earn higher future return, and leads to declining gold price.

Ghosh, Levin, Macmillan and Wright (2004) devise a theoretical model to explain the relationship between the inflation rate and gold price, using data over a sample period from 1976 to 1999. The results suggest that over time substantial short-term gold price movements are in line with the rising general inflation rate, and that gold can act as a hedge against long term inflation.

Another study also by Levin and Wright (2006) approaches the topic from another angle. The authors use cointegration techniques to analyze data over the sample period from January 1976 to August 2005. The empirical results show

that the inflation of the United States is the sole determinant of the gold price, but short run effects may at times cause deviations from long run relationship due to factors such as short-term variations in the credit risk, inflation volatility, US dollar exchange rate, and the gold lease rate. They find that a one per cent increase in general price levels in the United States corresponds to a one per cent increase in the gold price in the longer term. Both studies implicitly imply a causal relationship that inflation leads to higher production cost and further leads to higher gold price, by assuming that inflation is the driver of gold extraction costs and the gold price will rise to compensate mining companies in the long run.

Worthington and Pahlavani (2007) investigate whether there exists a long term relationship between the gold price and inflation between 1945 and 2006 in the United States. The authors employ modified cointegration approach which allows for structural breaks as both the CPI and gold market have been subject to structural change over time. Their findings show that a cointegrating relationship exists between inflation rate and returns of gold during the periods in the post second world war and the 1970s.

As there is a view about inflation expectations leading the gold price, there exists a group of research on the guiding role of gold in monetary policy. Commodity prices are generally regarded as more sensitive to new information as compared to consumer prices. The study by Mahdavi and Zhou (1997) examines the relationship between inflation and returns of the yellow metal from another angle; the authors show that the predictive performance of prices of gold and other commodities in forecasting CPI. Using quarterly data for the period from

1958 to 1994, they show that utilizing the error-correction model, coupled with the commodities price index being the dependent variable outperformed significantly than those using the prices of gold. As the predictive capability of the gold prices as inflation indicator is not statistically significant, this indicates that gold prices should not be considered as a leading guide of monetary policy. Yet it is consistent with the premise that gold prices are too volatile to forecast inflation rates which tend to move in a gradual fashion. The results also reveal that the link between inflation rates and prices of gold or commodities diminish over time.

The finding by Davis (2012) is consistent with the time-dependent proposition on the relationship between gold price and inflation by Mahdavi et al. (1997) above. Davis uses data between 1965 and 2007 of different countries to calculate the impulse response of core inflation with vector autoregressive model (VAR). The results indicate that, a transitory price shock in commodity prices would lead to a significant rise in core inflation in early periods, but the effect would diminish in later periods.

The studies above mainly focus on the gold price in US dollar term and inflation in the United States, in spite of the fact that gold is regarded as a currency without country boundary. In past two decades a number of studies have emerged, focusing on the relationship of gold price and world inflation. Sjaastad and Scacciavillani (1996) investigate the relationship between gold price and world inflation, and find that gold is a store of value as higher inflation increases the demand for gold. They use the data between 1982 and 1990 and estimate that

two thirds to three quarters of one per cent rise in the real price of gold corresponds to a one point rise in the inflation rate.

Harmston (1998) investigates the relationship between gold price and world inflation from the perspective of historical purchasing power and finds that the value of gold between 1896 and 1996 is in line with real purchasing power in the very long term in the United States, United Kingdom, Japan, Germany and France. Regardless of the price level, gold consistently reverts to its historical purchasing power parity. The author further concludes that as the real returns on gold do not have a positive relationship with other assets, gold could act as a diversifier in a portfolio.

Wang, Lee and Nguyen Thi (2013) examine the price adjustment process of gold and its usefulness as inflation hedge in the United States and Japan, by employing non-linear threshold regression model and the linear and non-linear cointegration tests. The authors use data of CPI and gold prices in the JPY and USD monthly frequency during the period from January 1971 to October 2006, they find that when gold price adjustment is in low-momentum regime it is not an effective hedge against inflation in both countries in the short run; whereas in the high-momentum regime gold return is a partial hedge against inflation in Japan but a full hedge for the United States. This finding indicates that the price adjustment process between the US CPI and the gold price is not as rigid.

Beckmann and Czudaj (2013) expand the number of countries studied, using data between 1969 and 2011 from Japan and the United States again, and

additionally the United Kingdom and Euro Area. The authors use both Producer Price Index (PPI) and CPI as measures of inflation and employ Markov switching approach to allow for nonlinearity. Their findings are threefold: first, as a cointegration relationship prevails over the lone run, gold is a partial hedge to inflation and the effect is more prominent for the United States and United Kingdom than that of Japan and the Euro Area. Second, gold's ability to hedge inflation depends on time horizon and it is a better hedge during market turbulence.

Tkacz (2007) uses data of 14 countries between 1994 and 2005, and finds that the gold price is a leading indicator of inflation in a number of countries for up to two years in advance. The statistically significant relationship is most prominent for the Organization for Economic Co-operation and Development (OECD) countries, which have stipulated inflation targets. The author conjectures that a set inflation target helps formulate expectations of inflation and therefore asset prices may be a reliable indicator of future price levels.

Nonetheless the results of the above studies, which focus on the positive association between the inflation rate and the gold price, are not clear cut and definitive, as they vary depending on the sample periods and countries being studied. A number of studies present competing views on inflation hedge property of gold. For example, Lawrence (2003) uses quarterly data over the sample period between 1979 and 2001 and finds that the correlations between the changes in macroeconomic variables such as GDP and inflation and the gold price are not statistically significant. Similarly, Garner (1995) only finds limited empirical

support for the assertion that gold is one of the leading inflation indicators, using data over the sample period between 1970 and 1995. Specifically, the author suggests that the gold price is only useful as a signal or confirmation that inflation is at a turning point and the rising gold price may only reflect the higher inflation expectations in certain geographic areas. In the same vein, Cecchetti, Chu and Steindel (2000) observe that the gold price alone cannot improve the autoregressive projection, which spans over the sample period from 1975 to 1996, meaning that it cannot forecast inflation independently, and conclude that the combined use of different leading indicators may be necessary for a more reliable inflation measure.

2.3 Gold and interest rates

Interest rate, money supply and inflation rate are the three intertwined variables that coexist in a lot of gold related literature. When there is an increase in money supply, interest rate, being the price of money, will fall due to rising supply. A number of literatures investigate the impact of inflation and interest rate together, as nominal interest rate is the summation of inflation rate and real interest rate.

Using the gold futures intraday data over the sample period from January 1994 to December 1997, Cai, Cheung and Wong (2001) examine the surprises in interest rates changes and their effects on gold prices. The authors find that the

change of absolute return during the sample period is caused by an unexpected rise in interest rates in Europe in 1997.

Diba and Grossman (1984) use daily data from 1975 to 1983 and their empirical analysis shows that there is a close relationship between gold price and real interest rates, and that interest rates corresponds to the fundamental value of gold price as an opportunity cost.

However, not all studies find such definitive relationship exists. Lawrence (2003) finds that there is no statistically significant relationship between the US certificate of deposit rates and gold price, using quarterly data over the sample period between 1979 and 2001. Tully and Lucey (2007) use data over the 1984 to 2003 period and find that the relationship between interest rates or inflation in the United States and gold price is statistically insignificant.

Baur (2011) uses data of monthly frequency for the period from 1979 to 2010, and finds gold price reacts positively with lower short term interest rates and higher long term interest rates. This contrast implies that short term interest rates represent an opportunity cost to investors while long term interest rates reflect higher expected inflation and each of these encourages investment in gold. This is analogous to the finding by Fortune (1987). Fortune examines quarterly data between 1973 and 1980, and finds negative relationship between US government bond yields and gold price.

Batten, Ciner and Lucey (2014) further extend this issue and investigate the time-varying nature of gold as a hedge against inflation rate using causality test and shows that the predictive power of both short term and long term interest rates on gold's CPI beta are statistically significant, and when interest rates are at low levels they become less important and inflation rates' importance rise.

Erb and Harvey (2013) find the long term inverse relationship between the real interest rate and the real price of gold, specifically they find that between 1997 and 2012 the correlation was −0.82 between the real gold price and the real yield of the Treasury Inflation Protected Security (TIPS). Although the empirical results confirm the causal relationship of these two variables, yet the authors find the negative relationship is compelling, but they argue that the negative correlation may be driven by the large negative macro events such as hyperinflation.

2.4 Gold and currency exchange rates

The relationship between gold price and US dollar exchange rate is another heavily researched area. Many previous studies in the literature find that US dollar exchange rate is one of the primary drivers of the gold price. Although gold constitutes a share in commodity indices and is traded by commodity traders, however, it is traded in the market along with other major currencies and its traits resemble to currencies in many aspects. In fact, Bank for International Settlement

(BIS) recommended that for risk management purposes, bank should manage their gold position in a manner similar to that of a currency rather than a commodity, as the price volatility of gold is in tandem with those of currencies.

Johnson and Soenen (1997) investigate whether gold is a feasible investment alternative to foreign investors by taking the standpoint of local investors in major developed countries such as the United States, Germany, Japan, Switzerland, Canada, France, and the United Kingdom, while limiting the investment alternatives to domestic bonds and stocks in the respective countries over the sample period from 1978 to 1995. The results indicate that gold is a good investment alternative for investors in France, Germany, Japan, Switzerland, and the United Kingdom between 1978 and 1983, but not for other periods. For investors in Canada and the United States, gold does not emerge as an attractive asset choice. This finding is in contrast to some assertions that gold is a good diversifier in a well-diversified portfolio, and that the main cause of a poor risk-return profile is a weakening gold price and US dollar exchange rate. The authors conclude that whether gold is a viable investment alternative is time-dependent.

Capie, Mills and Wood (2005) investigate the effectiveness of gold as a hedge against exchange rate fluctuations by assessing the gold price data and the GBP and the JPY exchange rates for the past thirty years. They find a negative relationship between the gold price and the two pairs of exchange rates, but the degree of significance is unstable over the sample period. As such, although gold can serve as a diversifier against exchange rate risk, in the past it has only done so to a certain extent during periods of political turbulence. Capie et al. propose two

reasons for the instability of gold as a US dollar hedge. First, investors may expect an exchange rate fluctuation to be only temporary and choose to ride out of the cycle instead of rearranging their portfolio. Second, the gold mining countries' local problems and the attitudes of various central banks toward gold cause variations in the gold supply.

Tully and Lucey (2007) use the asymmetric power generalized autoregressive conditional heteroskedasticity model (APGARCH). They examine the gold prices in both the cash and futures markets, and their relationships with economic variables over the sample period from 1983 to 2003, with emphasis on 1987 and 2001 when crises occurred. The authors find that over the long period, the US dollar exchange rate is the sole macroeconomic variable that affects the gold price.

Sari, Hammoudeh, and Soytas (2011) obtain similar findings in their study. They test the information transmission and the correlation between the gold spot prices and EUR exchange rate, using daily time series modeled in natural logarithms for the period between 1999 and 2007.

On the contrary, Sjaastad and Scacciavillani (1996) examine data between 1982 and 1990 and find that in the post Bretton Woods era, the floating exchange rates among the major currencies cause instability in the gold price. In fact, the fluctuations of the European currencies have a significant effect on the gold price, while the US dollar's influence is smaller.

Hammoudeh, Sari and Ewing (2009) investigate the co-movement of oil, gold, silver and copper, and explore the causal relationships between these commodities and a number of financial variables, including interest rates and exchange rates, to understand the predictive ability of the prices of these commodities in relation to the financial variables. The empirical results indicate that an increase in the gold price causes a weaker US dollar, as liquidity flows to the safe precious metal; whereas a rise in interest rates leads to a stronger US dollar, as investors seek higher returns. They also find that the gold price, among the four commodity prices under investigation, is the strongest leading indicator measured in terms of estimated effect. This implies that investors and policy makers should take the gold price into consideration when formulating their investment decisions as it sheds light on the future direction of the US dollar exchange rate.

Wang and Lee (2011) test the causality relationship between gold price and the JPY exchange rate for the period from 1986 to 2007 using a threshold vector autoregressive model (TVAR). They find that the JPY and gold price have a significant negative relationship when the depreciation rate of JPY breaches a threshold level of 2.62%.

Other papers offer competing views on the relationship between US dollar exchange rate and gold price. Pukthuanthong and Roll (2011) investigate empirically whether the negative relationship between gold price and US dollar exchange rate is merely a statistical one, by using data of gold price and exchange rates between the USD, EUR, JPY, and GBP over period from January 1971 to

December 2009, and find that when a particular currency is depreciating, positive gold returns measured in that currency are evident.

Similarly, O'Connor and Lucey (2012) present an alternative idea, they highlight that in fact gold has a negative relationship to the trade weighted value of the US dollar as it is an exchange rate that measures movements in the bi-lateral value of the US dollar against currencies of the trading partners. Using the data between 1975 and 2012, the authors find negative correlation between the returns of the trade weighted value of a currency and gold price expressed in the same currency.

2.5 Gold as a hedge or portfolio diversifier

One of the heavily researched areas in the gold related literature is its usefulness in portfolio diversification, and this yields a group of research on the relationship of gold price and other asset classes. Drawing on the differences between the fundamentals of gold and other financial assets or commodities, these studies explore the relationships between the gold price and other asset classes using different drivers, and further investigate gold's diversification role in a portfolio.

Chua, Sick and Woodward (1990) use data between 1971 and 1988, and find that the correlation between the S&P 500 and gold stocks rises during the

period, and question whether the diversification effect can be achieved in a stock portfolio with gold stocks. However, the authors agree that adding gold bullion to a portfolio can serve the purpose of diversification.

Jaffe (1989) examines four hypothetical portfolios with varying degrees of risk using daily data over the period between 1971 and 1987, he suggests that the risk and return profile improves when gold stock is added to the diversified portfolios.

A recent work by Emmrich and McGroarty (2013) extends on Jaffe's (1989) study using data of monthly frequency over the period between 1981 and 2011. The authors examine gold's role as a diversifying asset, and reiterate the finding by Jaffe (1989) that including gold in portfolios reduces portfolio volatility in the sample period, yet 10 per cent of gold allocation is the most ideal strategy. Specifically, they find the case for gold investment is strong after the financial crisis in 2007 and attribute this to higher inflation expectations.

Hillier, Draper and Faff (2006) investigate the role of precious metals in portfolios from 1976 to 2004. They find that all gold, platinum and silver have low correlation with equities and suggest that adding precious metals in a portfolio may provide diversification benefits due to their hedging capability, especially in times of high stock market volatility.

Lawrence (2003) uses the S&P500, Dow Jones Industrial indexes and 10-Year US government bond yields to investigate the correlation between different

asset classes, using quarterly data from 1975 to 2001. The results show that the gold price is not correlated with the financial indices. The author attributes this to the properties of gold that immunize it from the fluctuations caused by business or economic cycles.

A study by McCown and Zimmerman (2006) examines the investment performance of gold with traditional asset pricing models using data of MSCI World stock index and returns of gold over the sample period between 1970 and 2003. They find that the addition of gold to a portfolio does not increase the systemic risk and that the beta estimated by the capital asset pricing model is statistically indifferent from zero; moreover, the returns of gold and stock are not correlated.

Miyazaki and Hamori (2013) examine the long-run relationship between returns of gold and financial variables including the short term interest rates, the US dollar exchange rates and the stock market; data of daily frequency during the period from January 1990 to May 2013 is used in the study. The findings imply that gold is emerging as a financial asset, as illustrated by the increase in the estimation of coefficients between the gold price and other financial variables in later years. Nonetheless, it also implies that the diversification effect of gold may diminish as a result of increased correlations between gold and other assets.

Ciner (2001) investigates the relationship between the silver prices and gold futures contracts between 1992 and 1998, and the findings contradict the widely established view that there exists a stable relationship between the prices

of these two precious metals. The author further explains that these two financial assets should be regarded as two distinct markets and, therefore, should not be used as substitutes in hedging portfolio risk.

2.6 Gold as a safe haven

Apart from the literature on gold's returns and its diversification effects in a portfolio, a more recent body of research has examined the relationship between the gold price and the asset markets during crisis periods. An asset may be an effective hedge on average but fails to provide protection to the portfolio in times of market turbulence. Previous literature in this area focuses on the impact of political tensions on the gold prices. Both Koutsoyiannis (1983) and Abken (1980) include "political uncertainty" in their studies but find that it does not provide explanatory power, and economic factors appear to be sufficient to explain gold prices movement; Koutsoyiannis uses time series data of daily frequency during the sample period between January 1980 and March 1981 whereas Abken conducts empirical analysis with data between 1975 and 1980.

In contrast, Melvin and Sultan (1990) examine the gold prices risk premium with GARCH framework using the data over the period from 1975 to 1988, the results reveal that the political unrest in South Africa at the time has a significant effect on gold prices.

More recent works on safeguarding wealth, instead of concentrating on geopolitical risk, emphasize on gold's relationship with other assets in times of distressed market conditions, and this idea has received increasing attention in the past decade. Baur and Lucey (2010) provide formally the conditions of what constitute a safe haven. Unlike previous work that focuses on political tension, the authors define an asset being a safe haven if it can protect wealth from financial market turmoil. The study also investigates the insurance property of gold with respect to equities and bonds in three developed countries, namely Germany, the United Kingdom and the United States, using the daily closing prices of MSCI bond and stock indices, and spot gold prices between 1995 and 2005. The authors test the safe haven attribute in times of extreme shocks, in which gold returns are regressed on bond returns and stock returns. The results reveal that gold serves as a safe haven in each of these countries, although this depends on the varying degrees of quartile. Moreover, they find that there is co-movement between bonds and gold when bond prices fall. Specifically, they find that gold is an effective safe haven for equities only after extreme market meltdowns, and the safe haven effect is very short-lived.

Baur and McDermott (2010) extend the above study by examining the role of gold in a more global context and test whether gold is a safe haven against the stock market in different countries using econometric analysis covering the period between 1979 and 2009. The results indicate that gold can be both hedge and safe haven for the United States and major stock markets in Europe, but not other countries. The results also support the assertion that gold is a stabilizing element

among different financial markets by limiting the losses during periods of extreme market turbulence.

Basing on the definitions and methodology by Baur and Lucey (2010), Hood and Malik (2013) evaluate whether gold is a safe haven against the US stocks, using daily data between 1995 and 2010, a sample period much shorter than that of Baur and Lucey (2010). The results reveal that gold serves as a hedge and weak form of safe haven to stocks and there is no negative relationship between the two asset classes when the market is of extreme low or high volatility.

Positive skewness is necessary for an asset to become a safe haven. Lucey, Poti and Tully (2006), in addition to assessing the negative correlation between gold and other assets, examine the asymmetric distribution of gold's returns over the period from 1988 to 2003, with data analyzed on a weekly, monthly and quarterly basis. While explicitly considering the positive skewness of the curve that provides downside risk protection for a well-diversified portfolio, the authors examine the optimal asset allocation for portfolios and conclude that gold bullion has an important role in the composition.

Diebold and Yilmaz (2009) examine the correlation between asset returns and volatilities by investigating the interdependence of 19 global markets between 1992 and 2007 using a measure that is referred to as the spillover index, and find that the interdependence of the markets is time-varying. Specifically, they find empirical evidence indicating a trend toward a greater integration of financial markets.

Lucey and Li (2015) examine the safe haven property of gold over the period from January 1989 to July 2013 using data of daily frequency. They demonstrate the instability of gold's safe haven nature, and the results indicate that other precious metals serve as safe haven during some periods when gold does not. The authors also find that gold is not the strongest safe haven at times.

Choudhry, Hassan and Shabi (2015) examine the correlation between the returns of gold and the returns and volatility of stock market during the global financial crisis in 2008, using the data of stock indices FTSE 100, S&P 500, Nikkei 225 and gold returns for the period between January 2000 and March 2014. The results indicate that there is bidirectional interdependence between gold price, stock market returns and volatility during financial crisis, and gold may not function well as safe haven under such circumstance. Instead, gold performs well as a hedge to stocks under stable market conditions.

Cohen and Qadan (2010) study the relationship between Volatility Index (VIX) and returns of gold, using the data between 2004 and June 2009. They find that in times of market turbulence such as crisis in 2008, VIX is positively affected by gold return of previous day, indicating gold prices lead the VIX. The authors also find that there is a significant bi-directional causality during low volatility periods when the capital market exhibits stable or rising price trend. These findings imply that gold is a substitute investment in market of high uncertainty.

Coudert and Raymond (2011) examine the effectiveness of gold as a safe haven and/or hedge to stocks in France, Germany, the United States, the United Kingdom and the G7, with monthly data that runs from February 1978 to January 2009. The findings indicate that in most cases gold is a hedge and a weak safe haven during crises, and the authors conclude that gold should be used for diversification purpose especially in bear markets.

Tuysuz (2013) examines the conditional correlation between the returns of gold and other asset classes including S&P 500, high-yield bond, investment grade bond and crude oil. The results show that gold prices had gone up due to "flight to quality" in bear markets characterized by credit crunch, worries of recession and higher expected inflation. Therefore gold was a weak safe haven during stock market bubble burst in 2000 and a strong safe haven during the global financial crisis in 2008, but not during the Russian the Asian financial crises.

Baur and Glover (2012a) argue that the rising trend of gold's usage in hedging and speculative purposes in recent years has changed its safe haven property. The authors examine the time series data of gold prices and MSCI stock index over the period from January 1970 to August 2012, and argue that the effectiveness of a safe haven asset will be undermined if it has become an investment asset, as in the case of subprime crisis in 2008 when the safe haven effect of gold diminishes significantly.

2.7 Demand and supply for physical gold

One demand driver of gold that has only received little coverage in previous empirical studies is the role of physical gold, and research on demand from emerging markets is particularly lacking.

Batchelor and Gulley (1995) examine the relationship between gold price and jewelry demand in a number of developed economies including the United States, Italy, France, Germany, Japan and the United Kingdom. The price elasticity of demand for gold jewelry varies amongst these countries but in general lies between -0.5 to -1.0, with an average of −0.64; and usually it takes full effect in one year. As it is close to absolute 1, it implies that the elasticity of gold demand is somewhat elastic in these developed countries, which is a typical phenomenon for luxury or discretionary goods.

Starr and Tran (2008) examine the factors that determine demand for physical gold using gold imports penal data of 21 countries from 1992 to 2003. They find that trading has little influence in physical demand, rather it indicates an interest in owning physical gold. The authors also find heterogeneity in factors of gold demand amongst different countries, some countries such as India and China consistently demand more gold than their countries' economic conditions would suggest, and the authors explain that cultures might be a factor. The study also finds that determinants for physical demand differ between the developed and developing economies. In developed markets gold demand rises with per capital income, whereas for developing markets income has no significant impact on

demand for gold. In addition, the gold demand tend to be more robust for developing countries with unstable personal income and/or less developed credit market, reflecting gold is considered as precautionary wealth in these countries.

In an empirical study by Mozes and Cooks (2013), it uses annual and quarterly data from 1992 to 2012 to examine the relationship between the gold price and the gold demand drivers. They find that the consumer and investment demand for physical gold do not explain changes in gold returns. The authors explain that the well-being feeling of the consumers and the intention to maintain purchasing power are the contributing factors for physical gold demand while gold prices are driven by macroeconomic events. However, the data on physical demand used in the study is of different frequency which may not be able to reflect the effect of price changes on demand.

