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Historical Events and the Gold Price

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Abstract

Gold prices are quick to respond to world events. However, some of these events stand out, in the sense that they have had significant influence on the conditional mean and volatility of gold prices. In this paper, we have taken 30 historical events ranging from the suspension of dollar's convertibility into gold in August 1971 to the end of the Quantitative Easing in the US in October 2014 and studied their impact on real gold prices. We find that the US economy and the current dollar-based monetary system is still the main driver of real gold prices. Our empirical exercise in this paper finds that the mean and variance of real gold prices have experienced significant changes primarily when the historical events in question either reinforced or challenged the economic dominance of the US and the role of dollar in the global monetary system.

Keywords: Gold prices; historical events; hedge; safe haven
JEL: E4; G1; C52; C58

1. Introduction

In the course of human history, one of the most important roles that gold has played is that of money – a medium of exchange, a store of value and a unit of account. With the advent of modern paper currencies, gold lost is role as a medium of exchange and a unit of account; however, until the collapse of the Bretton Woods fixed exchange rate system, it continued to play a role of a real anchor over which all other monies were valued. Beyond its ornamental and industrial usage today, gold seems to have lost most of its monetary role, only playing a role of a store of value – an investment. However, a careful analysis of the dynamics of gold price points to the fact that, whenever the dominance of the major currencies of the world has been challenged, either by way of geopolitical events, such as wars, mayhem and political turmoil or by the devaluing effects of inflation and balance of payment problems, we have seen a resurgence in the role of gold. In this paper, we have taken 30 historical events from a period between April 1968 and December 2015 that we believe have profoundly impacted the world gold market and tested their impact on the mean and volatility of real gold prices. Our results indicate that the significant influences on real gold prices came primarily from historical events that either reinforced or challenged the economic dominance of the US and the role of dollar in the global monetary system.

For commodities that mainly act as intermediate inputs to production, such as crude oil, conflicts that lead to or have potential to cause supply disruptions are expected to affect prices. Noguera-Santaella (2016) contribute to the long literature exploring the effects of geopolitical events on economic variables by way of extending this analysis to the oil market. As surveyed by O'Connor et al. (2015), the economics of the gold market, however, is more nuanced. The authors show that although gold has some industrial use, the overwhelming majority of its demand originates from jewellery and investment demand.[1] The industrial demand for gold, which comes mainly from dentistry and electronics has been declining over time. The sociocultural factors that sustain the jewellery demand in Asia, and mainly in China and India, have also ensured a stable demand for physical gold in the world. The investment demand for gold has, however, been increasing over time and quite dramatically so from 2002. The gold investment demand comes mainly from demand for gold bars and coins and since 2003 the gold Exchange Traded Funds (ETFs) have also been a positive contributor.

[1] See O'Connor et al. (2015) for a survey of the academic research on jewellery and industrial gold demand.

As opposed to other storable commodities, as pointed out by O'Connor et al. (2015), the annual new gold supply is just 1% of its existing stock. This makes release of existing gold stocks into the market to be more important drivers of gold prices than the new supply, which comes from two main sources: mining and scrap. The academic literature supports this hypothesis as the majority of authors surveyed by O'Connor et al. (2015) argue that gold miners are price takers and not price makers. Moreover, Borenstein and Farrell (2007) by searching through 28 years of Wall Street Journal find no mention of supply shocks having an effect on gold price. The authors' findings were also corroborated by the interviews they held with mining executives.

O'Connor et al. (2015), however, find no significant academic research exploring the link between the supply of scrap gold and gold price. However, if gold miners are found to be price takers, we argue that gold scrap producers will also be the same. Feldstein (1980) argues that central bank gold sales, which is the primary means by which existing gold stocks are released into the market, must have a negative impact on world gold prices. In fact O'Connor et al. (2015) argue that central bank gold sales has been a major contributor to the gold bear market of the 1990's.

A dominant motive behind investors' demand for gold, as discussed in the literature, is its apparent ability to be a hedge asset. Baur and Lucey (2010) define a hedge as "an asset that is uncorrelated or negatively correlated with another asset or portfolio on average." Sumner, Johnson, and Soenen (2010) find almost no real return and volatility spillovers to gold from US stocks and bonds. Chua, Sick, and Woodward (1990) also find gold to be a low Beta asset. Another line of research try to find the optimal weight for gold in an investment portfolio [see Jaffe (1989), Hillier, Draper, and Faff (2006), Lucey, Tully, and Poti (2006), Bruno and Chincarini (2010), and Emmrich and McGroarty (2013).] Using various methodologies, these authors find gold's portfolio weight to vary from 0.1% to 12%.

Not only does gold exhibit hedging capabilities against stocks and bonds, the literature finds that it also provides a hedge against other currencies, and in particular, against the US dollar [see Capie, Mills, and Wood (2005), Joy (2011), Reboredo (2013), Lu and Hamori (2013), and Reboredo and Rivera-Castro (2014)].

Just as appreciation and depreciation of a currency changes its valuation vis-à-vis other currencies, inflation and disinflation (deflation) changes its valuation vis-à-vis real goods and services. Therefore, there is an active literature investigating gold's role as an inflation hedge.

Using data for different countries, observed in different frequencies and using a wide range of methodologies, a large body of literature finds empirical support of gold as an effective inflation hedge [see Fama and Schwert (1977), Levin et al. (1994), Taylor (1998), Adrangi et al. (2003), Levin et al. (2006), Worthington and Pahlavani (2007), Beckmann and Czudaj (2013), Batten et al. (2014), Dey (2014), and Bampinas and Panagiotidis (2015)].

Yet another attractiveness of gold as an asset is its apparent ability to act as a safe haven. Baur and McDermott (2010) define a safe haven as "an asset that is negatively correlated (uncorrelated) with another asset or portfolio in certain periods only, e.g. in times of falling stock markets." Baur and Lucey (2010) find gold to be a safe haven for US, UK and German stocks but not bonds. By extending this analysis for a wider set of countries, Baur and McDermott (2010) find gold to be a safe haven for major European stock markets and the US but not for Australia, Canada, Japan and large emerging markets such as the BRIC countries.

Major world currencies such as US dollar, UK pound and Euro are often viewed by investors as safe haven assets. It is interesting to note that the literature finds gold to provide safety even when other traditional safe haven assets, in particular US dollar and UK pound, are themselves facing downside risks [see Reboredo (2013), and Ciner, Gurdgiev, and Lucey (2013).]

Finally, we review the relevant literature examining the volatility of gold prices. Melvin and Sultan (1990) find that the conditional variance of gold spot prices is explained by political unrest and oil prices changes. Batten, Ciner, and Lucey (2010) find stock market returns, dividend yields, money supply and US CPI as important drivers of gold volatility. Hammoudeh et al. (2010) also find evidence of monetary shocks having long run effects on gold volatility.

In this paper, we identify historical events that has had major influences on the world gold market by way of affecting the gold market structure and the rate of release (absorption) of gold via official sector gold sales (purchases), along with events that affect the various investment motives of gold demand: hedging and capital preservation in times of market distress. We then test the effects of these historical events on the conditional mean and variance of real gold prices for a period between April 1968 and December 2015.

2. Historical Events

As discussed above, we look for events in history that has had major impact on the gold market. Table 1 in the Appendix chronologically lists those events along with their exact

dates. We club these events into four broad groups. The first group consist of events – both temporary and permanent that affected the gold market structure. The second group of events guided the rate of release or absorption of gold by a major player in the gold market – the central banks and the IMF. The third group of events induced gold investment demand with a motive to hedge against other assets, such as, equities, bonds and currency. The last group of events, primarily temporary in nature, consists of events that prompted investors to seek safety of gold investment under extreme market distress in other assets or under periods of crisis. In the first group we start with August 1971, when President Richard Nixon suspended the dollar's convertibility into gold. Under the Bretton Woods fixed exchange rate system, the values of all currencies were fixed in relation to dollar, which, in turn, was convertible to gold at the rate of $35 per ounce. This system required the US to hold enough gold in order to cover the volume of dollars in worldwide circulation. The suspension of dollar's convertibility into gold, at least temporarily, put this demand for gold into question. Next comes the attempt to salvage the Bretton Woods system under the Smithsonian Agreement signed in December 1971 at a devalued dollar convertibility into gold of $38 per ounce. The Smithsonian Agreement lasted till January 1973. Then after one more round of devaluation of dollar, the Bretton Woods system finally collapsed in March 1973 and made way for the current system of floating exchange rates.

Since May 1933 US citizens were forbidden to privately own gold coins and gold bullion. In December 1974, President Gerald Ford signed a bill to "permit United States citizens to purchase, hold, sell, or otherwise deal with gold in the United States or abroad." This date, we believe, was another major event in the world gold market.