In recent years, investors also make investment in gold ETFs, and the ETFs issuing institutions are active participants of physical gold market. Since World Gold Council launched the first Gold Bullion Securities ETF in 2003, dozens of other gold ETFs have been introduced to the market. Baur (2013b) finds the creation of ETFs has changed the structure of gold demand drivers in several ways. First, the convenience of purchasing and owning ETFs has brought about new source of gold investment demand from retail investors who wish to have exposure in gold investment. Moreover, as compared to other gold instruments (such as paper gold), investors have greater confidence in gold ETFs as each unit is physically backed by gold. Third, investors may also like the transparency the gold ETFs offer as most issuing institutions report gold holdings

daily. Baur argues that the rising gold price trend between 2002 and 2011 is partially caused by the launch of gold ETFs while the ETF providers' gold holding peaked at about 19 million ounces in 2012.

Similar to other assets, gold price may also be affected by supply fundamentals. A few articles find that there is a positive long-term relationship between mining output and gold price. Selvanathan and Selvanathan (1999) study the relationship between gold production in Western Australia and gold price empirically over the period from 1948 to 1994 and find the correlation to be positive. They find that over five years a one per cent rise of gold price in real term would result in approximately a one per cent increase in production. However, for a one year period, there is no real measurable change in volume produced to price changes, as mining industry is capital intensive and limitation on production can only be overcome in longer term.

A study by Rockerbie (1999) supports this point. He conducts a similar study using data between 1970 and 1995 of South Africa and finds the production adjustment process is about eight years due to sizable capital investment involved. Marsh (1983) finds similar results on the short-term relationship, he documents empirically the negative relationship between the gold price and mining output in short term and explains that mining companies would extract lower grades of ore at higher gold price which lead to reduction in total volume of output. However, Erb and Harvey (2013) inspect the data visually and suggest that production volume of gold is not significantly influenced by the rising price trend since 2000.

Kaufmann and Winters (1989) argue that annual production of gold is small relative to the sizable stock which has been in existence above ground, yet, substantial portion of the stock is already been taken out from market in the form of central bank's holdings and jewelry, therefore only incremental change in production supply would have great impact on gold prices. The authors devise a simple predictive model using regression technique to forecast the gold price between 1974 and 1988, and compare the results with actual gold prices. They determine that gold price is the function of the US inflation rate, the annual world production of gold and the US dollar exchange rate; they also find the inclusion of the supply change factor has improved the results.

Production costs are rarely incorporated in the empirical analyses of gold pricing model as a comprehensive and high-frequency data set is not available. Nevertheless, a few literatures on supply factors study the causal relationship between gold prices and production costs and offer two competing views on this issue. One proposition assumes production costs lead and determine gold price, whereas another proposition suggests otherwise.

Levin, Abhyankar and Gosh (1994) develop a model to assess the relationship between real interest rate and production cost with daily series data from 1990 to 1992. Their model assumes that gold production costs change in line with inflation rate in the long term, which will lead to higher gold price in order to compensate gold mining company for higher costs. Rockerbie (1999) also supports the causality from production costs to prices.

Other studies suggest that mining companies are price takers rather than price setters, implying that the causal relationship that runs from prices to productions costs. O'Connor, Lucey and Baur (2016) explain this with classic economic theory Ricardo's Law of Rent [12], that gold mines will continue production up to a point at which marginal costs equal marginal revenue. In other words, it is evident that production costs of gold mining companies are led and determined by gold prices, as high-cost mines with lower grade of ore will operate again to meet demand when gold price rises. The total production volume in response to gold price changes tends to stabilize the gold prices as supply increases with rising gold price and declines with falling gold price.

The observation by O'Connor et al. about the gold price being a determinant in decision of opening and closing of mines is consistent with the empirical study by Moel and Tufano (2002). They study the "real option" characteristic embedded in gold mines' opening and closure and how this option affects mining companies' strategy. They track the annual opening and closing gold mines data in North American between 1988 and 1997, and the authors find that the gold price is one of the factors being considered by the management when making decision as to whether to shut down the gold mines.

[12] The premise of the Law of Rent is that the rent (or the value) of a piece of land is equal to the economic advantage gained from occupying the land in its most efficient and productive way, over the advantage gained by utilizing an alternative best rent-free site for the same purpose.

2.8 Gold as a reserve asset

Since 2010, the central banks have reversed their attitudes towards gold and become net buyers of the yellow metal for the first time in almost three decades. The change of official holdings in gold may have an impact on gold prices. Cai, Cheung and Wong (2001) use COMEX gold futures price for the period between 1994 and 1997 to examine the impacts of macroeconomic variables and financial news on gold price changes. They find that 6 of the 25 largest price fluctuations are caused by announcements of gold sales by central banks.

Nugée (2000) discusses why central banks should keep gold and points out in the *Handbooks in Central Banking* the reasons why gold was the major reserve asset. There are a number of strategic reasons for the country reserves to hold gold. For example, gold is viewed as an asset to hold in times of turmoil due to its properties in inflation hedge, safeguarding wealth and store of value. Moreover, gold is without default risk and is the ultimate backing of fiat currency. However, the poor price performance in the 1990s is considered as "central bank overhang", that the market fears official sales of gold by central banks would become a trend. Nevertheless Nugée points out that gold still has a dominant role in country reserves due to its diversification effect, and central banks can enhance returns with various tools.

Aizenman and Inoue (2012) examine the patterns of central banks' gold trading activities and changes in gold reserves during the period from 1979 to

2010, they find that size of the gold holding is positively correlated to a country's "global power"[13]. Their analysis also suggests that central banks might under-report their gold position. The results are consistent with the view that gold has a prestigious status in central banks' reserve management, and the under-report of gold holdings might be a solution to avoid criticism from the public when gold price is low.

There have been a number of researches investigating the trend of reserve management of developing countries' central banks. Dominguez, Hashimoto and Ito (2011) find that during financial crisis emerging market economies which have accumulated sizable foreign currency reserves would allow their currencies to depreciate. Moreover, the authors also find that the post crisis economic recovery is usually stronger for countries which have accumulated large foreign currency reserves. Emerging market economies suffer criticism for their actions but argue that reserves accumulation is for the purpose of risk management in times of crisis.

In fact, Official Monetary and Financial Institution Forum (OMFIF) (2013) finds share of Asian central banks' reserves in world foreign exchange reserves increased from about 30 per cent in 1998 to more than 45 per cent in 2011. The study also points out that constituents of country reserves have changed in the past 15 years, as there has been a renewed interest in gold while US dollar and EUR have become less preeminent owing to financial and economic problems in the

[13] Measured in terms of dimensions such as whether a country's currency is widely used and accepted worldwide, size of the country, international relations and economic power.

United States and Europe. Apart from these two main reserve currencies, there is not much option for Asian central bankers. This is likely to be the main reason why China increases asset allocation to gold. OMFIF reports China has doubled its gold holdings between 2007 and 2012, with 1,054 tonnes of gold in its reserve in July 2012. China has been accumulating gold strategically for diversification purpose.

India is also building up its gold reserve. Karunagaran (2011) examines general demand trend for gold by central banks since the previous global financial crisis, and finds that central banks have either increased gold holdings or ceased to sell their existing stock. As many countries have employed heavy stimulus packages, there is a concern of depreciation of key currencies held by country reserves and this has pushed up reserves' demand for gold. He points out that the previous financial crisis has reiterated the continued importance of gold to central banks. As for India, he finds that although its official stock of gold is increasing, however the foreign reserves has been growing at an even faster pace, as such gold's proportion in country reserves decreased and accounted for about 7.9 per cent of the reserves in 2011, which is quite low as compared to developed countries.

World Gold Council (2015) examines the impact of the changing macroeconomic landscape has on the composition of country reserves. World Gold Council conducts simulations under three scenarios, including i) a more prominent role of China in world economy and the internationalization of the CNY, ii) lower growth rates for the global economy, and iii) fiscal vulnerabilities

in the United States and Europe. The results indicate that the strategic allocation of gold in central bank portfolios mainly depends on the gold price, inflation rate, economic growth and financial markets' volatility. The author also finds that the central banks of developing countries may increase their gold holdings from 3 per cent to 8 per cent under these scenarios. The model suggests developing countries will increase gold holdings by about one per cent over a five-year period if world economic growth is one per cent lower than the pre financial crisis period. Policy shocks such as rising debt levels in the United States and Europe will only have temporary impact on gold reserves.

Saidi and Scacciavillani (2011) examine the role of gold in a central bank's portfolio through a portfolio optimization exercise of reserve management with allocation to gold. The results of the optimization exercise indicate that for all level of risk, potential returns would increase by several basis points each year with allocation of gold in central bank's portfolio. Moreover, their back-testing test that the reserve portfolio with inclusion of gold would have earned 1.5 times more return than a reserve portfolio that is without gold over the period from January 1987 to May 2010.

Bhatia (2012) examines what is the optimal allocation to gold for central bank reserve portfolio from a domestic currency perspective using monthly data between March 1998 and June 2011. The results show that when the performance of a typical central bank reserve portfolio is being assessed using currencies of nine different emerging markets, the median range of optimal allocations to gold would be increased to the range of between 8.4 per cent and 10.0 per cent as

compared to the range of 4.6 per cent to 7.0 per cent in US dollar terms. Moreover, the findings show that inclusion of gold would improve risk-adjusted returns for the reserve portfolios, and that gold's volatility is very stable across emerging market currencies.

2.9 Unconventional monetary policy

In addition to the literature that investigates the relationship between gold price and money supply fueled by the traditional monetary policy, there emerges a set of empirical studies focusing on the impact of unconventional monetary policy has on the asset prices since the advent of the financial crisis in 2008. When conventional monetary policy becomes ineffective during severe market turbulence, tools of unconventional monetary policy, such as QE, may be utilized under such extreme condition.

Korniyenko and Loukoianova (2015) examine whether the international monetary and liquidity conditions are affected by unconventional monetary policy measures undertaken by the United Kingdom, the United States, Japan and Euro area since 2008, using the quarterly data covering sample period from the first quarter of 2002 to second quarter of 2014. The sample includes 131 countries, and 28 of them are categorized as advanced and 103 are emerging economies. Although the results reveal that the measures have a positive effect on money growth and global liquidity, but the program of each country may have

countervailing effects due to differences in the measures and financial systems. Additionally, the authors find the impact of measures on the money supply and funding liquidity in the emerging market economies is statistically significant.

Rafiq (2015) examines the impact of the unconventional monetary policy implemented by the United States has on the Asia Frontier Developing Economies[14] (FDE) using quarterly data covering the period between April 1996 and February 2013. The author finds that the effect of unconventional monetary policy on Asia FDE has been small, with the exception of India. There is little evidence of the spillover stemmed from the loose monetary shocks in the United States over into the FDE's domestic funding and foreign exchange markets. The author explains that it is partly due to the monetary independence made possible by FDE's managed capital accounts and primitive financial markets. The study assumes implicitly there will be symmetry phenomenon should the United States normalize its monetary policy and the impact of tapering on Asia FDEs will likely be immaterial. However, the author suggests that judging from the experience of India, which has a more developed financial market, Asia FDEs may increasingly be affected by external shocks as their financial markets grow.

Anzuini, Lombardi and Pagano (2012) investigate whether global monetary condition is a driver of commodity prices. The authors examine the empirical relationship between commodity prices and monetary policy shocks of the United Sates with VAR, using monthly data over the sample period from

[14] Bangladesh, Cambodia, India, Mongolia, Sri Lanka and Vietnam

January 1970 to September 2009. The findings show that the expansionary monetary policy shocks have elevated the constituents of the broad commodity price index, and the impact appears to be significant but not overwhelmingly enormous.

A study by ECB (2013) reviews whether the liquidity provided by its own unconventional monetary policy measures has resulted in asset price misalignments and financial imbalances. The study uses data between 1983 and 2013 and finds that there is little evidence of broad-based asset price misalignments or financial imbalances in the Euro area, and considers the prevailing asset prices are reflecting a risk premium demanded by investors. The study also comments that the growth in money and credit has been slow since the mid of 2010.

The study by Roache and Rossi (2013) estimates with risk-neutral density functions to examine the impact of the unconventional monetary measures of the United States has on the asset price risk. The sample includes option prices of the EUR/USD exchange rate, the S&P500 equity index, gold, and other commodities over the period from 2008 to 2012. The authors conclude that the measures help restore market confidence in times of market turbulence as they find that "tail risk" diminishes immediately after QE implementation.

CHAPTER 3: DATA AND METHODOLOGY

3.1 Data and variables

This study adopted monthly time series covering the sample period from January 1973 to May 2016. The start of the sample period is chosen to be 1973 because the free-float of gold market commenced during the early 1970s after the Bretton Woods system was dismantled; moreover, the US dollar trade-weighted average of foreign exchange rate index (USD Index) was also first introduced in that year.

To examine the time variant nature in the impact of the drivers on gold price, the whole sample period is partitioned into four sub-sample periods. Because the identified drivers are all macroeconomic and financial variables, the length of each sub-period is determined by the economic and interest rate cycles, rather than the bull-bear gold price cycle; the first sub-period is from January 1973 to December 1985[15], the second sub-period is from January 1986 to

[15] From late 1973 to the first quarter of 1975, the US economy was in a recession characterized by a stagflationary environment. The oil embargo is believed to have been the cause of recession, which eventually led to the high inflation. During the early 1980s, the US Fed tried to combat high inflation by implementing contractionary monetary policy, eventually resulting in another recession.

December 1998[16], the third sub-period is between January1999 and December 2007[17], and the fourth sub-sample period starts from January 2008 and ends in May 2016[18].The whole sample period has a total of 520 observations, and each of the four sub-sample periods has 155, 156, 108, and 101 observations, respectively.

Each of the sub-periods covers a full economic and interest rate cycle, with a peak and a trough, according to GDP growth rate and changes in short-term interest rates. The justification for the sub-period selection is that distinct financial, economic, and monetary conditions exist in each economic cycle, generating a different dynamic in each sub-period and affecting the gold price in different ways. Figure 7 displays the real GDP growth rates from 1970 to 2016 with the shaded area indicating negative GDP growth for two or more consecutive quarters. Figure 8 presents the interest rate cycle from 1970 to 2016, represented by the 3-month Treasury bill rate. Figures 7 and 8 are partitioned to illustrate that each sub-period covers a full economic and interest rate cycle.

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[16] The recession of the early 1990's was inflicted by the savings and loans industry, which later caused a financial crisis.

[17] The early 2000's recession mainly influenced developed economies. The burst of the tech bubble in 2000 and the September 11, 2001, incident coupled with slow economic activity amplified the effect of the recession. During the recession, no two consecutive quarters exhibited negative GDP growth; however, growth remained weak between 2000 and 2003 and matched the profile of a typical U shaped recession.

[18] Numerous factors contributed to the 2008 recession. A combination of events had led to the subprime mortgage crisis which eventually caused the severe recession. Those events include high leverage of households on mortgage, burst of the real estate bubble, deregulation of the derivative market, and the limited regulation of financial institutions.

In addition to traditional drivers, new price determinants are identified on the basis of the literature review. Inflation rates, interest rates, and US dollar exchange rates are factors that stem from gold's store of value properties. Other determinants include international and the United States monetary conditions, equities returns, and market risk.

The gold spot price data quoted in US dollars per troy ounce were based on the 3 pm London fixing at the LBMA. Price fixing is an open process in which gold market participants can trade at a single quoted price. The data were obtained from ICE Benchmark Administration, an organisation that provides governance and administration services to the LBMA.

Monetary conditions are represented by the broad money supply of various countries. The money supply is commonly categorized into M1, M2, and M3 and in some cases, M4, which are groups of assets in the economy that can be used to make payments or kept as investments. M1 includes the most liquid forms of assets such the currency in circulation that is held in public hands, and transaction deposits. M2 is commonly defined as M1 plus assets that are less liquid than those of M1 but can be quickly converted into cash, such as time deposits and money market funds. M3 is defined as M2 plus assets that are less liquid than those of M2, such as short-term repurchase agreements, institutional deposits, and money market funds. In this study, the M3 data of major economies are used because this is a broader classification of money supply. However, M2 data are used for the United States because the US Fed ceased publishing M3 monetary aggregate in 2006, and M4 data are used for the United Kingdom because this is

the broadest money stock with a complete dataset available. The components of M4 in the United Kingdom are similar to those of M2 in other countries; it is defined as the aggregate of currency, deposits, commercial papers, bonds, and similar instruments issued by the monetary financial institutions in the United Kingdom and held in the private sector.

US M2 represents the monetary conditions in the United States and is treated as an independent variable due to the country's economic power and active participation in the early years of the gold market. Monthly US M2 data are obtained from IMF.

The time series of the money stock of a group of countries including Russia, Australia, Canada, Japan, the United States, the United Kingdom, Brazil, China, and India as well as the Eurozone[19] are aggregated to represent the international money supply. The sum of the money of these countries is estimated to have accounted for approximately 85 per cent of the total global money in issue worldwide in mid 2016. M3 data of Russia, Australia, Canada, Japan, the Eurozone, and Brazil are acquired from the IMF. M3 data of China and India are obtained from Organization for Economic Co-operation and Development (OECD), and M4 data of the United Kingdom are obtained from both the OECD and BOE. China and Russia began publishing M3 data in 1990 and 1995, respectively; data prior to these dates are omitted from calculation because these

[19] Germany, Belgium, Ireland, France, Luxembourg, Spain, Italy, Portugal, Cyprus, Greece, Netherlands, Malta, Austria, Latvia, Slovenia, Finland, Estonia, Slovakia and Lithuania

countries were mostly operated as closed economies in those years before their economic reforms. As capital flows from both countries to the international market were restricted in those years, the amounts were immaterial.

All international money supply data are expressed in US dollars by converting the country's money supply in local currency at the prevailing exchange rate; however, a narrow effective exchange rate for the Eurozone is used to represent the euro exchange rate between January 1973 and December 1998, because this currency was not officially circulated in the market prior to January 1999. Denominating the international money supply in US dollars enables the purchasing powers of various countries to be accounted relative to the price of gold on the same term. Foreign currency exchange rates are obtained from Board of Governors of the Federal Reserve System of the United States (FRED).

The CPI on all items of the US was selected as the measurement for the inflation. The CPI measures the changes in the prices of general items purchased by households in the United States. The data are obtained from the US Bureau of Labor Statistics.

To examine the independent effects of the inflation and interest rates on the gold price, real, rather than nominal, interest rates are used. Moreover, following Baur (2011), both short-term and long-term real interest rates' impact on the returns of gold are tested separately because different relationships may exist between these variables. The short-term real interest rates are calculated using the rate of 3-month Treasury bills deflated with CPI. The long-term real

interest rates are derived using the 10-year Treasury constant maturity rate[20] deflated with CPI. Data of both the Treasury bill rate and 10-year Treasury constant maturity rate are acquired from FRED.

The relationship between gold and interest rates is usually measured using US interest rates. This approach is adopted for several reasons. First, the gold price is denominated in US dollars; second, despite its decreasing popularity, the US dollar remains the world's reserve currency; third, investments in the US assets or investments denominated in US dollars account for a substantial portion of the global portfolio; and fourth, the US real rates often lead and synchronize the interest rates cycles of the other parts of the world, particularly emerging markets, because of the economic dominance of the United States.

The USD Index is used in this study to reflect the level of the US dollar exchange rate against a basket of foreign currencies including the British pound, Swedish krona, euro, Canadian dollar, Japanese yen, and Swiss franc. The data are obtained from FRED.

The Standard & Poor's 500 composite price index (S&P 500) is employed in this study as the stock price reference for the stock market. The S&P 500 is widely regarded as the most representative gauge of equities performance because its 500 constituents are all leading US companies with market capitalization of at

[20] This rate is based on the average yield of a group of treasury bonds with an adjusted maturity of 10 years. The US Treasury decides the yield of Treasury securities with constant maturity with reference to a daily yield curve.

least USD5.3 billion. It is a weighted stock index that covers approximately 80 per cent of the available market capitalization.

The market risk is measured by the volatility of the stock market. The one month standard deviation of the S&P500 calculated on the basis of the daily returns of the index in monthly frequency is used as the proxy of the market risk. Data of both daily and monthly S&P500 close are obtained from DataStream.

Inflation expectation is represented by the expected changes of inflation rates that have been published by the University of Michigan since 1978. Inflation expectation represents the median expected price change of consumers for the next 12 months. The university conducts monthly consumer surveys to capture the changing consumers' inflation expectation. This time series is used in the third and fourth sub-periods due to data availability constraint.

3.2 Methodology

The relationship between the returns on gold and the exogenous variables determined on the basis of studies discussed in Chapter 2 is expressed in the following function:

$R_{gold} = f\,(MS_{US}, MS_{international}, Inflation, I_{short\ term}, I_{long\ term}, USD\ Index, R_{equities}, Risk, Exp.\ Infl., \theta)$

where:

R_{gold} is the return on gold;

MS_{US} is the growth rate of the M2 money supply of the United States;

$MS_{international}$ is the growth rate of the international money supply, the aggregate of the broad money supplies of the United States, Russia, Australia, Canada, Japan, the Eurozone, the United Kingdom, Brazil, China, and India;

Inflation is the per cent change of the inflation rate, measured by the US CPI;

$I_{short\ term}$ is the change of the short-term real interest rates of the United States;

$I_{long\ term}$ is the change of the long-term real interest rates of the United States;

USD Index is the per cent change of US dollar exchange rates, represented by USD Index;

$R_{equities}$ is the return on equities, represented by the S&P500;

Risk is the market risk, measured by the change of the monthly standard deviation of the S&P500;

Exp. Infl. is the inflation expectation, measured by the change of the median expected price of US consumers for the following12 months;

θ is the unmeasured determinants of the return on gold.

To examine the independent effects of each exogenous variable on the gold price, univariate regression is first conducted. The return on gold is regressed with changes in each of the nine exogenous variables:

$$R_{gold,\,t} = \mu + \beta_i \Delta X_{i,t} + \varepsilon_{i,t} \qquad (1)$$

where μ is a constant, β_i is the coefficient estimate of the exogenous variable X_i, Δ denotes the change of the variable between times $t - 1$ and t, and $\varepsilon_{i,t}$ is an error term.

To determine the joint influences of and interplay between all potential drivers of the gold price and to avoid omitting variable bias, a multiple regression model with a stepwise procedure is implemented:

$$R_{gold,\,t} = \alpha + \beta_1 \Delta X_{1,t} + \beta_2 \Delta X_{2,t} + \beta_3 \Delta X_{3,t} + \beta_4 \Delta X_{4,t} + \beta_5 \Delta X_{5,t} + \beta_6 \Delta X_{6,t} + \beta_7 \Delta X_{7,t} + \beta_8 \Delta X_{8,t} + \beta_9 \Delta X_{9,t} + \varepsilon_{i,t} \qquad (2)$$

where α is a constant, β_i is the estimated coefficient of the exogenous variable X_i, Δ denotes the change of X_i between times $t - 1$ and t, and $\varepsilon_{i,t}$ is an error term.

The multiple regression model with a stepwise procedure combining both forward selection and backward elimination is used as the model selection method in this study. This approach enables the variables to be explored interactively to obtain a final model selection with a good fit.

For forward selection process, a model begins with nil variables; then, exogenous variables are selected to be incorporated into the model successively based on the level of significance of their respective coefficient estimates, until a point is reached when no remaining parameters could satisfy the criterion. Normally, either t-statistics, F-values, or p-values is used as the threshold value for entry of a variable into the model.

A reverse process is adopted for backward elimination. A model initially contains all exogenous variables, and the least significant variable removed successively from the model in each step; the process continues by refitting a reduced model until only statistically significant variables remain.

Each of the forward and backward variable selection procedures has some limitations. Forward selection's drawback is that an exogenous variable included early in the process may later become insignificant due to its relationship with other variables incorporated into the model afterwards. Therefore, the final model may contain variables with little explanatory power. Likewise, backward

elimination may remove variables in earlier steps that would be statistically significant when added back to the final reduced model. This suggests that a model selection method compromised of both forward and backward procedures should be adopted.

Therefore, a stepwise regression approach combining both forward selection and backward elimination is employed in this study. This tackles the weakness of forward selection and backward elimination by checking the significance level of the added exogenous variables at each step; a variable will be deleted if it has become redundant in a later stage or a variable that is removed at one point to be included back in the model.

The following stepwise regression procedure is implemented: First, a model is initialised by adding the most significant variable x_i, determined by the highest absolute t-statistic (|t|) of the coefficient estimates of x_i generated through regression, in which the gold returns are regressed with each x_i individually. Second, gold returns are regressed with the remaining x_i's along with the variables that are already included in the model, and the most significant x_i (with highest |t|) is added to the model if $|t| > 2$. Third, among variables already incorporated in the latest model, the variable with the lowest |t| is removed if $|t| < 2$. Repeat the second and third steps and successively include or omit x_i's that satisfy the criterion into or from the model, until no further variables can be incorporated or eliminated. In this study, the threshold to include or omit a variable is set at $|t| = 2$, which is equivalent to a 5% significance level.

Apart from stepwise regression, other widely used model selection methods in studies on the gold price include vector autoregression (VAR; Davis, 2012; Lawrence, 2003; Sari et al., 2011; Wang and Lee, 2011) and generalized autoregressive conditional heteroskedasticity (GARCH; Hammoudeh et al., 2010; Cai et al., 2001; Tully and Lucey, 2007; Capie et al., 2005; Pukthuanthong and Roll, 2011; Hillier et al., 2006; Baur and Lucey, 2010; Lucey and Li, 2015; Choudhry et al., 2015; Hood and Malik, 2013; Coudert and Raymond, 2011).

These methods are used to address different research objectives. VAR investigates the linear interdependencies among variables, and is often used in empirical studies that aim to provide forecasting. VAR can be implemented without a theoretical framework basis, because this approach assumes that the forecast depends only on the lags of the endogenous and exogenous variables' time series; thus, prior knowledge of the economic fundamentals regarding the interactions between variables is not required. Therefore VAR is often criticized for its lack of explanatory power for economic structures and phenomena. GARCH process is an autoregressive model that is used to estimate volatility. It uses past observations and variances to forecast volatility and is widely used to model asset returns during crises.

Stepwise regression is chosen for this study for additional practical reasons. First, the nine potential variables would result in excessive parameters to be estimated for a VAR. Additionally, this study has insufficient observations in each sub-period to provide a reasonable degree of freedom for the data for a VAR

with large number of parameters; thus, the reliability of the results would be compromised.

CHAPTER 4: EMPIRICAL RESULTS AND ANALYSIS

The determinants of the gold price have evolved with the changing role of gold in financial markets and the monetary system. The aim of this empirical analysis is to explore whether the combination of real gold price drivers has changed since the introduction of the free-float gold market. How and why the changing combination of factors has affected the gold price over time is also explored.

To examine this, the whole sample period from January 1973 to May 2016 is split into four sub-sample periods. The first sub-period is from January 1973 to December 1985, the second sub-period starts from January 1986 and ends in December 1998, the third sub-period is between January 1999 and December 2007, and the fourth sub-sample period is from January 2008 to May 2016. Table 3 lists the descriptive statistics of all the variables.

4.1 Univariate regressions

Univariate regressions are performed to examine the isolated effect of each driver on the return on gold; the results are listed in Tables 4 to 12.

Figure 9 shows the relationship between the M2 money supply of the United States and the gold price; Table 4 lists the univariate regression results of gold returns regressed with the monthly change of US M2. The US money supply

and the gold price have a positive significant relationship throughout the sample period and fourth sub-period with respective t-statistics of 2.18 and 2.61 and coefficient estimates of 0.3530 and 2.4645. Such findings are consistent with previous empirical studies that have demonstrated that the US market and economy influence the gold price through investment flows because of the country's economic dominance. The positive relationship may be due to gold's store of value property—investors turn to hard assets under easing monetary conditions because they lose confidence in fiat currencies, which are debased continuously when governments expand the money supply; gold would never be debased in a similar fashion.

Figure 10 presents the relationship between the international money supply and the gold price, and Table 5 lists the univariate regression results of gold returns regressed with the growth of international money supply. The positive relationship between these two variables is robust across the whole sample period and all sub-periods. All coefficient estimates are statistically significant at the 1% level. The findings suggest that the global money supply has a strong positive influence on the gold price and coincides with the changing structure of gold demand. Although the US economy remains relevant to the gold market, assessment must be made in the context of the global economy, especially because the international money supply increased drastically during the post crisis period. The source of physical and investment demand for gold has become increasingly diverse and is derived from various countries; therefore, the US money supply alone cannot fully explain gold returns.

Figure 11 displays the relationship between the gold price and the US CPI, and Figure 12 presents the change of the gold price versus the change of the US CPI. The time series in Figure 12 exhibit a similar pattern, especially during the 1970s, 1980s, 2000s and the majority of the 2010s, indicating their positive relationship. Table 6 shows the univariate regression results of gold return regressed with the US CPI. The coefficient estimates are statistically significant for the whole period and all sub-periods with the exception of the second sub-period. This indicates that although gold is an inflation hedge in general, it does not provide continual protection against rising prices in every point of time. During the second sub-period, a change in inflation expectation was characterized by the relatively low and stable inflation rates at the time; therefore, inflationary pressure was not perceived as a risk to financial markets or the economy. Table 7 summarizes the univariate regression results of gold returns regressed with changes in inflation expectation. The statistics in Tables 6 and 7 reveal that the CPI has stronger explanatory power than the Michigan inflation expectation in explaining the inflation component of the gold price determinant.

Figures 13 and 15 present the time series of the gold price and short-term real interest rates. To reveal the relationship between them, the real gold price and short-term real interest rates are used, and the figure illustrates a generally inverse relationship except during early 1990s and mid 2000s. Figures 14 and 16 show the relationship between long-term real interest rates and the real gold price; these plots reveal that the relationship is changing over time. The two variables were negatively related in the 1970s and after 2000, but no clear relationship is

exhibited from the late 1980s to 2000. The two time series appear to have opposite trends at the turning point of each long-term interest rate cycle.

Tables 8 and 9 list the univariate regression results of the gold price returns regressed with the change of short-term real interest rates and the change of long-term real interest rates, respectively; these two regressions reveal different findings. Short-term real interest rates are negatively associated with the gold price, with robust results across all intervals except the second sub-period. The coefficients of long-term real interest rates are also negative and are statistically significant for the whole period and the third and fourth sub-periods, but not in the first and second sub-periods. These findings indicate that interest rates represent the cost of carry[21] and opportunity cost for investors when holding an asset. Because gold investments do not receive dividends or interest payments and may incur storage and transportation costs, investors are susceptible to high opportunity cost and cost of carry. Therefore, a low interest rate environment would encourage investment in gold; this was particularly evident in the 1970s and after 2008. During these time periods, despite positive nominal interest rates, real interest rates were negative[22] and coincided with record high gold prices. These findings suggest that real interest rates drive the gold price.

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[21] Cost of carry is the cost of holding an asset in a physical form, including insurance, storing, and handling expenses.

[22] The real interest rate is equal to the nominal interest rate minus the inflation rate.

Figure 17 displays the relationship between the S&P 500 and the gold price. No connection is apparent between these two time series. Table 10 summarizes the univariate regression results of returns on gold regressed with returns on the S&P 500; the findings illustrate that gold does not co-move with equities overall, except during post crisis period when an inverse relationship between the returns on gold and equities is evident with coefficients that are statistically significant at 10% level. This finding illustrates a weak safe haven status of gold during times of market stress.

Figures 18 and 19 illustrate the relationship between the USD Index and the gold price. To identify the true relationship, the real gold price adjusted with inflation is used in the plots. These time series exhibit an inverse relationship during the overall sample period, except when the USD Index was moving sideways during the late 1980s and early 1990s. Table 11 presents the univariate regression results of gold returns regressed with changes in the USD Index; the findings indicate that the USD Index negatively affects the gold price, and this relationship was statistically significant across all sub-periods. The inverse relationship between these two variables is consistent with the findings of a previous empirical study. This negative correlation is due to the higher gold price in US dollar terms and the higher floor price resulting from the increased production cost when the US dollar depreciates.

Table 12 lists the univariate regression results of gold returns regressed with the standard deviation of the S&P 500. The findings suggest that the gold price does not hedge against market uncertainty. Gold is considered a counter-

cyclical investment, therefore such empirical evidence does not support the safe haven property but is in agreement with recent studies on the safe haven literature. Recent study by Baur and Lucey (2010) finds that gold's safe haven effect lasts for only 15 days during a financial crisis. Therefore, a considerably higher data frequency is needed to assess the safe haven property, and a statistical model specifically dedicated to testing market shocks, such as ARCH, GARCH, or asymmetric ARCH volatility functions, must be used. Otherwise, with the low frequency data, the significance of the safe haven effect is washed out. Another possible cause of its diminishing safe haven status is gold's emergence as a popular investment asset. Investing in gold is currently very convenient due to gold ETFs or accounts. Because an increasing quantity of gold now held solely for trading purpose, investors thus trade gold in a similar way as other assets when market volatility increases. During the 2008 financial crisis, the volatility and returns spilled over tremendously to other asset classes.

4.2 Multiple regressions

Many variables are only statistically significant in a univariate regression framework in which it is assumed that the other independent variables that would have impact on gold price potentially are constants or not even exist. In reality, interactions between various variables contribute to asset price changes. A multiple regression model with a stepwise procedure is conducted to examine the joint influences of the variables on gold returns. The significance of some

variables subsides whereas that of others' gains robustness. Therefore, the model assesses the relative importance of variables in driving the gold price. The whole sample period and all the sub-periods are analysed to assess the robustness and time variant nature of the relationships between gold returns and the variables.

First sub-sample period

Table 13 presents the results of stepwise multiple regression for the first sub-period. In the initial univariate regression, the USD Index, US CPI, and international money supply are significant respectively in the first sub-period. Table 13 shows that only the USD Index and US CPI are significant, with t-statistics of −5.00 and 2.66, and coefficient estimates of −1.6904 and 4.3517, respectively. The results are consistent with the findings of previous empirical studies that the US dollar exchange rate is negatively related to the gold price and that the inflation rate positively affects the gold price. The oil embargo crisis in the 1970s led to stagflation for most of the first sub-period; gold was seen as an inflation hedge under this type of hyperinflationary environment.

Second sub-sample period

Table 14 displays the results of stepwise multiple regression for the second sub-period of January 1986 to December 1998. In the initial univariate regression, the USD Index, short-term real interest rates, and international money supply are significant respectively in the second sub-period. The multiple regression results indicate that the USD Index, short-term real interest rates, and long-term real interest rates are strongly associated with the gold price, with t-statistics of −4.67, −5.43, and 4.35 and coefficient estimates of −0.5692, −5.3618, and 4.1645, respectively. The results indicate that the US dollar exchange rate and short-term real interest rate negatively influence the gold price, whereas the long-term real interest rates are positively related to the gold price.

Many studies consider that interest rates and the gold price are negatively related because higher interest rates would suppress demand for gold due to holders of gold forgoing interest income or yields offered by other interest-bearing securities; the ceded yield would eventually cause a drop in the gold price. Therefore, investors evaluate the relative attractiveness of gold according to the total return they can obtain elsewhere.

These empirical results are consistent with those of Batten et al. (2014) and Baur (2011), who argue that the short-term interest rates represent the cost of carry and the long-term interest rates reflect inflation expectation; the types of interest rates affect the gold price in opposite directions. However, in the current

study, the interpretation of the empirical finding is slightly different, because real interest rates are used and the inflation rate is treated as a separate variable. During the second sub-period, inflationary pressure did not pose a concern to investors because the hyperinflationary environment had subsided and inflation rates were moderate and stable. Moreover, the normal yield curve slowly flattened at the beginning of the period and became inverted, signalling a future decline in economic growth and low inflationary pressure ahead[23], which actually later materialized in the early 1990s. The declining gold price coincided with lower long-term interest rates, which were signalled by the flattened yield curve. This implies that an anticipated slower gold demand resulted from the upcoming economic recession. Therefore, in an environment with low and stable inflation, gold price would be less sensitive to inflation shocks and long-term real interest rates would have a more prominent positive association with gold price. These empirical results reinforced the findings of Batten et al. (2014), who reveal that the association between the gold price and inflation is time variant and affected by the underlying macroeconomic factors. They also suggest that such variations in the relationship are linked to interest rates. During the second sub-period, both the gold price and long-term real interest rates declined.

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[23] A yield curve plot compares the interest rates of debt instruments of the same credit quality with deferring maturity. Most commonly referred yield curve in the market is the US Treasury yield curve, it describes the yields of short-term Treasury bills and long-term Treasury notes or bonds on the same plot. The shape of the yield curve indicates possible future changes in interest rates and economic conditions. It is normally upward sloping because investors demand higher yields for longer maturities into the future, for compensation for the uncertainty associated with the future interest and inflation rates, and for the future value of cash flows.

Third sub-sample period

Table 15 lists the results of stepwise multiple regression for the third sub-period. In the initial univariate regressions, the international money supply, US CPI, short-term and long-term real interest rates, USD Index, and inflation expectation are all significant in the third sub-period. Despite the strong associations of these variables with the gold price in the univariate regression models, Table 15 shows that only the USD Index is significant at the 1% level, with a t-statistic of −5.40 and a coefficient estimate of −1.1337. Apart from the recessionary period during the early 2000s, the economy experienced moderate GDP growth and stable interest rates during the third sub-period. Inflationary pressure was not a threat, despite the upward trend of the CPI towards the end of the sub-period. The empirical results indicate that under such stable economic environment with moderate GDP growth, steady interest rates, and mild inflation, the USD Index remains a primary price determinant and significance of other variables subsides.

Fourth sub-sample period

Table 16 lists the results of stepwise multiple regression for the fourth sub-period. In the initial univariate regressions, all variables are related to gold

returns except the standard deviation of the S&P 500 and inflation expectation. Unlike in previous sub-periods, Table 17 indicates that during the fourth sub-period, the USD Index is not the sole and most important driver; conversely, the international money supply, S&P500, and long-term real interest rates are significant at 1% level, with t-statistics of 5.48, −4.08, and −3.28 and coefficient estimates of 1.7051, −0.3041 and −2.2523, respectively.

During the fourth sub-period, the subprime crisis and the burst of real estate bubble caused severe recession. The overnight federal funds target rate in the United States reached zero and short-term rates in other countries also reached record lows. Many central banks implemented unconventional monetary policies to revive the economy when low interest rates were considered insufficient. The empirical results indicate that the massive injection of money supply to the international monetary system by central banks worldwide was the most important driver of the gold price during the post crisis period, because more money is in the system chasing hard assets.

The results also reveal that the S&P500 is negatively related to the gold price. This finding is consistent with the view of gold as a diversifier or hedge against equities. Long-term real interest rates and gold are negatively related, and the relationship is unstable over time. The coefficient estimates of the long-term real interest rate switched sign in different sub-periods; while in the second sub-period, they are positively correlated. The influence of gold price drivers evidently varies under different economic conditions.

The changing nature of the relationship between the gold price and long-term real interest rates can be explained by the market expectation theory[24] of yield curve. For most of the fourth sub-period, long-term real interest rates were negative, yet instead of having a normal positive slope, the yield curve was flat or even inverted, indicating that the market expectation of future interest rates is depressed to low levels for an extended period of time. The low interest rates anticipated by the market encouraged investment in real assets. The observation of long-term real interest rates in this study is somewhat analogous to that of Batten et al. (2014). They claim that when the interest rates are low they become less important in explaining the returns on gold and that the gold price is more sensitive to inflationary shocks. The inverse relationship between the low (sometimes even negative) long-term real interest rates and the gold price indicates that the market expects future inflationary pressure due to the suppressed interest rates. This phenomenon is in agreement with the market expectation theory of yield curve in classical economics literature.

Whole period

Table 17 lists the results of stepwise multiple regression for the whole sample period. The results reveal that the USD Index is the most dominant price

[24] Market expectation theory suggests that the expectations of market participants on the future interest rates determine the shape of the yield curve. The theory assumes that debt instruments with deferring maturities are perfect mutual substitutes.

determinant in the sample period, with t-statistic and coefficient estimate of −6.80 and −1.5580, respectively. The empirical result that gold price exhibits a negative correlation with the USD Index is consistent with the findings of previous studies. This inverse relationship has several explanations. First, because gold is denominated in US dollars, it is priced at a higher US dollar price when the US dollar depreciates. Second, gold's store of value attribute makes it a preferred alternative to fiat currency. Third, the purchasing power of non-US dollar currencies increases as the US dollar depreciates, leading to higher demand for gold and hence higher gold prices. Finally, most operation costs of mining firms are reported in US dollars; thus, overseas extraction and production costs reported increase to reflect a depreciating US dollar, resulting in a higher floor price for gold.

The CPI, US money supply, and S&P 500 are also statistically significant at the 1% level, with t-statistics of 3.67, 2.95, and − 2.62 respectively and coefficient estimates of 2.2419, 1.7162, and −0.1256, respectively. The empirical finding that gold is a hedge against inflation and the equities market is consistent with the results of previous studies. The international money supply is significant at the 5% level, with a t-statistic of −2.39 and a coefficient estimate of −0.6050.

The negative correlation between the international money supply and the gold price during the sample period may due to various reasons. First, the availability of other investment alternatives in the market and the unsuitable prevailing economic and financial conditions may not provide a suitable climate

for gold investment. Second, in the post Bretton Woods era, the ratio of gold holdings in country reserves relative to money issued has been decreasing because central banks were discouraged from holding gold and had been divesting gold holdings through gold sale contracts. Third, in the absence of unconventional monetary policies, the growth of the international money supply did not create excess liquidity in the international monetary system that would have been translated to demand for hard assets. The economic dominance of the US market during the sample period may also explain the divergence between the regression results generated for the US and international money supplies.

In summary, the empirical findings and analysis support the hypothesis that the gold price drivers change and their influences are time-varying across the sub-periods. Most notably, the US CPI exhibits a positive influence in the first and second sub-periods but becomes irrelevant in the later periods. The short-term and long-term real interest rates are both significant in the second sub-period, and the long-term real interest rates are significant in the fourth sub-period, but the nature of the relationship is reversed. The influence of the US dollar exchange rate remains prominent throughout the sample period with the exception of the fourth sub-period, when the international money supply becomes the most crucial factor under the new landscape of monetary conditions.

Several notable observations can be drawn from these results. First, when the inflation rate is high, the gold price is more sensitive to inflation shocks, and these variables are positively correlated. Second, the gold price is more responsive to short-term real interest rates when the rates are low, and they exhibit

an inverse relationship. Third, the nature of the association between the gold price and long-term real interest rates varies depending on the prevailing interest rate environment; these variables are significantly positively related when yield curve shape is normal and negatively correlated when the yield curve is flat or inverted. Finally, the US dollar exchange rate is the most dominant determinant for most the sample period; however, the international money supply is the most crucial factor following the 2008 financial crisis when unconventional monetary policies are in effect.

Validation

Tables 18 and 19 present results for validation. Due to the constraint of timely availability of the macroeconomic data after sample period ended in May 2016, the validation test is conducted using the data from the fourth sub-period. In addition, the sample is split equally because the number of observations in the fourth sub-period is relatively low[25]. The first and second periods are from January 2008 to February 2012 and March 2012 to May 2016, respectively. The validation test examines the validity of the empirical finding in the fourth sub-period, whether excess liquidity in the monetary system brought by the

[25] For validation, the data points of a sample in general are split into two sets: a training set and a test set. The data points are conventionally split into 70 per cent and 30 per cent for the training and test sets, respectively. In this case, the sample is split evenly because there are relatively few observations for the number of variables.

unconventional monetary policies has become the most prominent driver of the gold price. The first and second half of the fourth sub-period include only approximately 50 observations each, which is insufficient to provide a proper degree of freedom for the estimate given the number of independent variables; ideally, at least 10 data points are needed per variable. The robustness and the stability of the validation results may be compromised as a result. Therefore, for the stepwise procedure in this part, the thresholds are relaxed slightly to |t| of 1.645 or p-value 0.1. These criteria correspond to a significance level of 10%, which prevents significant variables from being removed from the model in the process, due to the small number of observations.

Because they are restricted by the number of observations, the findings presented in Tables 18 and 19 do not fully validate the results of Table 17. Comparing the significant variables entered into the models in Tables 17, 18, and 19, the long-term real interest rates is the only independent variable identified in all of the three tables; the other independent variables identified in Table 17 (i.e., returns on equity and international money supply) are included separately in the model in Tables 18 and 19. However, these results are in agreement with the economic reality of the time. Notably, for the first half of the fourth sub-period, the US money supply is statistically significant, and for the second half, the international money supply is significant. The results imply that the excess liquidity brought by the money supply has become an important determinant of the gold price. The fact that the US and international money supply are significant in the first and second half, respectively, is in close agreement with the

underlying economic situation. The United States was the first country to introduce unconventional monetary policies, and it was followed by other countries in later years. Although the validation is constrained by the small sample, it remains meaningful in interpreting the results.

CHAPTER 5: CONCLUSION

5.1 Conclusion

In this study, an econometric analysis is performed to identify the determinants of the gold price. Large swings in the gold price in recent years have attracted new attention to the gold market. The changing macroeconomic and financial conditions have produced several economic cycles in the past few decades, each of which was underpinned by a different interplay of parameters; therefore, the role of gold in the financial and monetary system and the significance of the gold price drivers, may have changed over time.

To investigate the time-variant nature of the price determinants, the whole sample period from January 1973 to May 2016 is divided into four sub-sample periods according to the economic cycles. The US dollar exchange rate is the most significant variable for the whole sample period and for all sub-sample periods except the fourth sub-period, among other factors.

In addition to the US dollar exchange rate, the US CPI is also significant in the first sub-sample period. The short-term real interest rates and long-term real interest rates are negatively and positively related to the gold price, respectively, during the second sub-sample period. The third sub-sample period is characterized by a stable economic environment with moderate GDP growth, steady interest rates, and mild inflation. The US dollar exchange rate remains a

primary price determinant during this sub-period, whereas the significance of other variables fades.

The empirical results of first, second and third sub-periods are consistent with the findings of studies including Sari et al. (2010), Sjaastad and Scacciavillani (1996) and Tully and Lucey (2007). They all find that the US dollar exchange rate is negatively related to the gold price and is by far the most important factor in explaining the gold price. This is because gold is traded and quoted in US dollars. A depreciating US dollar, as measured by the USD Index, translates to higher gold prices in terms of the US dollar. Similarly, non-US investors increase their gold holdings because they perceive its denomination in US dollars becomes cheaper; this demand eventually drives up the gold price. Another basis for the negative relationship is that after the collapse of the gold standard, the US dollar and gold have become competing world reserve assets; when one asset is out of favour, investment allocation to the other asset rises.