Gold market primarily trades in gold futures. New York Commodity Exchange (COMEX) started forward trading in gold in February 1975 and this exchange became one of most important centers of gold futures trading in the world. Hence, February 1975 was another important date in the history of gold market. Then in 1980, the US Congress established the US Gold Commission to evaluate the role of gold in the monetary system. The Commission in March 1982 submitted its report rejecting a return to the gold standard. Hence, March 1982 is considered to be an important date in the history of gold. Next important date in this group is January 1987, when some of the leading gold mining companies of the world came together and established the World Gold Council with an aim to manage the world gold supply chain and stimulate world gold demand. We argue that establishment of the World Gold Council was a major event in the history of gold market. We

then move forward to August 1997 when US Congress passed the Taxpayers Relief Act, which allowed Individual Retirement Account holders to buy gold bullion of purity 99.5% and above for their accounts. This again is presumed to be an important event for the world gold market.

With the gradual shift in the demand for physical gold from West to East, October 2002 marked an important milestone in the development of world gold market in the form of establishment of the Shanghai Gold Exchange, currently the world's largest physical gold exchange. The birth of the Shanghai Gold Exchange contributed to the price discovery, liquidity, transparency and efficiency of the global gold market. Our final event in this first group of historical events is the date when SPDR Gold Trust ETF, the largest gold ETF in the world, was launched.

We begin the second group of events with the 5-year IMF gold sales program, under which over the period spanning June 1976 and May 1980, the IMF sold 25 million ounces of gold at a series of public auctions for the benefit of developing countries. Another 25 million ounces of gold were distributed to its members, in proportion to their IMF quotas at the then official rate of SDR 35 per ounce. We believe this release of gold by the IMF has had a major impact in the world gold market and by January 1980 gold price reached its then all-time high of $850 per ounce. However, by the late 1990's there was widespread concern that uncoordinated central bank gold sales had destabilized the gold market by sharply driving down the prices. As a response to these concerns in September 1999, 15 European central banks, accounting for 45 percent of global gold reserves, signed an agreement in Washington DC to collectively limit their gold sales to 2000 tonnes over five years, or around 400 tonnes a year. Various versions of the initial central bank agreement was subsequently signed in every five year interval and we are currently in the middle of the fourth central agreement that came into effect in September 2014. We consider the beginning of the central bank agreements as a stabilizing force in the global gold market and hence as a historical event that has the potential to change the dynamics of the world gold prices.

As part of the new income model agreed in April 2008, the IMF started its gold sales to the market in February 2010, and by December 2010 when it concluded the gold sales program, IMF sold 191.3 tonnes of gold in a series of public auctions. We consider February to December 2010 to be a period of heightened activity for one of the major official sector players of the gold market, the IMF, with potential to impact the gold price dynamics.

According to World Gold Council in 2010, the central banks became net buyers of gold from the market. Between 1989 and 2007 central banks sold on average 400-500 tonnes of gold per year to the market. In 2008, the central bank gold sales halved from its 18 year annual average and by 2009 it was just 30 tonnes. In fact, between 2010 and 2015 net purchases of central banks was 2926 tonnes, or around 488 tonnes per year. This was a stark departure from the usual official sector behavior of a steady seller of gold into the market post dismantling of the Bretton Woods system. We believe this period of net purchase by the central banks was a major event for the world gold market.

The above behavior of the central banks post 2010 can of course be seen as central banks trying to rebalance their foreign currency assets in favor of gold, which was providing a hedge against all other depreciating currencies. This naturally brings us to the third group of historical events that is envisaged to induce gold investment demand with a motive to hedge against other assets, such as, equities, bonds and currency. The erstwhile USSR provided a potentially viable political and economic alternative to the democratic market economies of the West and especially to its most dominant representative, the US. With the fall of the Berlin wall in November 1989, the momentum towards a more open form of political and economic system within the USSR and Eastern Europe gathered pace. The eventual collapse of the USSR began in August 1991 with an unsuccessful coup against President Mikhail Gorbachev and the dissolution of the Central Committee. This process finally ended in December 1991 with the creation of the Commonwealth of Independent States, resignation of Mikhail Gorbachev as the President of USSR, replacement of the Soviet flag with the Russian tricolor and elevation of Boris Yeltsin as the President of Russia. The fall of the USSR left behind a situation where the US became the only superpower in the world. We believe this event had the potential to have an impact on the value of gold, which is often seen as a hedge against dollar.