Nevertheless, during the fourth sub-period, the international money supply replaces the US dollar exchange rate as the most crucial gold price driver and returns on equities and long-term real interest rates are also significant. International economic and monetary conditions have changed drastically following the 2008 financial crisis, and central banks worldwide have implemented QE programmes to combat severe recession during the past 9 years. These international QE programmes, which are collectively referred to as unconventional monetary policies, have increased the international money supply worldwide at an unprecedented pace.

Previous studies, such as Bailey (1988), Batten et al. (2010) and Roache and Rousset (2013), investigate the effects of the money supply and monetary stance on asset prices. These studies reveal that the market liquidity fuelled by the easing of the money supply is supportive of asset prices. More recently Sipkova and Sipko (2014) find that the US M2 money supply is a main factor for the gold price. Therefore, investigation is warranted into the influence of unconventional monetary policies, which are currently in effect, on the gold price. The current study fills this research gap by examining the role of the international money supply in the gold market.

One of the rationales for the money supply proposition is that the money in circulation has previously been backed by gold reserves. During the classical gold standard era of 1870 to 1914, the US dollar was backed by 25 per cent of gold, and approximately 20 per cent to 40 per cent in the subsequent gold standard and Bretton Woods systems. At present, the foreign exchange reserves of most economies still contain a certain proportion of gold for currency backing. Such gold holdings represent an implicit function of gold relative to issued money, similar to the spirit of the gold standard. Therefore, a straight forward method to determine the gold price is thus to compare its value against the total money in issue in the monetary system; in other words, to uphold the implicit ratio of gold holding to aggregate money supply, the gold price must rise in proportion to the money supply surge.

The quantity theory of money[26] and the store of value property of gold also argue for the money supply premise. According to the quantity theory of money, an increase in the money supply causes higher price levels if either or both money velocity and volume of economic activities remains constant or grows at a faster pace. A classic view of how the relationship between gold price and price level has evolved is derived from gold's attributes as a store of value and currency in the monetary system. Unlike fiat money, which can be 'printed' by way of easing monetary policy, the gold stock supplied from mines is limited and inelastic. In other words, fiat currencies can debase with increased money supply, but gold would never debase in a similar manner. This explains why gold maintains its value whereas the purchasing power of fiat currencies diminishes in an inflationary environment. Combining the store of value property of gold and the quantity theory of money, it can be inferred that the positive association between money supply and gold price is built on the role of inflation, assuming the money velocity and the total economic output to remain constant.

Previous studies examine the contribution of the store of value property to the positive relationship between the money supply and the gold price. Baur and Glover (2012a) find that the gold price and general price level co-move together because of the store of value attribute of gold. Jastram and Leyland (2009) reveal

[26] MV = PY or V = PY/M; where M is the money supply, V is the velocity of money circulation, P is the average general price level, and Y is the aggregate volume of goods and services transactions in the economy.

that although the purchasing power of gold has been fluctuating over the centuries, it returns to a constant level over time.

The empirical results of this study reveal that no individual variable in isolation drives the gold price. Thus, there is no simple relationship between the money supply growth and the gold price because all variables are operating in a broader economic context. The international money supply as a gold price determinant is actually an alternate phenomenon of the store of value property narrative: growth in the international money supply causes inflationary pressure; because gold is a traditional inflation hedge, its price is positively correlated to the money supply.

The growth in the international money supply accelerates in the fourth sub-sample period along with the rising gold price. However, the unconventional monetary policies implemented by central banks worldwide should be interpreted in a broader economic context; that is, the same price determinant may affect the gold price differently in different economic conditions. The unique feature of the money supply flow under the current unconventional monetary policies is that the increased monetary liquidity enters the asset market, whereas in previous times of monetary expansion (e.g., the 1970s), the money stock mostly went to real economic activities such as services, consumer goods, and commodities. These activities led to high inflation and encouraged considerable gold purchase among investors for hedging inflation risk in the 1970s. However, despite the flood of money supply due to the QE programmes since the 2008 financial crisis, the global economy has been growing at a level below its long-term trend; thus, the

excess liquidity in the monetary system has steered investors to allocate their money into hard assets such as gold. Therefore, the gold price rose in both monetary expansion periods as investors were seeking a store of value, but for very different reasons.

In summary, the following conclusions are drawn on the basis of the empirical results and analysis. The US dollar exchange rate is a stable determinant of the gold price; however, at times when there are drivers in force that would have led to change of inflation or inflation expectation, the store of value property of gold is triggered and those price determinants will dominate, as in the case of international money supply in the post-crisis period.

5.2 Current economic conditions

Although it can only be confirmed in retrospect, recent economic development suggests that the global economy has been transitioning into a new cycle since 2016, as reflected by the hike of overnight US dollar London Interbank Offer Rate (LIBOR) as shown in Figure 20. In fact, despite the continual flow of money into the international monetary system from central banks, the gold price has been trading in a relatively narrow range between USD1,060 and USD1,400 per ounce since mid 2013. Therefore, the gold price may not move in tandem with the international money supply going forward.

This phenomenon can again be explained by the quantity theory of money. As the velocity of money generally refers to the frequency of a unit of currency being used to transact within the economy during certain period of time (MV = PY), it can also be expressed as the ratio of GDP to money supply (V = PY/M) for the measurement of the state of the economy relative to consumers' spending attitudes. According to the formula, if the velocity of money is unchanged and the money supply rises more than the economic output, the price level will rise and vice versa. In the case of the United States, the money aggregate M2 increased a total of 75 per cent between 2008 and 2016. If the velocity of money had remained constant, the general consumer price level would have risen by a similar magnitude. However, US CPI growth was merely 1 to 2 per cent per year during the period. This was mainly due to a declining velocity of money. At the end of 2016, the velocity of M2 money in the United States reached a record low of 1.436. This means that the money in the economy was transacted only 1.436 times per year, as compared with 1.9 times per year in the pre-crisis period. Although world data is unavailable, but judging from the GDP and CPI data of major economies, the respective international velocity of money must have decelerated by a similar degree. This implies that the effect of the massive injection of international money supply was offset by the slowing money velocity and consequently failed to yield a corresponding growth in GDP; this trend appears to be continuing going forward.

The phenomenon of slow money velocity, modest price level, and sluggish economic growth indicate that people are hoarding cash instead of spending it. In

other words, less money goes to consumer spending and more money is safeguarded as people have become risk averse. This may be due to the loss of creditors' and consumers' confidence in a gloomy economy; for example, even with the implementation of unconventional monetary policies, many corporations, typically in some Asian countries, still face tight credit situations as financial institutions are reluctant to make loans to the commercial sector. Additionally, a prolonged low interest period has driven investors away from interest-bearing investments and caused them to hoard cash.

Therefore, future expected inflation would remain mild and the store of value property may not be an active driving factor for the gold price. Figure 21 illustrates the relationship between the velocity of money and the gold price, and Figure 22 displays the historical data of the velocity of money.

5.3 Theoretical implications of the research findings

This study presents various theoretical implications. The findings reveal that the composition of the price drivers of gold returns in force changes over time throughout all the sub-sample periods; there is no single or fixed set of variables determines the gold price in the long term. For the first, second and third sub-periods, the US dollar exchange rate is the primary and most significant driver, whereas other factors such as inflation, the short-term real interest rates, and the long-term real interest rates are significant variables in different periods. In the

fourth sub-period, the international money supply becomes significant, among other variables. Previous empirical studies identify different gold price determinants; including money supply (Batten et al., 2010; Sipkova and Sipko, 2014), interest rates in general (Cai et al., 2001), short-term and long-term interest rates (Baur, 2011), real interest rates (Diba and Grossman, 1984; Erb and Harvey, 2013), inflation rate (Levin and Wright, 2006; Wang et al., 2013; Beckmann and Czudaj, 2013), and exchange rates (Capie et al., 2005; Hammoudeh et al., 2009; Tully and Lucey, 2007; Sari et al., 2011). Each of these studies is valid in its own right, and the current study shows that, no simple relationship exists between a factor and the gold price because all variables interact within a broader economic context. This study reveals that a reciprocal of the variables in different economic environments through the cycles overtime is the actual cause for such disparity among previous studies.

This study further infers that the combination of the quantity theory of money and the store of value property of gold provide the basis for the premise of the positive relationship between the money supply and the gold price. Assuming that money velocity and total economic output remain constant, the current results also suggest that the positive association between the money supply and the gold price is built on the role of inflation.

This study also makes a theoretical contribution by investigating the effect of unconventional monetary policies on the gold price, through the new variable of international money supply. The empirical results also suggest that the international money supply as a gold price determinant is actually an alternate

phenomenon of the store of value property narrative: gold hedges against inflation brought by the surge of money supply.

Furthermore, the results provide evidence that other traditional price determinants identified in existing literature stem from the store of value property. This study finally deduces that the underlying economic reasons for all determinants of gold price are the same - movement of a driver in force that will eventually or is perceived as having the potential to lead to higher inflation; or a change of gold price in US dollar terms through US dollar exchange rate movement.

5.4 Practical implications of the research findings

This study presents various practical implications. As gold emerges as a financial asset, whether it can still be an effective diversifier or a safe haven matters to asset management industry practitioners and reserve managers. The findings reveal no apparent linkage between the returns of gold and equity, illustrating that gold does not co-move together with equities overall; in the fourth sub-period, an inverse relationship even exists between the two variables. The results indicate that gold can still be a diversifier or hedge against stocks in general, and the negative correlation indicates that gold is at least a weak safe haven during the post crisis period.

The gold price trend is critical or asset and reserve managers to conduct tactical trading and asset allocation, and it is a key input for hedging strategy and operation or extraction decisions in the mining and jewellery industries. For central bankers, the gold price trend is essential for reserve rebalancing activities, and its price movement is a major consideration for determining the proportion of gold holdings relative to reserve assets and money in issue to be maintained.

Practically, this study sheds lights on the interactions between financial, economic, and other factors under different economic cycles. The findings suggest that the economy may have been entering a new phase since 2016, as indicated by the hike of LIBOR, the tapering plans and the hawkish comments released by central bankers of many major economies. This study also reveals that unconventional monetary policies are in fact an alternate phenomenon of the store of value property. On one end QE programmes worldwide are still fuelling the intentional monetary liquidity, on the other side the tapering is on the horizon. The economic environment and monetary system are further complicated by the slowing money velocity. Echoing on the viewpoints in previous sections and considering no one factor in isolation can drive the gold price, all variables in force should be assessed and interpreted in a broader economic sense. The current study brings all these variables and considerations into light, and coupled with the findings that all other significant variables are linked to the store of value property, this study further put forward that, in the current economic context, the effect of international money supply will subside and the US dollar exchange rate will again become prominent in the new cycle, until the store of value property of the

next price driver is triggered. Therefore, the results and analysis of this study deepen the knowledge of the economics of the gold price, which will aid practitioners to navigate the current economic landscape and examine various variables when conducting fundamental analysis to forecast gold price trends.

5.5 Research contributions, limitations, and directions for future study

This study provides numerous contributions to the research on the economics of the gold price. The focuses and objectives of previous empirical studies are varied, and none of them examines the influence of international demand on the structure of demand, and specifically the effect of unconventional monetary policies on the returns on gold. As to a more macro level, it is envisaged that previous studies may be prone to narrow focus in the United States and Western countries. This study approaches these issues by investigating the role of the international money supply in gold market and exploring the changing composition of gold price determinants in force which evolve with the economic conditions over time. This thesis makes contributions by addressing these gaps in the literature.

Despite these contributions to the literature, some potential price determinants are not examined in this study because adequate empirical data is unavailable. The reserves rebalancing actions of central banks must affect returns on gold, but many countries only offer limited data transparency for their foreign

currency reserves, and some even under-report their gold positions. Moreover, some indicators such as GDP, income effect, and physical supply are relevant variables, but higher frequency data are required to generate reliable results in an econometric model; currently, only quarterly or annual data are available. Similarly, recent data reveal that the demand for gold derived from the jewellery and official sectors of India and China are robust. This substantial growth in demand would indicate a structural change in the gold market. However, many of the data types that can be used to represent rising demand from emerging markets are either unavailable or of a short history.

Whether gold is a counter-cyclical investment (a strong form of safe haven) is inconclusive in the current study because of limitations due to the nature of the empirical data. During the outbreak of the global financial crisis, the asset market experienced excessive volatility in the fourth quarter of 2008 and first quarter of 2009; however, only six data points represent these extreme market conditions out of the 101 observations in the sub-period, the influence is hence smoothed out by the low frequency data. For example, Baur and Lucey (2010) indicate that the safe haven effect of gold lasts for only 15 days during a stressed market. Therefore, to determine whether gold is a strong form of safe haven, higher frequency data and a shorter sample period are needed for the model.

Additional research areas that are beyond the scope of this study are critical to the literature and industry. First, some existing literature suggest that the negative relationship between the gold price and the US dollar exchange rates is merely a statistical one (Pukthuanthong and Roll, 2011; O'Connor and Lucey,

2012), and they reveal negative correlations between the returns on gold and the trade weighted value of a currency if gold prices are expressed in the same currency. Therefore, it is relevant to explore the gold price determinants using other world currencies. Second, gold demand stemming from gold ETFs has risen considerably as gold has become easier to trade. Similarly, the investment outflows from and the unwinding of gold ETFs in 2013 is considered as one of the causes for the sharp fall of gold price. The gold price movements thus may have been exacerbated by the gold ETFs trades. In summary, future research should expand the scope of this study by investigating the roles of country reserves, world currencies, gold ETFs, and emerging market demand to generate a more robust result when the empirical data becomes available.

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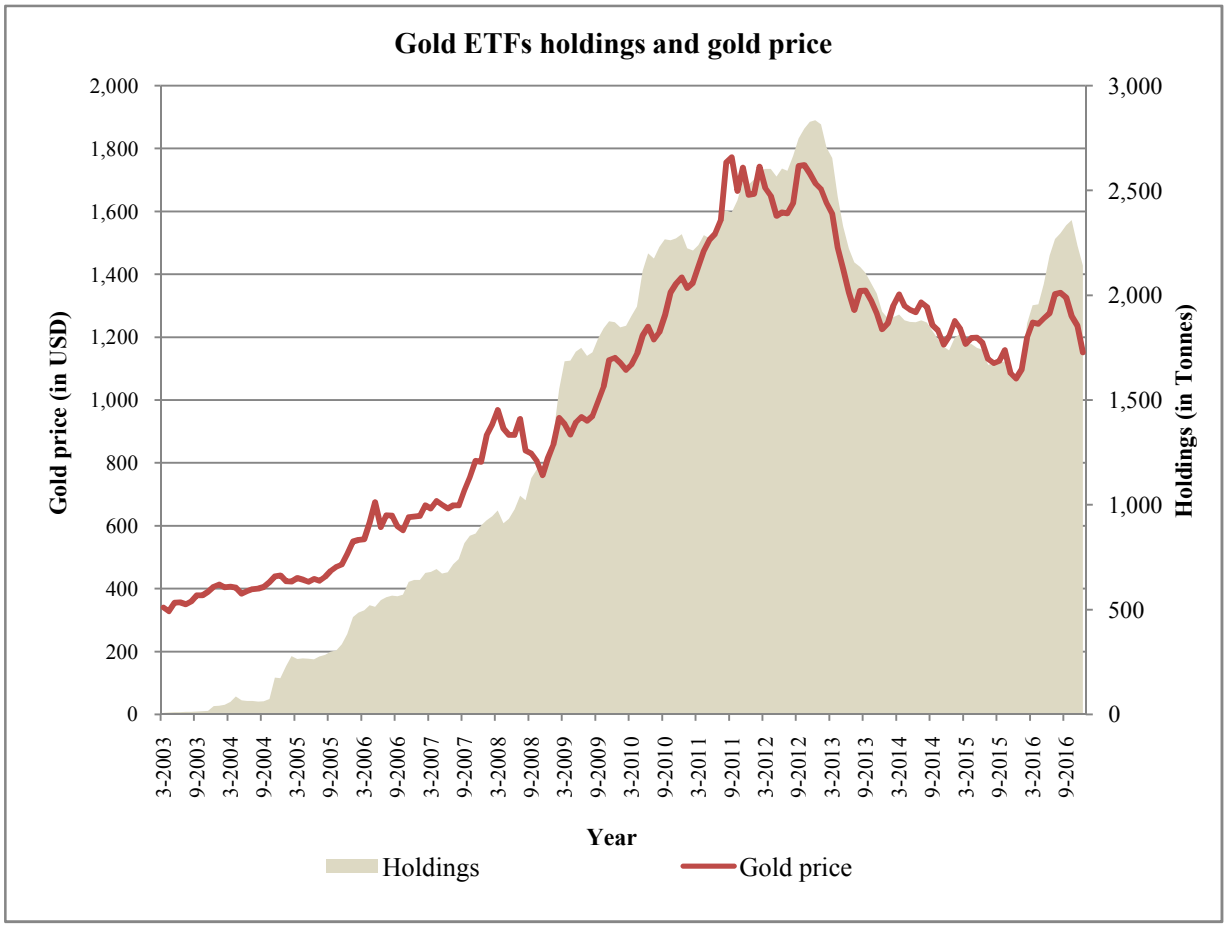
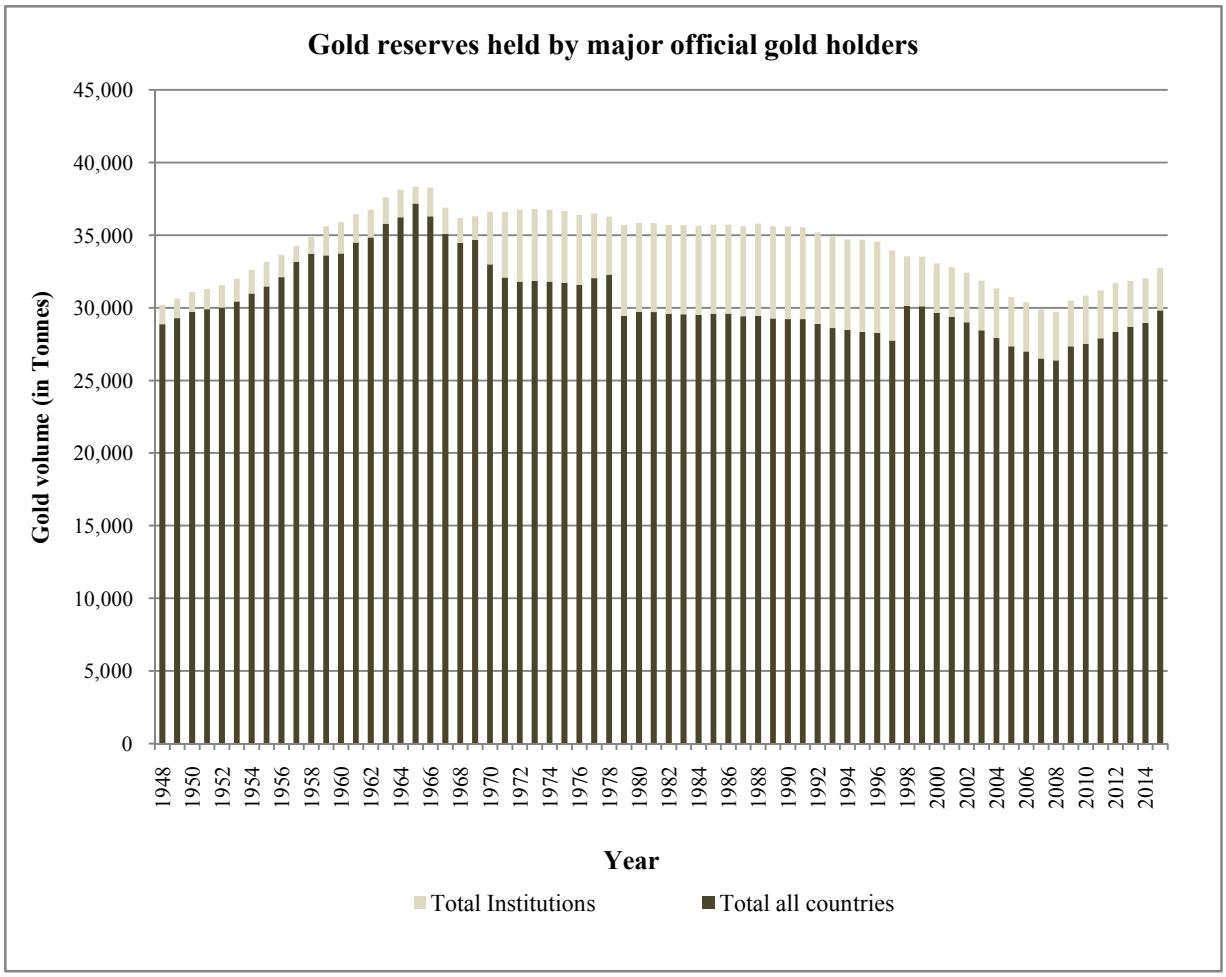
APPENDIX

Figure 1: Gold ETFs' and similar products' gold holdings and gold price



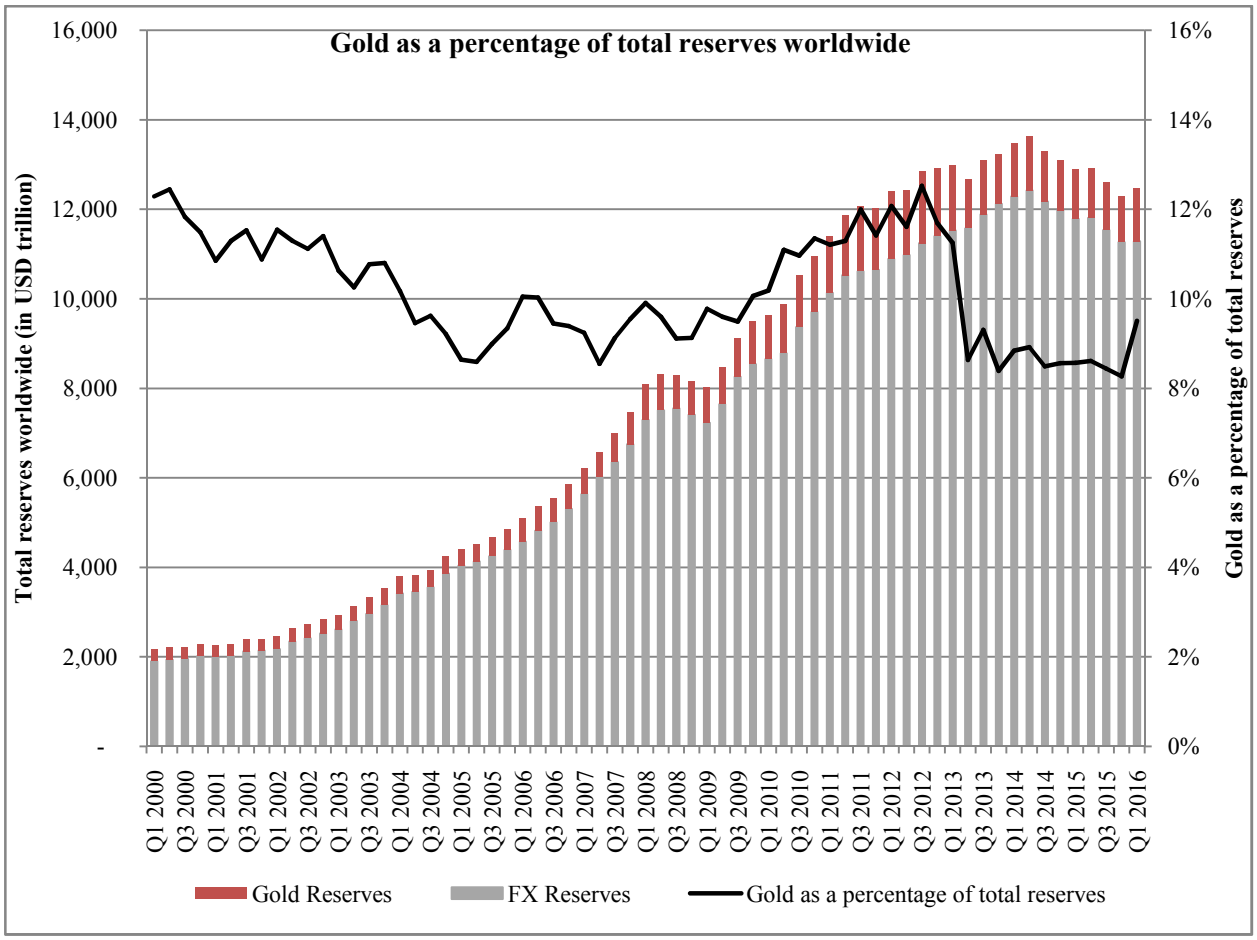
Source: Various ETF providers, LBMA, Bloomberg and World Gold Council

Figure 2: Gold reserves held by major official gold holders



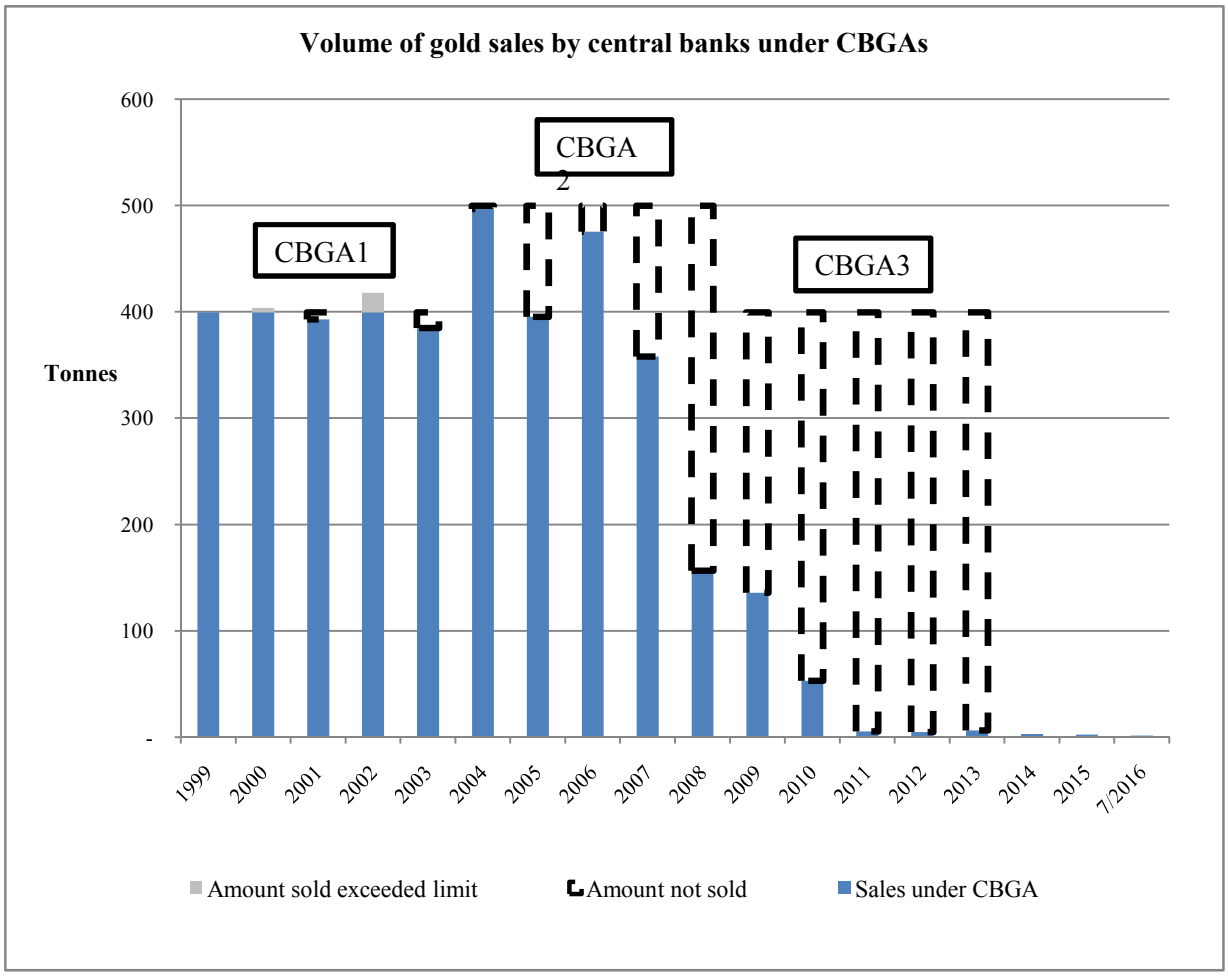
Source: Calculations by World Gold Council based on data from IMF and national sources

Figure 3: Gold as a percentage of total reserves worldwide



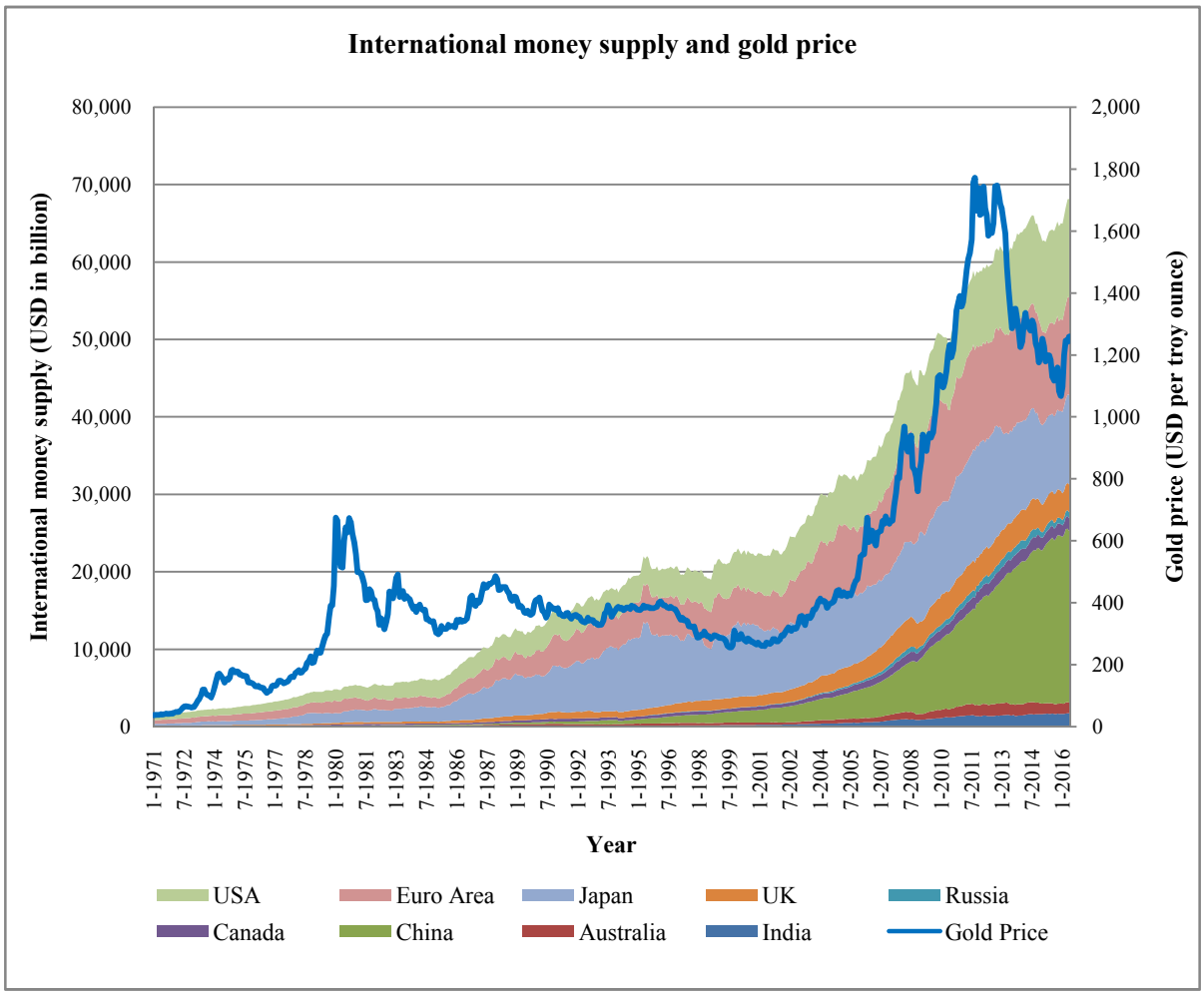
Source: IMF Statistics and World Gold Council

Figure 4: Volume of gold sales by central banks under CBGAs



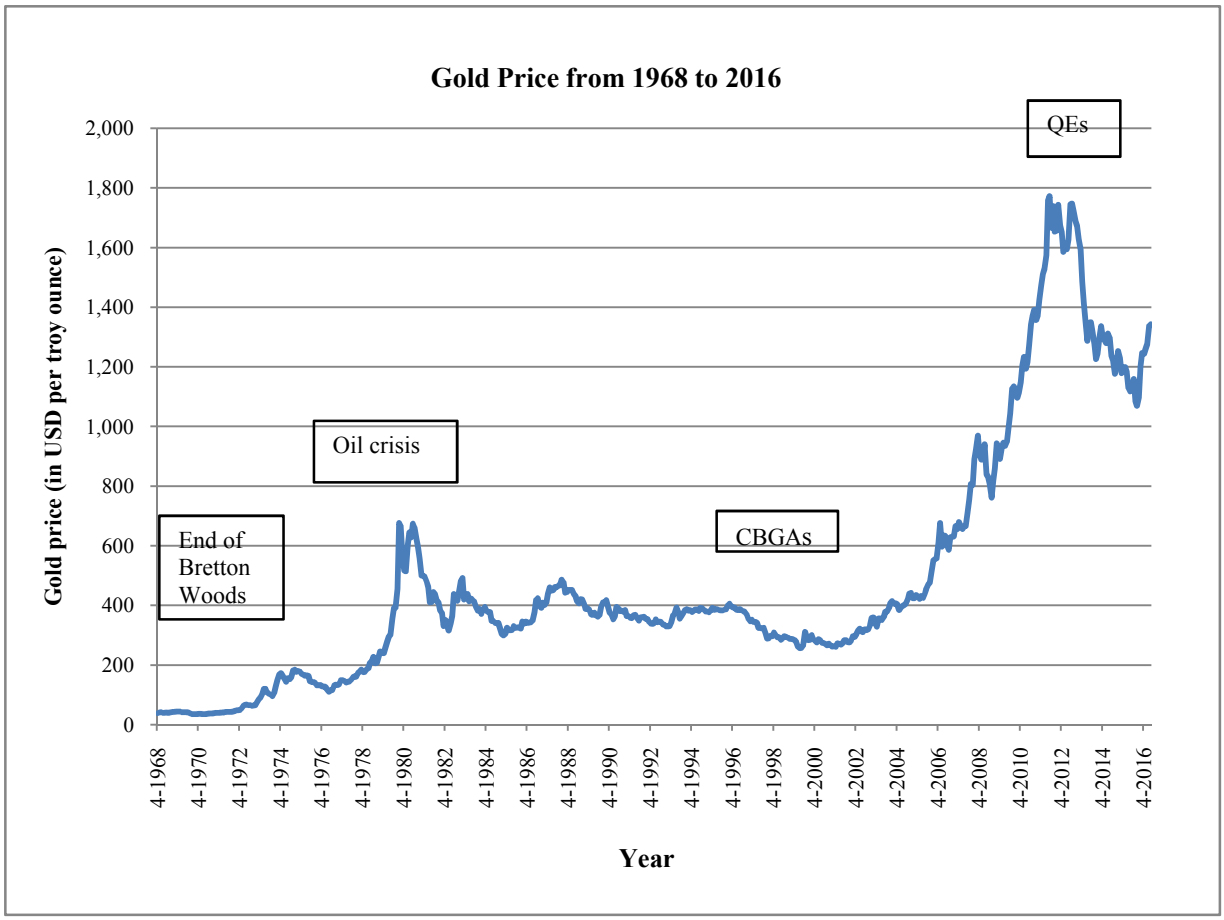
Source: IMF Statistics, ECB and World Gold Council

Figure 5: International money supply represented by major economies and gold price from 1971 to 2016



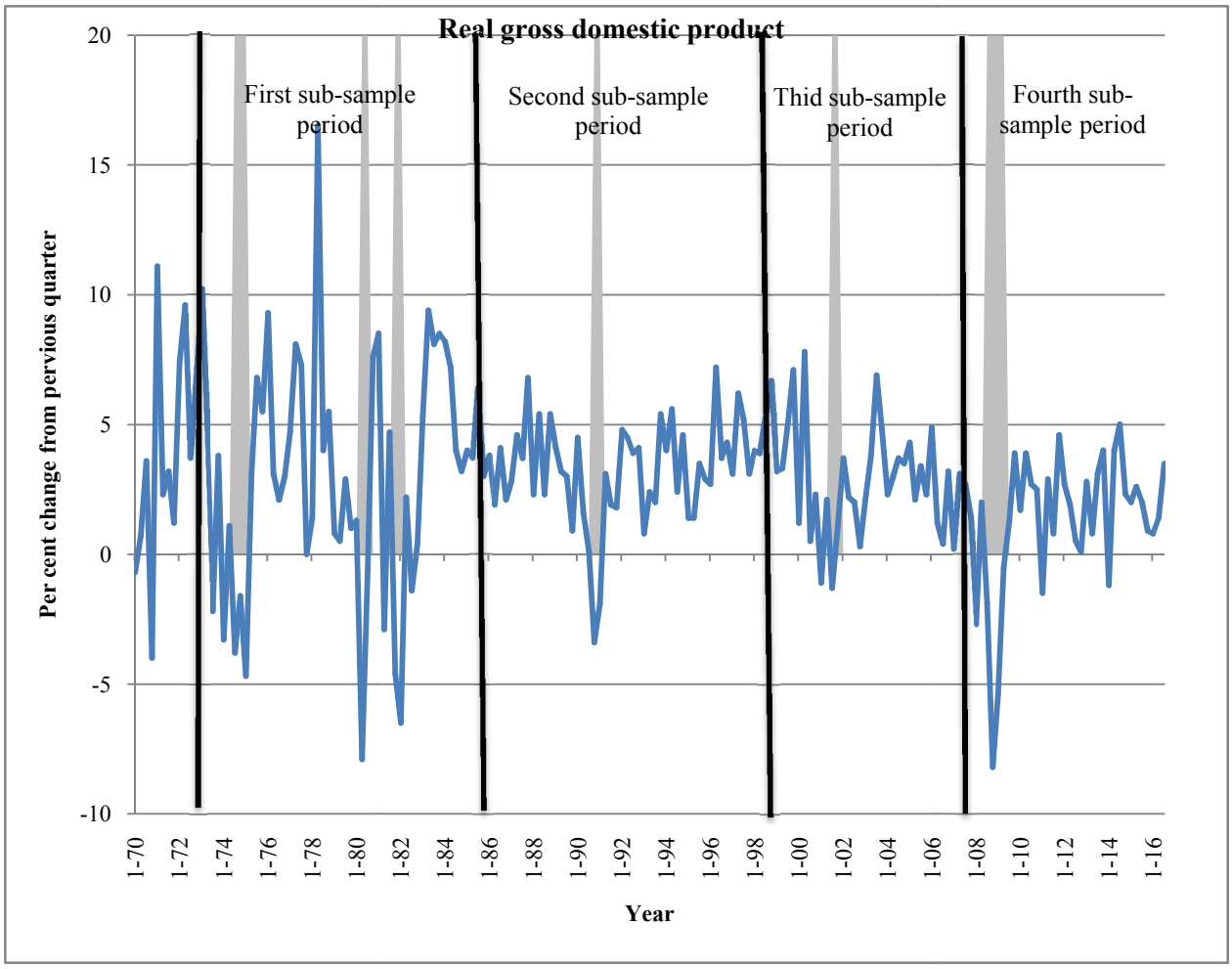
Source: IMF, OECD, BOE, FRED (US) and IBA

Figure 6: Gold price history



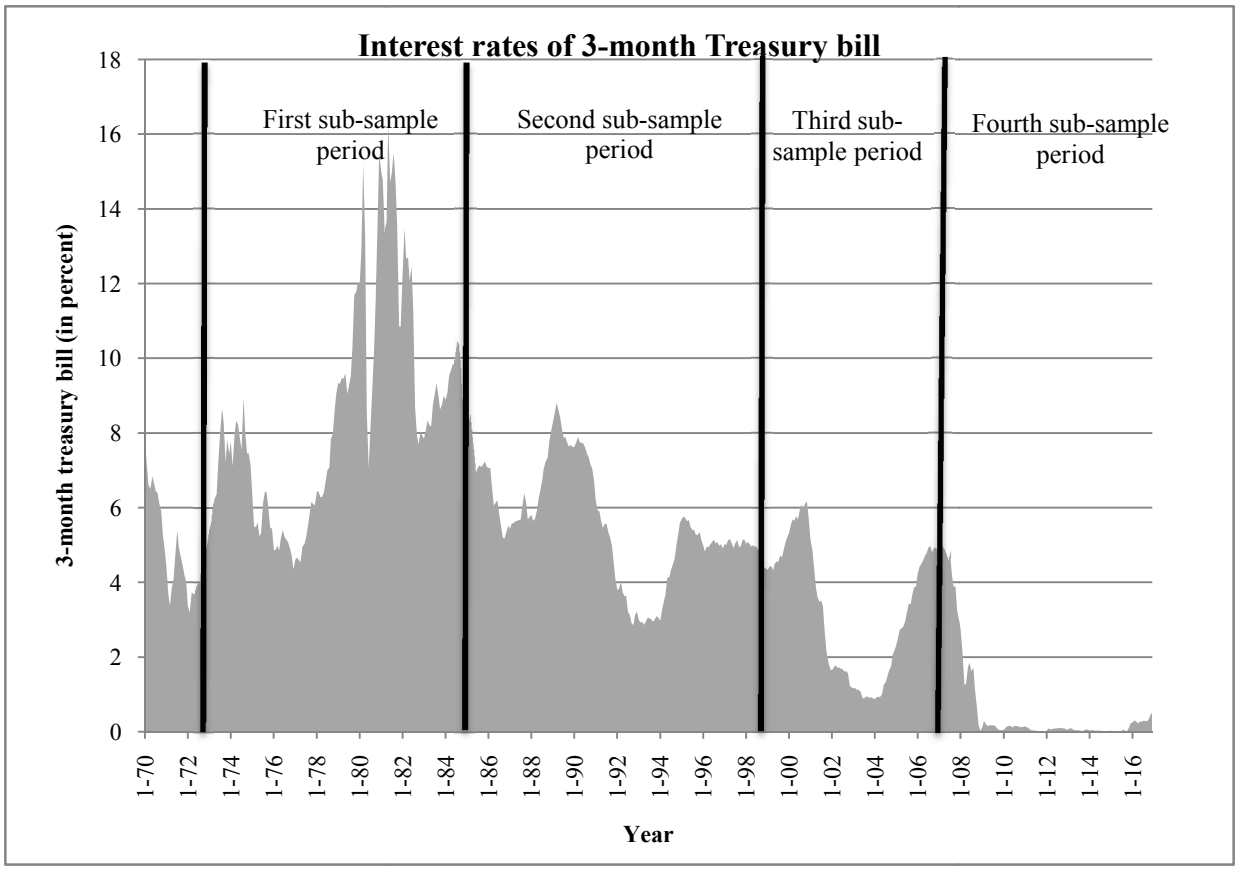
Source: IBA, Gold Fixing Price 3:00 P.M. (London time) in London Bullion Market

Figure 7: Real gross domestic product in the United States



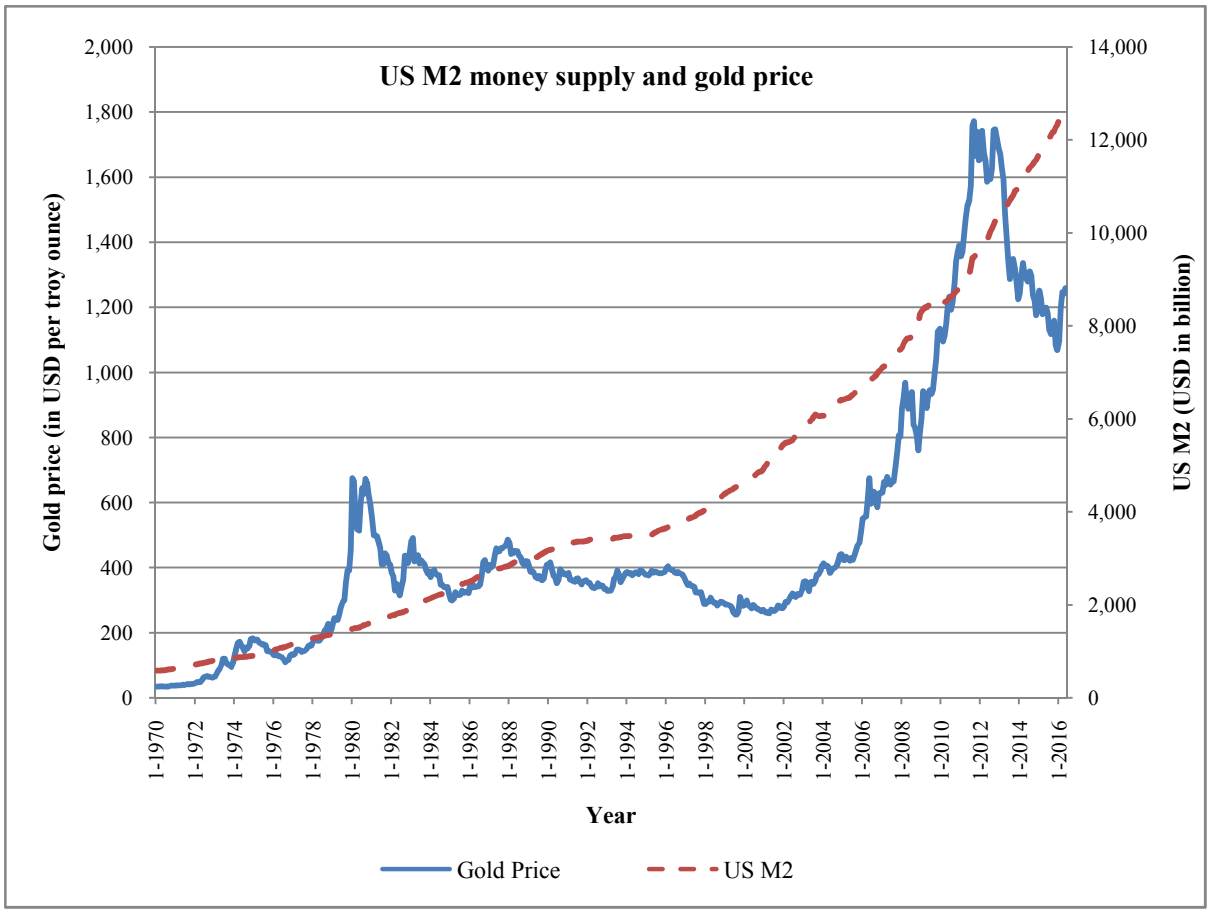
Source: US Bureau of Economic Analysis

Figure 8: Interest rates of 3-month Treasury bill of the United States



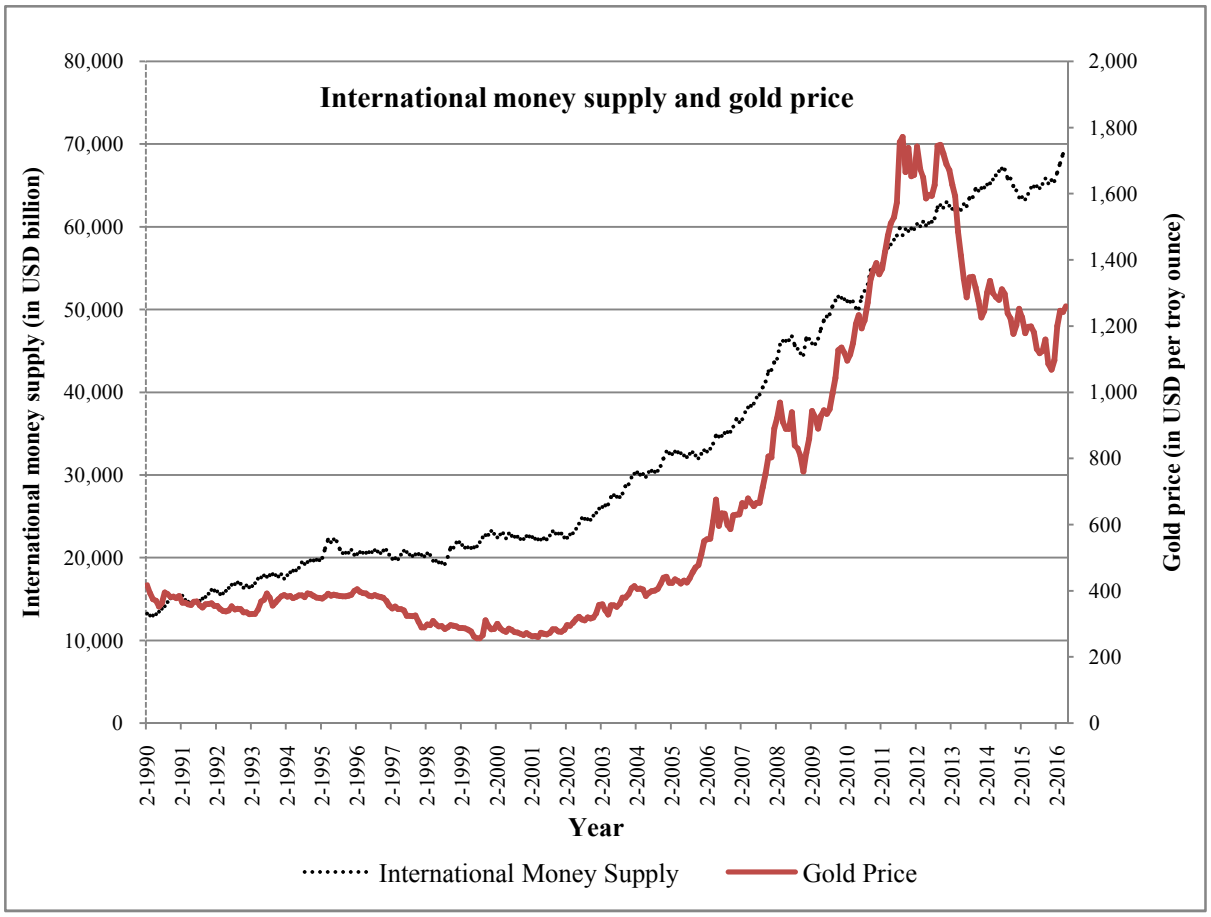
Source: FRED (US)

Figure 9: US M2 money supply and gold price



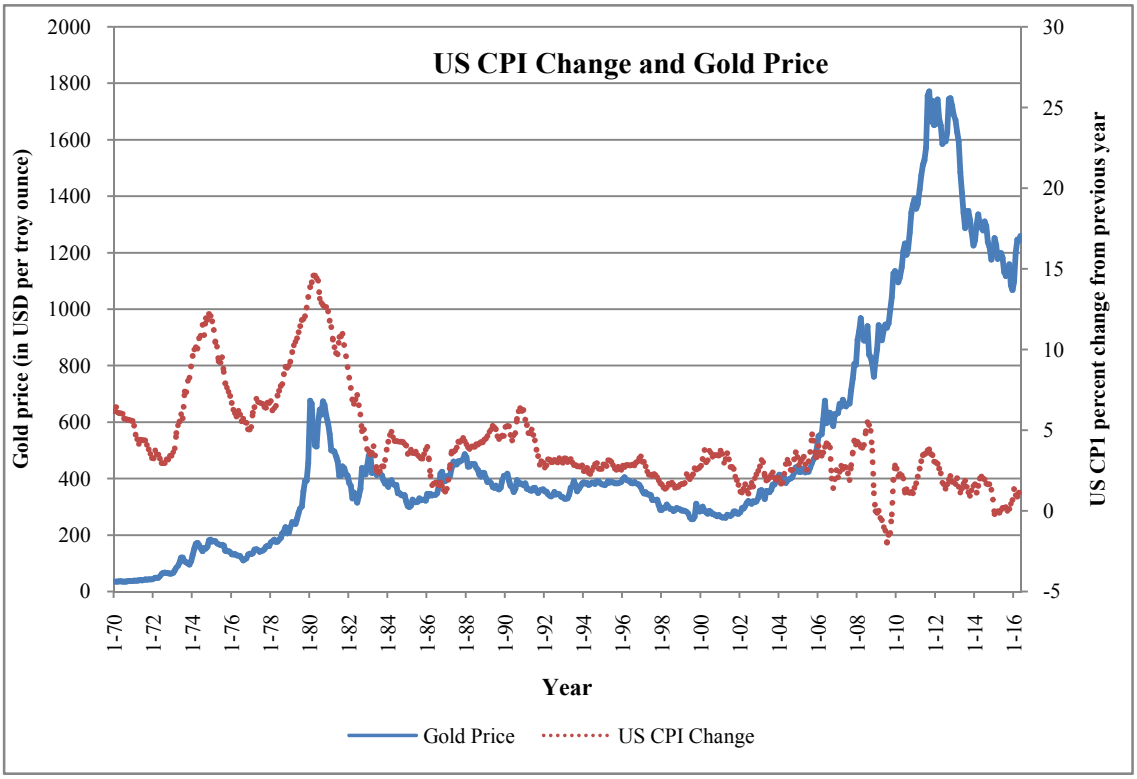
Source: FRED (US) and IBA

Figure 10: International money supply and gold price from 1990 to 2016



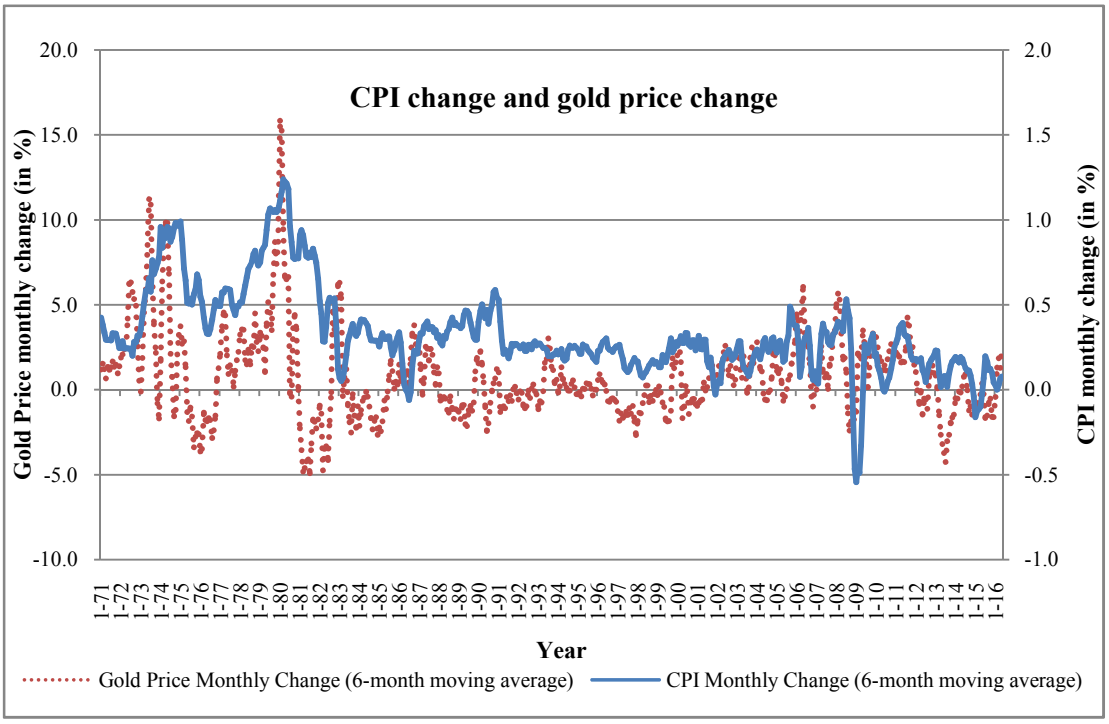
Source: IMF, OECD, BOE, FRED(US) and IBA

Figure 11: US CPI change and gold price



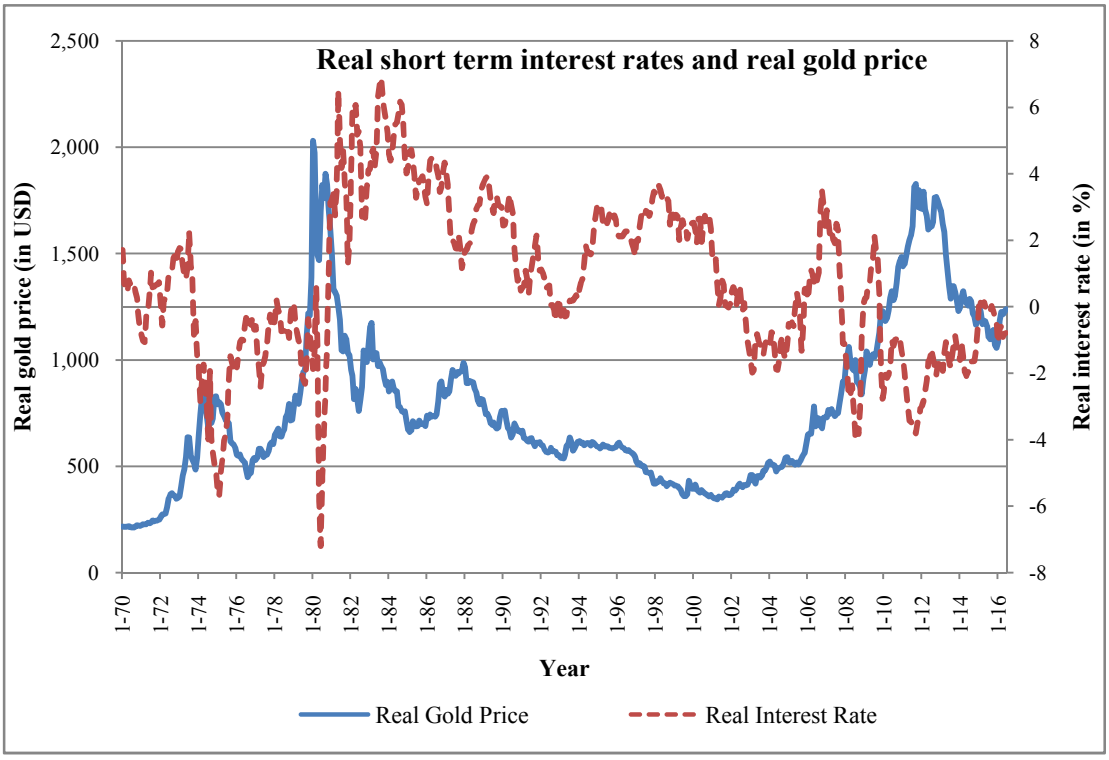
Source: US Bureau of Labor Statistics and IBA

Figure 12: US CPI change and gold price change, smoothed with 6-month moving average



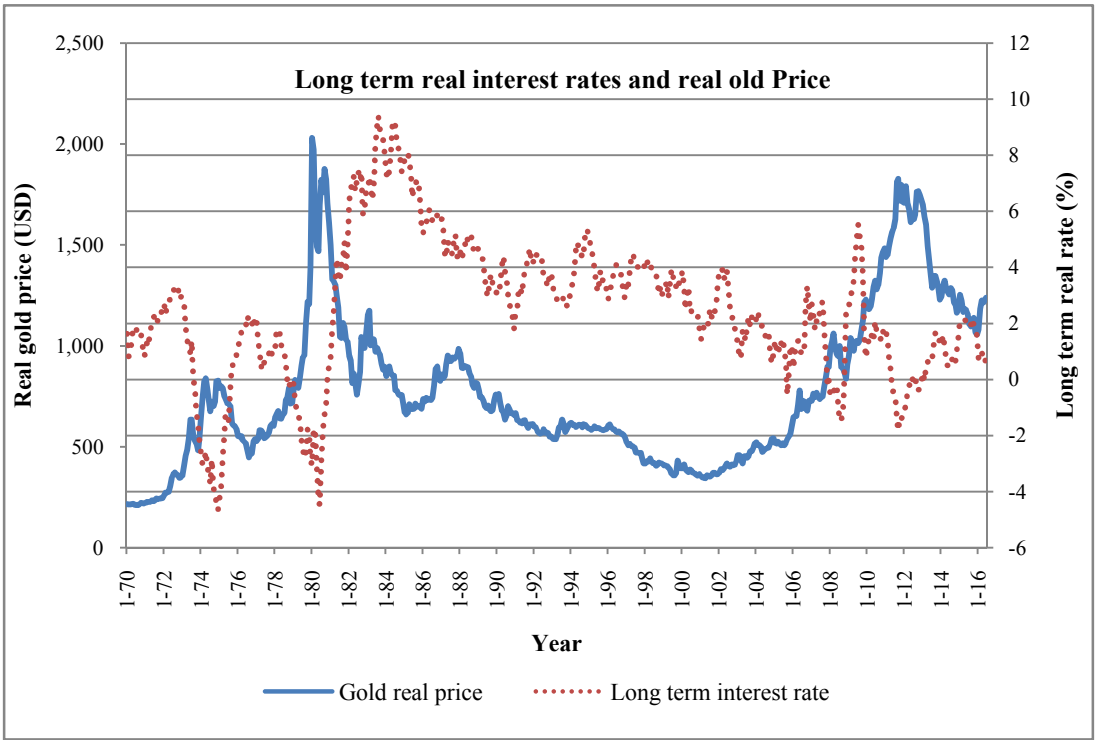
Source: US Bureau of Labor Statistics and IBA

Figure 13: Short term real interest rates and real gold price



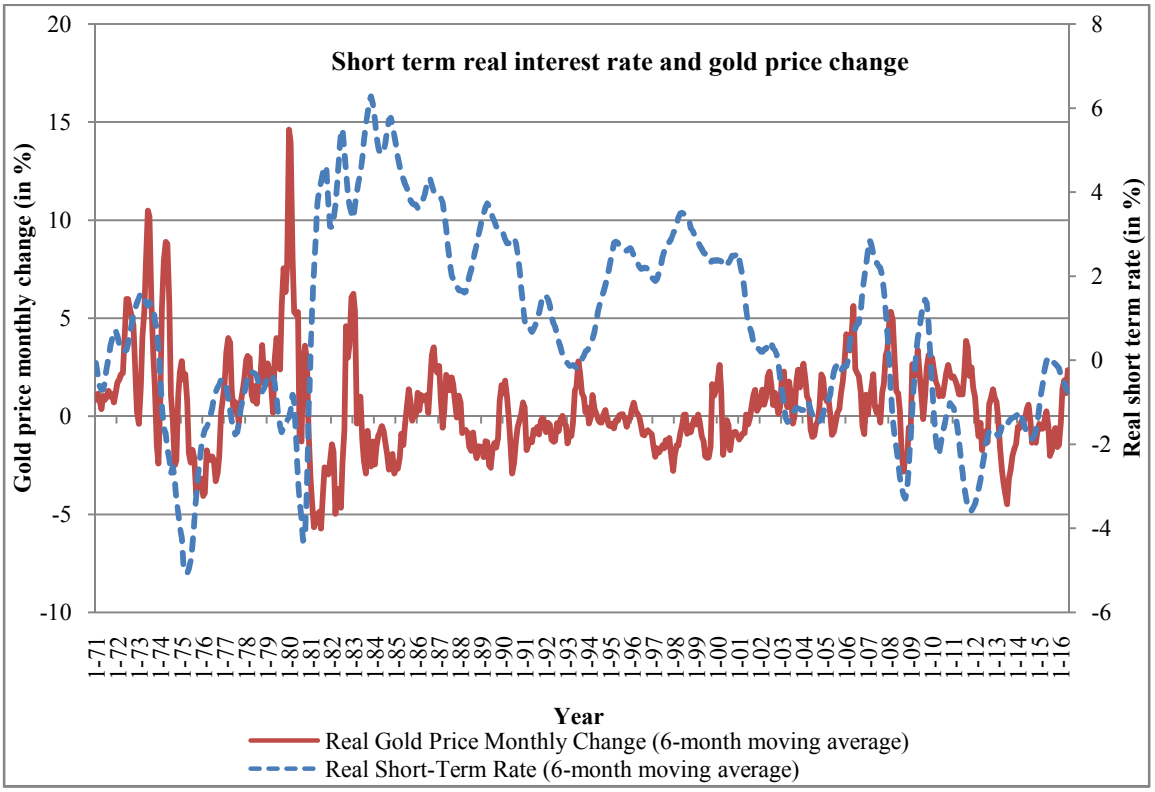
Source: FRED (US) and IBA

Figure 14: Long term real interest rates and real gold price



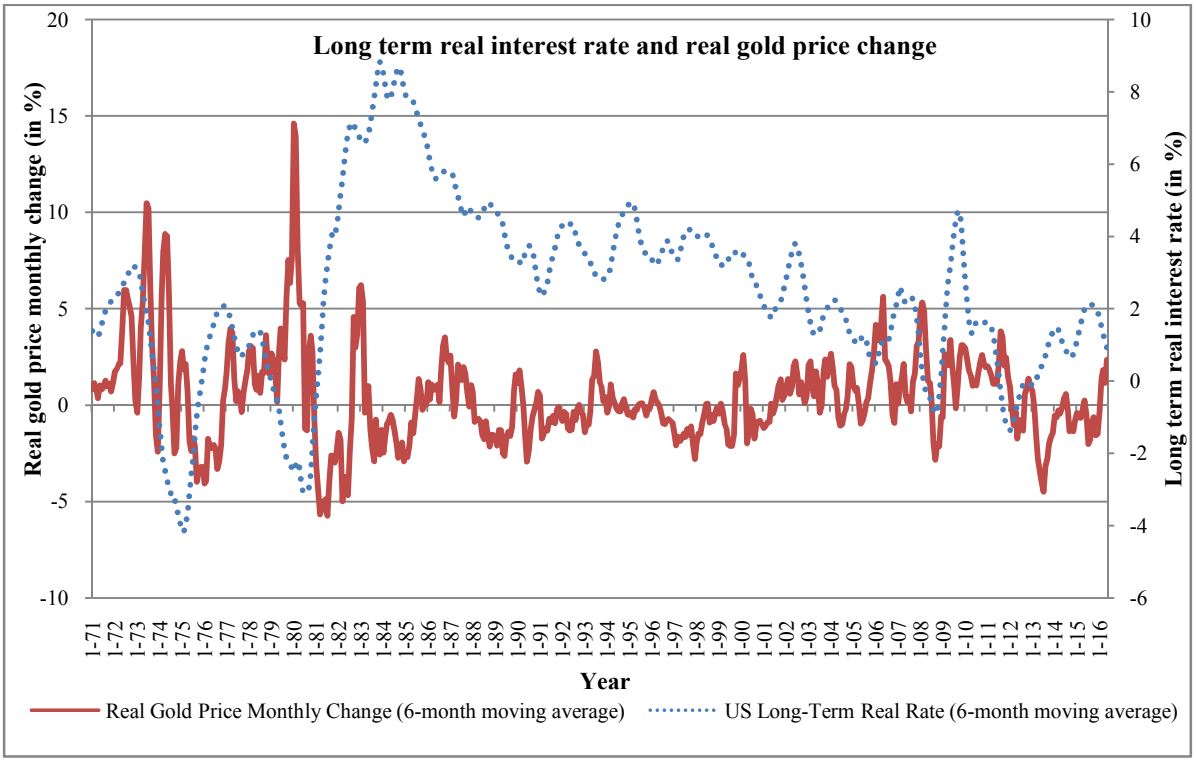
Source: FRED (US) and IBA

Figure 15: Short term real interest rates change and real gold price change, smoothed with 6-month moving average



Source: FRED (US) and IBA

Figure 16: Long term real interest rates and real gold price change, smoothed with 6-month moving average

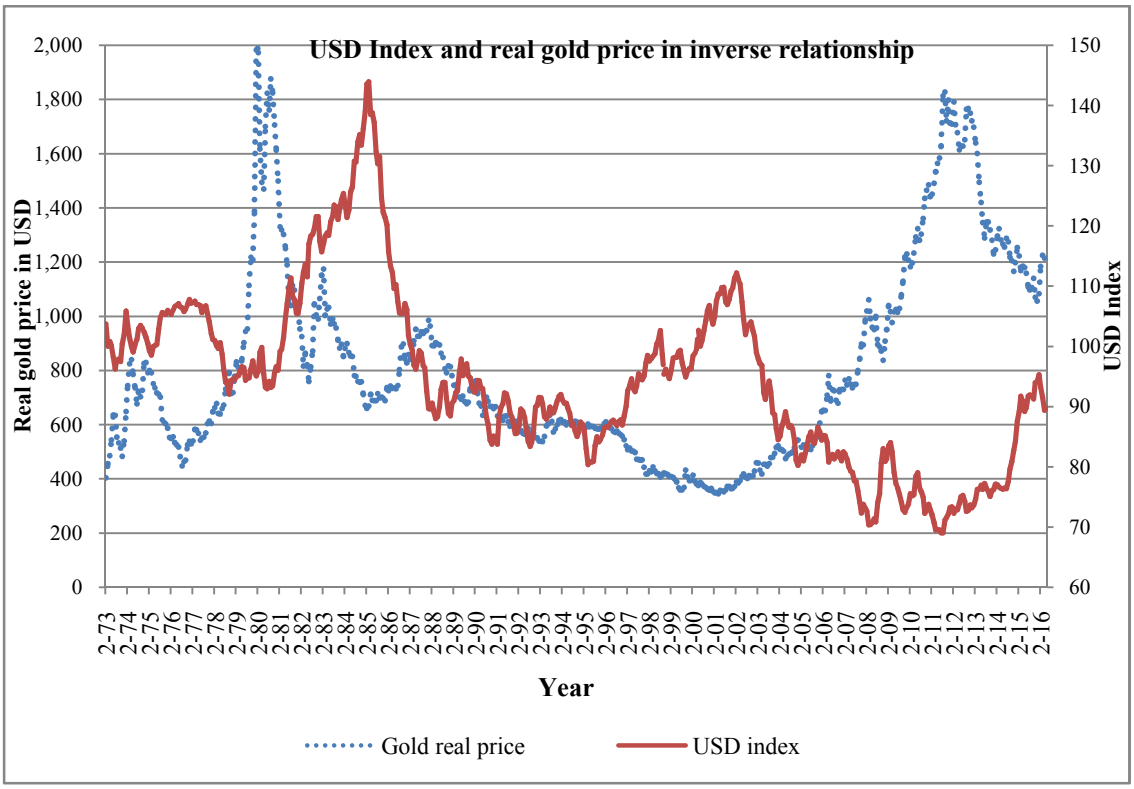


Source: FRED (US) and IBA

Figure 17: S&P 500 index and gold price

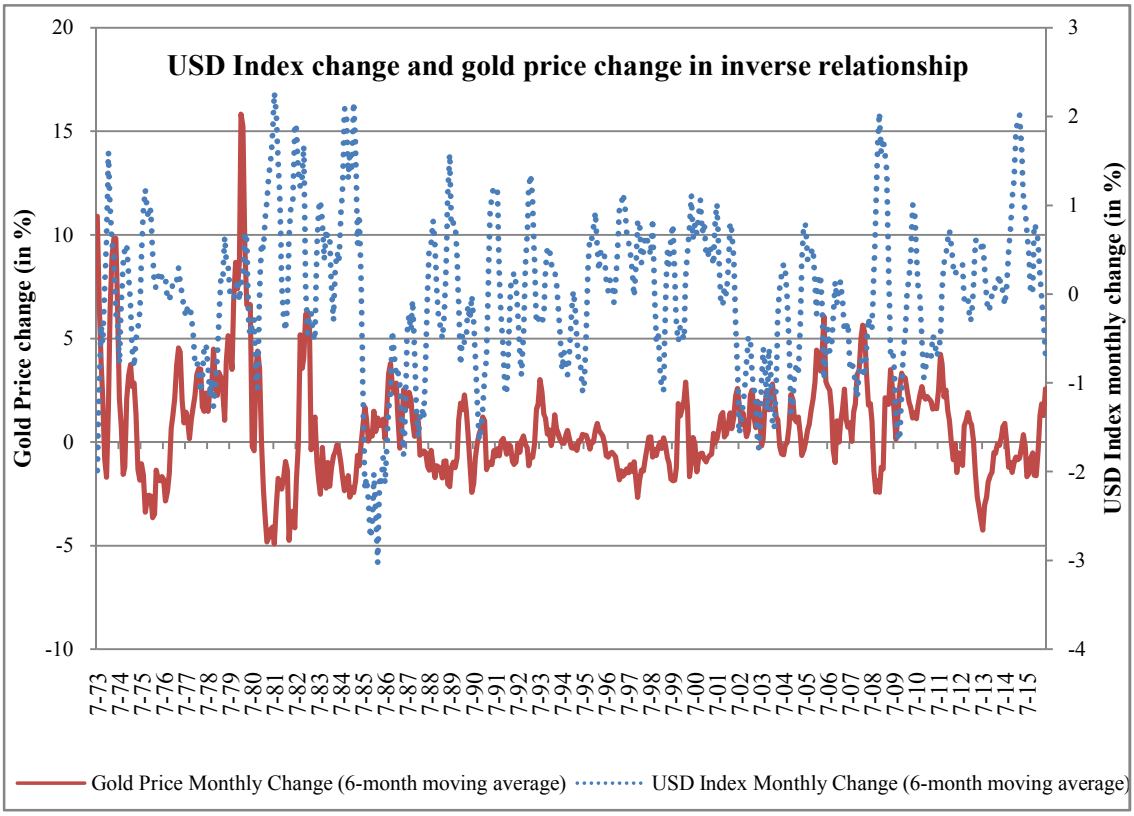
Source: DataStream and IBA

Figure 18: USD Index and real gold price in inverse relationship



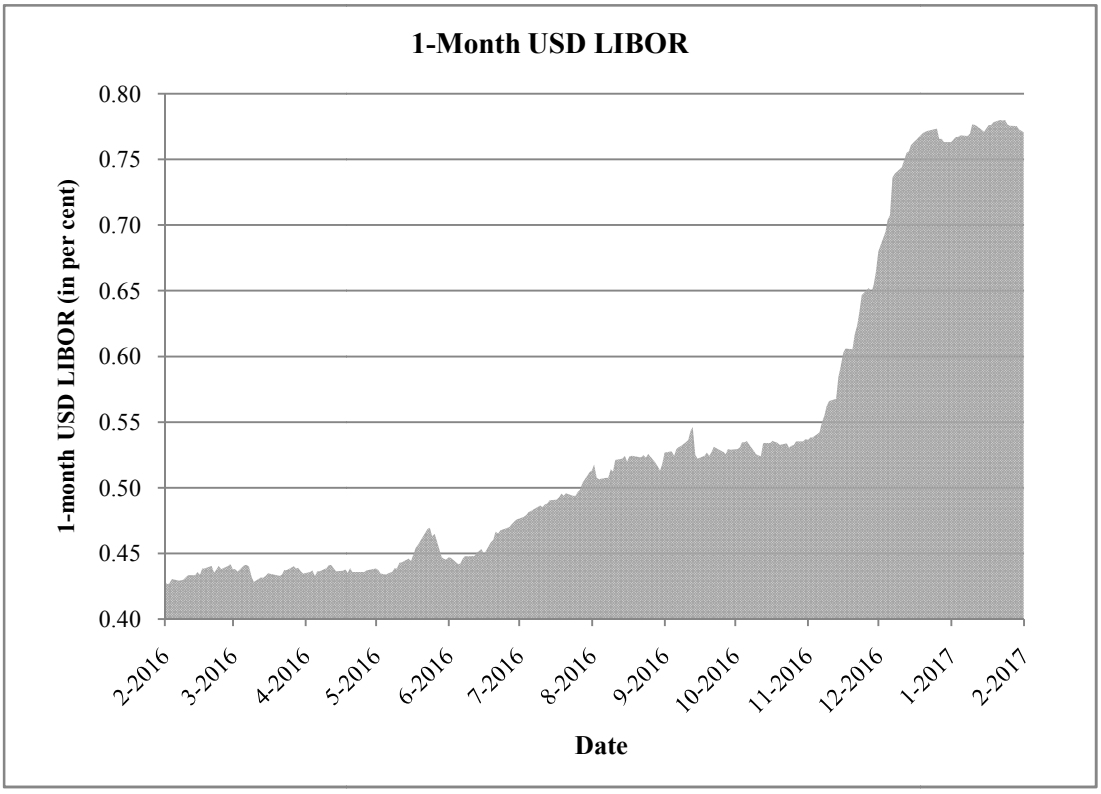
Source: FRED (US) and IBA

Figure 19: USD Index change and gold price change in inverse relationship



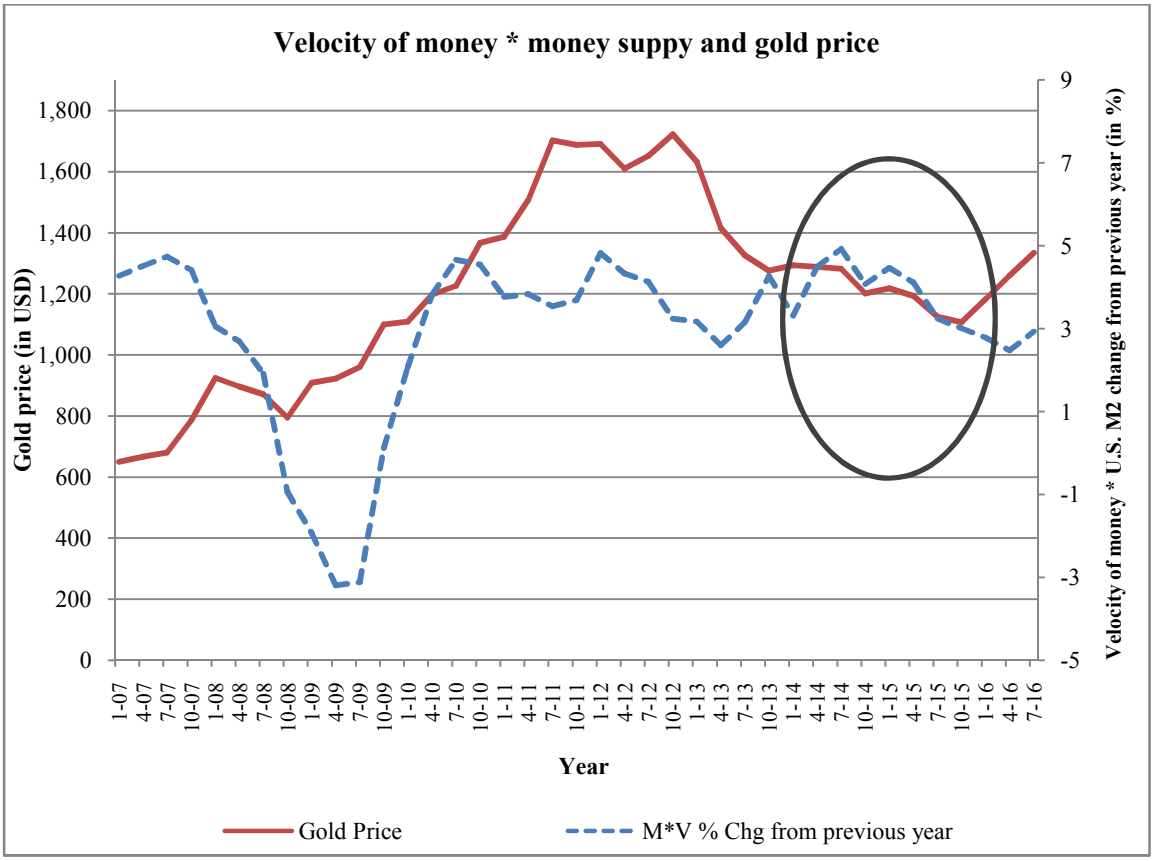
Source: FRED (US) and IBA

Figure 20: 1-Month USD LIBOR



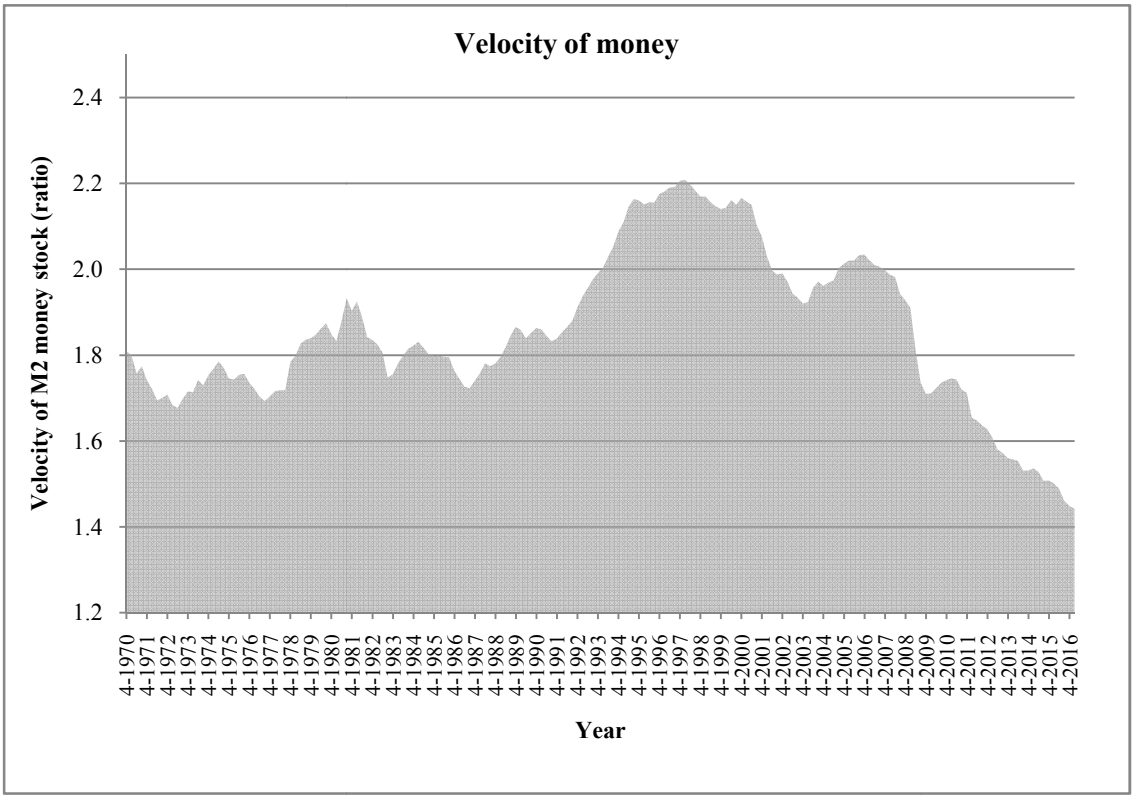
Source: IBA

Figure 21: Velocity of money * US M2 and the gold price



Source: FRED (US) and IBA

Figure 22: Velocity of US M2 money stock



Source: FRED (US)

Table 1: Identifiable gold demand by category

(in Tonnes)

Year	Jewelry	Bar and coin investment	ETF and similar products	Technology	Central banks	Total
2004	2,673.0	346.0	132.6	416.0	-497.0	3,070.6
2005	2,266.8	387.8	208.1	429.4	-395.6	4,122.2
2006	2,301.4	429.8	258.7	471.7	-365.4	3,096.2
2007	2,424.9	437.5	259.6	477.7	-483.8	3,116.0
2008	2,306.2	917.9	325.0	464.7	-235.4	3,778.3
2009	1,816.3	832.3	644.6	414.4	-33.6	3,674.0
2010	2,051.8	1,202.9	420.8	460.5	79.2	4,215.1
2011	2,091.1	1,495.8	238.5	428.6	480.8	4,734.8
2012	2,129.3	1,300.2	306.7	381.3	569.3	4,686.8
2013	2,682.7	1,707.1	-915.5	355.9	623.8	4,454.0
2014	2,480.6	1,040.0	-183.8	348.7	583.9	4,269.3
2015	2,388.6	1,047.0	-128.3	332.0	576.5	4,215.8
2016	2,041.6	1,029.2	531.9	322.5	383.6	4,308.7

Source: Metals Focus; GFMS Thomson Reuters; IBA; World Gold Council

Table 2: Historical data of physical gold supply

Year	Mine Production	Net Producer Hedging	Official Sector Sales	Recycled Gold	Total Supply
			(Tonnes)		
2002	2,589	-412	545	835	3,557
2003	2,593	-279	617	939	3,870
2004	2,469	-427	470	849	3,361
2005	2,522	-86	659	889	3,984
2006	2,467	-403	319	1,069	3,452
2007	2,476	-444	484	956	3,472
2008	2,409	-349	236	1,217	3,513
2009	2,554	-257	44	1,549	3,890
2010	2,745	-109	0	1,683	4,319
2011	2,846	23	0	1,667	4,536
2012	2,917	-45	0	1,684	4,556
2013	3,076	-28	0	1,263	4,311
2014	3,155	105	0	1,191	4,451
2015	3,233	13	0	1,117	4,363
2016	3,236	26	0	1,309	4,571

Source: Metals Focus; GFMS Thomson Reuters; IBA; World Gold Council

Table 3: Descriptive statistics

The table presents the descriptive statistics of the gold returns and the change or the returns of the independent variables for the whole sample period from January 1973 to May 2016.

	Observations	Mean	Median	Standard Deviation	Maximum	Minimum
Gold price	520	0.699	0.049	5.224	48.392	-16.795
US money supply	520	0.532	0.508	0.368	2.781	-0.760
International money supply	520	0.693	0.554	1.544	6.234	-4.372
Inflation rate	520	0.333	0.284	0.344	1.810	-1.771
Short term real interest rate	520	-0.005	0.006	0.596	2.954	-4.457
Long term real interest rate	520	-0.004	-0.022	0.471	2.351	-2.129
Equities S&P 500	520	0.657	0.923	4.434	16.305	-21.763
USD exchange rates	520	-0.021	0.051	1.711	6.684	-5.247
Market risk	520	0.000	-0.015	0.453	4.612	-3.894
Inflation expectation	460	-0.006	0.000	0.442	2.100	-2.000

Table 4: Univariate regression analysis of return of gold price on M2 money supply of the United States

$R_{gold,\,t} = \mu + \beta_i \Delta\, MS_{US,t} + \varepsilon_t$

R_{gold} is the returns of gold price. $\Delta\, MS_{US}$ is the growth rate of money supply M2 of the United States;

	Whole period		First sub-period	Second sub-period	Third sub-period		Fourth sub-period	
Intercept	-0.0201		0.7412	-0.5003	1.7194	**	-0.7693	
	(-0.05)		(0.5)	(-1.31)	(2.49)		(-1.21)	
US Money Supply	1.3530	**	0.7849	1.3295	-1.4021		2.4645	**
	(2.18)		(0.43)	(1.59)	(-1.21)		(2.61)	
n	520		155	156	108		101	
R Square	0.0091		0.0012	0.0161	0.0137		0.0643	
Adjusted R Square	0.0072		-0.0053	0.0097	0.0044		0.0549	
F-value	4.75		0.18	2.52	1.47		6.80	

t-value is shown in the parenthesis
***1% level of significance
**5% level of significance
*10% level of significance

Table 5: Univariate regression analysis of return of gold price on international money supply

$R_{gold,\,t} = \mu + \beta_i \Delta MS_{international,\,t} + \varepsilon_t$

R_{gold} is the returns of gold. $\Delta MS_{international}$ is the growth rate of international money supply.

	Whole period		First sub-period		Second sub-period		Third sub-period		Fourth sub-period	
Intercept	0.0907		0.3278		-0.3520		0.3040		-0.2108	
	(0.37)		(0.46)		(-1.47)		(0.78)		(-0.52)	
International Money Supply	0.8789	***	1.1384	***	0.4738	***	1.1282	***	1.5404	***
	(6.12)		(2.74)		(4.02)		(4.26)		(4.74)	
n	520		155		156		108		101	
R Square	0.0674		0.0466		0.0948		0.1462		0.1851	
Adjusted R Square	0.0656		0.0404		0.0889		0.1381		0.1768	
F-value	37.47		7.49		16.12		18.15		22.48	

t-value is shown in the parenthesis
***1% level of significance
**5% level of significance
*10% level of significance

Table 6: Univariate regression analysis of return of gold price on CPI

$R_{gold,\,t} = \mu + \beta_i \Delta\, Inflation_t + \varepsilon_t$

R_{gold} is the returns of gold price. Δ *Inflation* is the per cent change of inflation rate, measured by the CPI for all urban consumers of all items in the United States.

	Whole period	First sub-period	Second sub-period	Third sub-period	Fourth sub-period
Intercept	-0.2582	-0.9951	-0.5080	0.1637	0.1785
	(-0.82)	(-0.81)	(-1.23)	(0.33)	(0.42)
US CPI	2.8787 ***	3.7838 **	1.8682	3.6545 ***	2.8366 **
	(4.40)	(2.16)	(1.44)	(2.65)	(2.36)
n	520	155	156	108	101
R Square	0.0360	0.0296	0.0132	0.0622	0.0534
Adjusted R Square	0.0341	0.0232	0.0068	0.0533	0.0439
F-value	19.33	4.66	2.07	7.03	5.59

t-value is shown in the parenthesis
***1% level of significance
**5% level of significance
*10% level of significance

Table 7: Univariate regression analysis of return of gold price on inflation rate expectation

$R_{gold,\,t} = \mu + \beta_i \Delta\, Exp.\ Infl._t + \varepsilon_t$

R_{gold} is the returns of gold price. $\Delta Exp.\ Infl.$ is the inflation expectation, measured by the change of the median expected price for the next 12 months by the consumers of the United States

	Whole period	First sub-period	Second sub-period	Third sub-period	Fourth sub-period
Intercept	0.5561 **	0.9963	-0.0166	1.0001 ***	0.5308
	(2.46)	(1.21)	(-0.07)	(2.68)	(1.29)
Inflation Expectation	1.8270 ***	2.4180 **	0.5932	2.0981 **	0.1619
	(3.57)	(2.15)	(0.70)	(2.11)	(0.13)
n	460	95	156	108	101
R Square	0.0271	0.0475	0.0032	0.0403	0.0002
Adjusted R Square	0.0250	0.0372	-0.0033	0.0313	-0.0099
F-value	12.78	4.63	0.49	4.45	0.02

t-value is shown in the parenthesis

***1% level of significance

**5% level of significance

*10% level of significance

Table 8: Univariate regression analysis of return of gold price on change of short-term real interest rate

$R_{gold,\,t} = \mu + \beta_i \Delta I_{short\ term,t} + \varepsilon_t$

R_{gold} is the returns of gold price. $\Delta I_{short\ term}$ is the change of short term real interest rates of the United States

	Whole period		First sub-period		Second sub-period		Third sub-period		Fourth sub-period	
Intercept	0.6929	***	1.3217	**	-0.0302		0.9451	**	0.5436	
	(3.06)		(2.12)		(-0.13)		(2.55)		(1.38)	
Short Term Real Interest Rate	-1.3226	***	-0.8605		-2.9015	***	-2.0116	**	-2.0141	**
	(-3.48)		(-1.22)		(-3.93)		(-2.56)		(-2.49)	
n	520		155		156		108		102	
R Square	0.0228		0.0097		0.0913		0.0583		0.0582	
Adjusted R Square	0.0209		0.0032		0.0854		0.0495		0.0488	
F-value	12.08		1.49		15.47		6.57		6.18	

t-value is shown in the parenthesis
***1% level of significance
**5% level of significance
*10% level of significance

Table 9: Univariate regression analysis of return of gold price on change of long-term real interest rate

$R_{gold,\,t} = \mu + \beta_i \Delta I_{long\ term,t} + \varepsilon_t$

R_{gold} is the returns of gold price. $\Delta I_{long\ term}$ is the change of long term real interest rates of the United States.

	Whole period		First sub-period		Second sub-period		Third sub-period		Fourth sub-period	
Intercept	0.6924	***	1.3361	**	-0.0255		0.9453	**	0.5502	
	(3.06)		(2.14)		(-0.11)		(2.60)		(1.42)	
Long-Term Real Interest Rate	-1.7518	***	-1.3427		-0.3241		-2.5574	***	-2.8361	***
	(-3.64)		(-1.24)		(-0.43)		(-3.28)		(-3.63)	
n	520		155		156		108		101	
R Square	0.0250		0.0100		0.0012		0.0921		0.1176	
Adjusted R Square	0.0231		0.0035		-0.0053		0.0835		0.1087	
F-value	13.26		1.54		0.19		10.75		13.19	

t-value is shown in the parenthesis
***1% level of significance.
**5% level of significance
*10% level of significance

Table 10: Univariate regression analysis of return of gold price on change of S&P 500 returns

$R_{gold,\,t} = \mu + \beta_i \Delta R_{equities,t} + \varepsilon_t$

R_{gold} is the returns of gold price. $\Delta R_{equities}$ is the returns of equities, represented by S&P 500.

	Whole period		First sub-period		Second sub-period	Third sub-period		Fourth sub-period	
Intercept	0.7475	***	1.3062	**	0.0582	1.0410	***	0.6023	
	(3.23)		(2.07)		(0.24)	(2.74)		(1.48)	
S&P 500	-0.0732		0.0142		-0.0636	-0.0961		-0.1573	*
	(-1.42)		(0.10)		(-1.19)	(-1.00)		(-1.82)	
n	520		155		156	108		101	
R Square	0.0039		0.0001		0.0091	0.0093		0.0323	
Adjusted R Square	0.0019		-0.0065		0.0027	0.0000		0.0225	
F-value	2.01		0.01		1.41	1.00		3.30	

t-value is shown in the parenthesis
***1% level of significance.
**5% level of significance
*10% level of significance

Table 11: Univariate regression analysis of return of gold price on USD exchange rates

$R_{gold,\,t} = \mu + \beta_i \Delta\, USD\ Index_t + \varepsilon_{i,t}$

R_{gold} is the returns of gold price. Δ *USD Index* is the per cent change of USD exchange rate, represented by USD Index.

	Whole period		First sub-period		Second sub-period		Third sub-period		Fourth sub-period	
Intercept	0.6764	***	1.4578	**	-0.1069		0.7455	**	0.7279	*
	(3.15)		(2.49)		(-0.48)		(2.22)		(1.93)	
USD Index	-1.0797	***	-1.6278	***	-0.6194	***	-1.2104	***	-0.9465	***
	(-8.6)		(-4.73)		(-4.8)		(-5.81)		(-4.53)	
n	520		155		156		108		101	
R Square	0.1250		0.1277		0.1302		0.2414		0.1720	
Adjusted R Square	0.1233		0.1220		0.1246		0.2343		0.1636	
F-value	74.01		22.40		23.06		33.74		20.56	

t-value is shown in the parenthesis
***1% level of significance
**5% level of significance
*10% level of significance

Table 12: Univariate regression analysis of return of gold price on change of market risk

$R_{gold,\,t} = \mu + \beta_i \Delta\, Risk_t + \varepsilon_{i,t}$

R_{gold} is the returns of gold price. Δ *Risk* is the monthly absolute change of monthly standard deviation of S&P500.

	Whole period	First sub-period	Second sub-period	Third sub-period	Fourth sub-period
Intercept	0.6992 ***	1.3154 **	-0.0218	1.0185 ***	0.5319
	(3.05)	(2.10)	(-0.09)	(2.68)	(1.30)
Market Risk	0.4388	-1.1808	0.4457	0.8139	0.6869
	(0.87)	(-0.44)	(1.10)	(0.83)	(0.91)
n	520	155	156	108	101
R Square	0.0015	0.0013	0.0078	0.0064	0.0083
Adjusted R Square	-0.0005	-0.0053	0.0013	-0.0030	-0.0017
F-value	0.75	0.19	1.20	0.68	0.83

t-value is shown in the parenthesis
***1% level of significance
**5% level of significance
*10% level of significance

Table 13: Estimation results of multiple regression on the return of gold price on change of independent variables for the first sub-sample period

Identified independent variables with stepwise procedure are USD exchange rate and inflation rate. The model is:

$R_{gold,\,t} = \alpha + \beta_1 \Delta\, USD\ Index_t + \beta_2 \Delta\, Inflation_t + \varepsilon_{i,t}$

	First sub-period	
Intercept	-1.1913	
	(-1.04)	
USD Index	-1.6904	***
	(-5.00)	
US CPI	4.3517	***
	(2.66)	
n	155	
R Square	0.1666	
Adjusted R Square	0.1556	
F-value	15.19	

t-value is shown in the parenthesis
***1% level of significance
**5% level of significance
*10% level of significance

Table 14: Estimation results of multiple regression on the return of gold price on change of independent variables for the second sub-sample period

Identified independent variables with stepwise procedure are USD exchange rate, short-term real interest rates and long-term real interest rates.

The model is:

$$R_{gold,\,t} = \alpha + \beta_1 \Delta\, USD\ Index_t + \beta_2 \Delta\, I_{short\ term,\,t} + \beta_3 \Delta\, I_{long\ term,\,t} + \varepsilon_{i,t}$$

	Second Sub-period	
Intercept	-0.0533	
	(-0.26)	
USD Index	-0.5697	***
	(-4.67)	
Short-term real interest rates	-5.3618	***
	(-5.43)	
Long-term real interest rates	4.1645	***
	(4.35)	
n	156	
R Square	0.2730	
Adjusted R Square	0.2586	
F-value	19.02	

t-value is shown in the parenthesis
***1% level of significance
**5% level of significance
*10% level of significance

Table 15: Estimation results of multiple regression on the return of gold price on change of independent variables for the third sub-sample period

Identified independent variables with stepwise procedure are USD exchange rate. The model is:

$R_{gold,\,t} = \alpha + \beta_1 \Delta\, USD\ Index_t + \varepsilon_{i,t}$

	Third Period	
Intercept	0.2171	
	(0.50)	
US Index	-1.1337	***
	(-5.40)	
n	108	
R Square	0.2659	
Adjusted R Square	0.2519	
F-value	19.01	

t-value is shown in the parenthesis
***1% level of significance
**5% level of significance
*10% level of significance

Table 16: Estimation results of multiple regression on the return of gold price on change of independent variables for the fourth sub-sample period

Identified independent variables with stepwise procedure are international money supply, returns of equities and long-term real interest rates. The model is:

$$R_{gold,\,t} = \alpha + \beta_1 \Delta\, MS_{international,\,t} + \beta_2 \Delta\, R_{equities,\,t} + \beta_3 \Delta\, I_{long\ term,\,t} + \varepsilon_{i,t}$$

	Fourth Sub-period	
Intercept	-0.1319	
	(-0.36)	
International Money Supply	1.7051	***
	(5.48)	
S&P 500	-0.3041	***
	(-4.08)	
Long-term real interest rates	-2.2523	***
	(-3.28)	
n	101	
R Square	0.3606	
Adjusted R Square	0.3409	
F-value	18.24	

t-value is shown in the parenthesis
***1% level of significance
**5% level of significance
*10% level of significance

Table 17: Estimation results of multiple regression on the return of gold price on change of independent variables for the whole sample period from January 1973 to May 2016

Identified independent variables with stepwise procedure are: USD exchange rate, inflation rate, US money supply, return of equity and international money supply.

The model is: $R_{gold,\,t} = \alpha + \beta_1 \Delta\, USD\ Index_t + \beta_2 \Delta\, Inflation_t + \beta_3 \Delta\, MS_{US\,t} + \beta_4 \Delta\, R_{equities\,t} + \beta_5 \Delta\, MS_{international\,t} + \varepsilon_{i,t}$

	Whole Period	
Intercept	-0.4906	
	(-1.13)	
USD Index	-1.5580	***
	(-6.80)	
US CPI	2.2419	***
	(3.67)	
US Money Supply	1.7162	***
	(2.95)	
S&P 500	-0.1256	***
	(-2.62)	
International Money Supply	-0.6050	**
	(-2.39)	
n	520	
R Square	0.1801	
Adjusted R Square	0.1722	
F-value	22.59	

t-value is shown in the parenthesis
***1% level of significance
**5% level of significance
*10% level of significance

Table 18: Estimation results of multiple regression on the return of gold price on change of independent variables for cross validation, using sample data of first half of fourth sub-sample period

Identified independent variables with stepwise procedure are long-term real interest rates, US money supply, USD exchange rates and returns on equity. The model is:

$$R_{gold,\,t} = \alpha + \beta_1 \Delta\, I_{long\ term,\,t} + \beta_2 \Delta\, MS_{US,\,t} + \beta_3 \Delta\, USD\ Index_t + \beta_4 \Delta\, R_{equities,\,t} + \varepsilon_{i,t}$$

	First half of fourth sub-sample period January 2008-February 2012	
Intercept	0.7831 (1.22)	
Long-term real interest rates	-2.6855 (-3.62)	***
US Money Supply	1.5422 (1.80)	*
USD Index	-1.1139 (-4.10)	***
S&P 500	-0.3772 (-3.88)	***
n	50	
R Square	0.5398	
Adjusted R Square	0.4989	
F-value	13.20	

t-value is shown in the parenthesis
***1% level of significance
**5% level of significance
*10% level of significance

Table 19: Estimation results of multiple regression on the return of gold price on change of independent variables for cross validation, using sample data of second half of fourth sub-sample period

Identified independent variables with stepwise procedure are international money supply, short-term real interest rates and long-term real interest rates. The model is:

$$R_{gold,\,t} = \alpha + \beta_1 \Delta MS_{international,\,t} + \beta_2 \Delta I_{short\ term,\,t} + \beta_3 \Delta I_{long\ term,\,t} + \varepsilon_{i,t}$$

	Second half of fourth sub-sample period March 2012-May2016	
Intercept	-1.2062 (-2.89)	***
International Money Supply	2.0019 (4.17)	***
Short-term real interest rates	7.6375 (3.08)	***
Long-term real interest rates	-6.0604 (-2.19)	**
n	51	
R Square	0.3552	
Adjusted R Square	0.3141	
F-value	8.63	

t-value is shown in the parenthesis
***1% level of significance
**5% level of significance
*10% level of significance

Table 20: Survey on literature

Author(s)	Study period	Dependent variable/ Research objectives	Independent variables	Results	Methodology
Kitchen (1996)	March 1981 - July 1994	Gold price	Federal deficit projections	Gold price reacts positively to higher deficit projection due to expected increase in an inflation risk premium.	Regressions
Laurent (1994)	April 1968 - December 1993	Gold price	General price levels	The gold price and general price level tend to move together over long term, but not over the short term horizon.	Regressions
Tandon and Urich (1987)	July 1977 - December 1982	Gold price	Money supply changes, US CPI and PPI, interest rates	Unanticipated changes in PPI have a positive effect on gold prices.	Regressions
Bailey (1988)	October 1982 - December 1985	Ex-ante volatility of gold price	Money supply announcements	Changes in estimated gold volatility are associated with unanticipated growth of money supply.	Implied standard deviation, Newton-Raphson gradient method
Hammoudeh, Yuan, McAleer and Thompson (2010)	January 1999 - November 2007	Volatility and correlation interdependence	Monetary policy changes, geopolitics news and own post volatility	Monetary policy changes have a long term effect on volatility of gold price, gold is also the safest haven amongst the metals in the flight from the USD.	VARMA-GARCH model, and multivariate dynamic conditional correlation GARCH
Batten, Ciner, and Lucey (2010)	1986 to 2006	Volatility of gold price	S&P 500 and its dividend yield, US M2, world ex US index and its dividend yield, term structure, industrial production, inflation, USD Index, consumer confidence	US CPI and money supply are consistently related to the price returns of gold, but not to other precious metals.	ARCH model

Author(s)	Study period	Dependent variable/ Research objectives	Independent variables	Results	Methodology
Sipkova and Sipko (2014)	August 1971- August 2013	Gold price	Gold mining stocks, COMEX futures, S&P Depository Receipts, gold shares ETF and macroeconomic variables	Factors driving the gold prices are expected inflation, money supply expectations and investor speculation.	Regressions
Moore (1990)	January 1970 - November 1988	Gold price	Leading inflation index	Investors would have earned about 18 per cent per annum by using the leading inflation index for trading	Backtesting
Fortune (1988)	Third quarter of 1973 - second quarter of 1980	Gold price	Inflation, consumer and wholesale prices, US government bond yields	Gold price is positively related to expected future price level.	Equilibrium model
Ghosh, Levin, Macmillan and Wright (2004)	January 1976 - December 1999	Gold price	US retail price index, world inflation, real world income, stock index, world exchange rates, default risks	Substantial short-term price movements in the gold price are consistent with the rising general inflation rate over time.	Cointegration regressions
Levin and Wright (2006)	January 1976 - August 2005	Gold price	US inflation, credit risk, inflation volatility, the USD exchange rate, and the gold lease rate	A one per cent increase in general price level in the US corresponds to a one per cent increase in the long-term gold price.	Cointegration techniques
Worthington and Pahlavani (2007)	January 1875 - February 2006	Gold price	US CPI	Cointegrating relationship exists between gold price and inflation.	Modified cointegration
Mahdavi and Zhou (1997)	1958 - 1994	Commodities price index and gold price	US CPI	The link between inflation rates and prices of gold or commodities diminish over time.	Error-correction model

Author(s)	Study period	Dependent variable/ Research objectives	Independent variables	Results	Methodology
Davis (2012)	1965 - 2007	Gold price and commodity prices	Inflation rate of various countries	A price shock in commodity prices would lead to a significant rise in core inflation in early periods, but effect would diminish over time.	VAR
Sjaastad and Scacciavillani (1996)	January 1982 - December 1990	Gold price	World inflation and major currencies	Two thirds to three quarters of one per cent increase in the real price of gold corresponds to a one point increase in the inflation rate.	Fractional differencing
Harmston (1998)	1896 - 1996	Gold price	Inflation in US, U.K., France, Germany, and Japan	Gold price consistently reverts to its historic purchasing power parity.	Cumulative real returns comparison
Wang, Lee and Nguyen Thi (2013)	January 1971 to October 2006	Gold price	CPI in the US and Japan	In the high-momentum regime gold's return is a partial hedge against inflation in Japan but a full hedge for the US.	Non-linear threshold regression model and the linear and non-linear Cointegration test
Beckmann and Czudaj (2013)	December 1969 - December 2011	Gold price	PPI and CPI in Japan, US, and U.K. and Euro Area	Gold is a partial hedge to inflation and the effect is more prominent for the US and U.K. than that of Japan and the Euro Area. Gold is a better hedge during market turbulence.	Markov-switching vector error correction model
Tkacz (2007)	September 1994 - December 2005	Gold price	Leading indicator of inflation in OECD countries	Gold price is a leading indicator of inflation in a number of countries for up to two years in advance.	DF - GLS unit root test

Author(s)	Study period	Dependent variable/ Research objectives	Independent variables	Results	Methodology
Lawrence (2003)	January 1975 - December 2001	Gold price	GDP, inflation, interest rates, US certificate of deposit rates, S&P500, Dow Jones Industrial indexes and 10-Year US government bond yields	There is no significant relationship between gold returns and GDP, inflation and interest rates. Other commodities have stronger relationship with equity and bond indices than gold.	VAR
Cai, Cheung and Wong (2001)	January 1994 - December 1997	COMEX gold futures price	Interest rates, gold sales by central banks	Unexpected interest rate rise caused change of absolute return of gold	Fractionally integrated GARCH (FIGARCH) model and flexible fourier form (FFF) regression
Diba and Grossman (1984)	January 1975 - March 1983	Gold price	Real interest rates	Interest rates corresponds to the fundamental value of gold price as an opportunity cost	Diagnostic checks for stationary in data
Tully and Lucey (2007)	1984 - 2003	Gold price	Interest rate, inflation and stock indices in US and UK, USD and GBP exchange rates	Relationship between interest rate or inflation in US and gold price is statistically insignificant. The USD is found to be the sole driver for gold price.	Asymmetric power GARCH model
Baur (2011)	January 1979 - January 2010	Gold price	Stock market indices, Commodity price indices, CBOE VIX, short-term and long-term interest rates	Gold price reacts positively with lower short-term interest rates and higher long-term interest rates, as the gold price increases with lower short term opportunity cost or higher long term inflation expectation.	Regression model

Author(s)	Study period	Dependent variable/ Research objectives	Independent variables	Results	Methodology
Batten, Ciner and Lucey (2014)	January 1985 - June 2012	Gold price	US CPI	The predictive power of both short term and long term interest rates on gold's CPI beta are statistically significant and when interest rates are at low levels they become less important and inflation rates' importance rises.	Causality test
Erb and Harvey (2013)	January 1975 - March 2012	Gold price	US CPI, real interest rate, unexpected inflation, personal income, stock index	Long-term inverse relationship between the real interest rate and real price of gold is found	Correlations and total return
Johnson and Soenen (1997)	January 1978 to December 1995	Gold price in a portfolio context	Domestic bonds and stocks in US, Germany, Japan, Switzerland, Canada, France, and the U.K.	The results indicate that gold is a good investment alternative for investors in France, Germany, Japan, Switzerland, and the U.K. between 1978 and 1983, but not for other periods. Whether gold is a viable investment alternative is time-dependent.	Reward-to-variability index and correlation
Capie, Mills and Wood (2005)	January 1971 - February 2004	Exchange rate hedge	GBP and JPY	Negative relationship between the gold price and the two pairs of exchange rates, but the degree of significance is unstable over the sample period.	Exponential GARCH
Sari, Hammoudeh, and Soytas (2011)	January 1999 - October 2007	Gold price	USD and EUR exchange rates	The USD is the sole macroeconomic variable that influences the gold price over time.	Variance decomposition method and VAR

Author(s)	Study period	Dependent variable/ Research objectives	Independent variables	Results	Methodology
Wang and Lee (2011)	April 1986 - March 2007	Gold price	USD and JPY exchange rates	YEN and gold price have a significant negative relationship when the depreciation rate of YEN breach a threshold level of 2.62 per cent.	Threshold vector autoregressive model (TVAR)
Pukthuanthong and Roll (2011)	January 1971 - December 2009	Gold price	EUR, JPY, and GBP	Negative relationship between gold price and USD is merely a statistical one. When a particular currency is depreciating, positive gold returns measured in that currency	GARCH model
O'Connor and Lucey (2012)	January 1975 - February 2012	Gold price	USD, AUD, CAD, GBP, EUR, JPY and CHF	Negative correlation between the returns of the trade weighted value of a currency and gold price expressed in the same currency.	Rolling correlation
Batchelor and Gulley (1995)	1978 - 1993	Gold price	Jewelry demand in the US, Japan, Germany, France, Italy, and the UK	Demand for gold is elastic in developed countries, as the elasticity of demand is close to absolute -1.	Regression with seemingly unrelated regressions estimator procedure (SURE)
Mozes and Cooks (2013)	1992 – 2012	Gold price	Consumer and investment gold demand, real US interest rates, USD and US expected inflation	Consumer and investment demand for physical gold do not explain changes in gold returns	Regression
WGC (2015)	Simulation of scenarios	Central banks' gold holding	Global economic growth, world inflation, volatility in global financial markets, gold price	Developing countries will increase gold holdings by about one per cent over a five-year period if world economic growth is one per cent lower than the pre financial crisis period.	Simulation

Author(s)	Study period	Dependent variable/ Research objectives	Independent variables	Results	Methodology
Selvanathan and Selvanathan (1999)	1948 – 1994	Gold price	Gold production	Central bank's reserves portfolio with inclusion of gold would have earned 1.5 times more return than a reserves portfolio that is without gold	Correlation and back testing
Marsh (1983)	1974 – 1981	Gold price	Mining output	Negative relationship between the gold price and mining output in short term.	The elasticity of supply
Kaufmann and Winters (1989)	1974 - 1988	gold price	US inflation rate, world production of gold, USD exchange rate and supply change factor	Gold price is the function of the US inflation rate, the annual world production of gold and the USD exchange rate.	Predictive model using a regression
Levin, Abhyankar and Gosh (1994)	December 1990 - December 1992	Gold price	Gold production costs, inflation rates and real interest rates	Gold production costs change in line with inflation rate in the long term.	Granger causality, cointegration test and regression
Chua, Sick and Woodward (1990)	September 1971 - December 1988	Gold's return in portfolio context	Gold stocks and the S&P 500	Gold bullion in a portfolio can serve the purposes of diversification	Regression
Emmrich and McGroarty (2013)	January 1981 - May 2011	Gold's return in portfolio context	Gold, stock index, bond index, commodity index, CPI	Gold in portfolios reduces portfolio volatility	CAPM and sampling
Hillier, Draper and Faff (2006)	January 1976 - April 2004	Gold's return in portfolio context	Gold and silver prices, and world stock indices	Adding gold in a portfolio provides diversification benefits in times of high stock market volatility	GARCH model and regression

Author(s)	Study period	Dependent variable/ Research objectives	Independent variables	Results	Methodology
McCown and Zimmerman (2006)	1970 - 2003	Gold's return in portfolio context	US and world stock indices, US GDP and industrial production, exchange rates and default spreads and CPI	Addition of gold to a portfolio does not increase the systemic risk of the portfolio	CAPM
Miyazaki and Hamori (2013)	January 1990 - May 2013	Gold's return in portfolio context	Short-term interest rate, USD, and stock market indices	Gold has begun to emerge as a financial asset and diversification effect of gold may diminish as a result	Cointegration test and regression
Saidi and Scacciavillani (2011)	January 1987 - May 2010	Gold's return in portfolio context	Fixed incomes and major currencies	Gold would enhance the returns by several basis points each year in central bank's portfolio	CAPM and portfolio optimization exercise
Baur and Lucey (2010)	November 1995 - November 2005	Gold's return in volatile market (role as safe haven)	MSCI and bond indices, USD, GBP and EUR	Gold is not a safe haven for stocks all the time and effect is very short-lived	Regression and asymmetric GARCH process
Baur and McDermott (2010)	March 1979 – March 2009	Gold's return in volatile market (role as safe haven)	53 World stock index	Gold acts as a stabilizing element among different financial markets and limit losses during crises	Regression
Lucey and Li (2015)	January 1989 - July 2013	Gold's return for US investors in volatile market (role as safe haven)	S&P 500 index and US bond Index	During some periods other precious metal act as safe haven when gold does not	Dynamic Conditional Correlation Multivariate GARCH Model (DCC)
Choudhry, Hassan, and Shabi (2015)	January 2000 - March 2014	Gold's return in volatile market (role as safe haven)	Stock indices of UK, US and Japan	Gold may not function well as safe haven due to bidirectional inter-dependence between returns of gold, stock and stock market volatility during financial crises	GARCH process and Multivariate nonlinear Granger causality model

Author(s)	Study period	Dependent variable/ Research objectives	Independent variables	Results	Methodology
Hood and Malik (2013)	November 1995 – November 2010	Gold's return in volatile market (role as safe haven)	S&P 500 Index and VIX	Gold serves as a hedge and weak form of safe haven against stock market	Regression and GARCH
Coudert and Raymond (2011)	February 1978 - January 2009	Gold's return in volatile market (role as safe haven)	Stock indexes of US, UK, Germany and France, MSCI index for the G7	In most cases gold is a weak safe haven and a hedge during crises	Bivariate ARMA-GARCH-X model
Tuysuz (2013)	January 1997 - August 2011	Gold's return in volatile market (role as safe haven)	Bond prices, S&P 500 index and crude oil price	Gold was a weak safe haven during dot-com bubble burst in 2000 and a strong safe haven during the subprime crisis in 2008	Dynamic Conditional Correlation model
Bhatia (2012)	March 1998 - June 2011	Optimal allocation to gold for central bank reserve portfolio	Reserve assets denominated in emerging market currencies	8.4 per cent and 10.0 per cent in local currencies, and 4.6 per cent to 7.0 in USD terms	Portfolio allocation

CURRICULUM VITAE

Academic qualifications of the thesis author, Ms. LEE Lai Ming:

- Received the degree of Bachelor of Arts major in Economics from the University of Toronto, Canada, in November 1991.
- Received the degree of Master of Business Administration emphasis in Finance from the University of San Francisco, the United States, in May 1994.

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