The adoption of a single currency – the Euro – in January 1999 by eleven of the fifteen countries of the European Union marked the beginning of a new Europe. The European Monetary Union created an economic area comparable in size to that of the US and backed by the European Central Bank, the Euro became a currency with the potential to be a rival of the dollar. The birth of a rival currency to dollar is likely to have implications for the price of gold as it becomes attractive as a hedge asset for investors in case the rival starts to challenge the dominance of dollar and eventually unseats dollar from its preeminent position.

Although the Iraq war was short-lived, US troops remained in Iraq for almost eight long years - from May 2003 to December 2011. The US troops in Iraq was stationed to control the

sectarian violence that broke out after the fall of the Saddam Hussein regime. During this period of a long occupation in Iraq, the total US public debt as a percent GDP rose almost 1.6 times from 58.7 to 96.4. Moreover, the trade-weighted US dollar index depreciated almost 15% percent from a value of 118.0 in May 2003 to 100.4 in December 2011.

Next, we come to the Great Recession, which saw the US GDP contract by 4.2 percent and employment fall by 5 percent. Between December 2007 and June 2009, S&P 500 index fell by around 37 percent from 1479.2 to 926.1. Moreover, the US High Yield Total Return index fell from 589.9 in December 2007 to 406.5 in December 2008 (a fall of around 31 percent) and then recovered to 559.8 by June 2009. With both bonds and equities generating negative returns in the US, the hedging motive is expected to have made gold attractive for global investors during the Great Recession. This is also evident from the fact that, gold price during this period appreciated by almost 18 percent.

We now turn to the periods of Quantitative Easing and Operation Twist. The first episode of Quantitative Easing started in November 2008 and ended in August 2010. This was followed by the second episode which began in August 2010 and ended in June 2011. Then came the period of Operation Twist between September 2011 and June 2012. Finally, the last episode of Quantitative Easing lasted for almost two years from September 2012 and October 2014. These episodes saw some of the most dramatic increases of money stock in the recent monetary history of the US. Just before the first episode of the Quantitative Easing began in November 2008, the US M2 money stock as a percentage of nominal GDP was at 52.3 percent. By the time the periods of Quantitative Easing and Operation Twist ended in October 2014, this percentage increased to 65.3 percent. During the same time, we saw almost 3.2 percent depreciation of the trade-weighted US dollar index and 61.5 percent appreciation in gold price.

We conclude this third group of historical events with the S&P downgrade of the US sovereign credit rating from AAA to AA+ in August 2011. This downgrade was in response to the failure of the US political system to reduce spending or raise revenue in order to reduce the rate of increase of the US public debt.

Our final group consists of events, primarily temporary in nature, which prompted investors to seek safety of gold investment. We start with the Iranian hostage crisis that began with the storming of the US embassy in Tehran and taking of more than 60 Americans as hostage in November 1979. The crisis ended with release of the hostages in January 1981. The dollar depreciated by almost 12.6 percent against the British pound and gold price appreciated by almost 42.5 percent during this crisis period. Next, we turn to the Black

Monday stock market crash of October 1987, when the Dow Jones Industrial Average dropped 22.6 percent in a single trading session, the largest one-day stock market decline in its history. Then we turn to the Gulf War episode from August 1990 to February 1991. Our next two episodes include the September 11th terrorist attack and the Afghan War, which began in September 2001 and ended in December 2001. We then come to the Iraq War between March and April 2003. Our final episode in this group is the 2006 Iran nuclear crisis that began with the breaking of UN seals at the Natanz uranium enrichment plant in January 2006 and ended with the unanimous approval of the UN Security Council sanctions intended to curb Iran's nuclear program. The sanctions imposed a ban on import and export of materials and technology used for uranium enrichment or reprocessing and for the production of ballistic missiles. The dollar depreciated by almost 11 percent against the British pound and 8.9 percent against the Euro and gold price appreciated by almost 14.6 percent during this crisis period.

3. Empirical Model and Results

Our gold price measure is the Gold Fixing Price at 10:30 A.M. (London time) in London Bullion Market, based in U.S. Dollars. We use monthly frequency gold price data from April 1968 to December 2015. The gold price data is then deflated by the monthly US Consumer Price Index (CPI). Both the gold price and the CPI data is extracted from the FRED database. We transform the real gold price data to logarithms. Figure 1 shows the log real gold price over our sample period. There is a general upward trend in the graph along with persistent movements away from it. The graph also seems to suggest a non-stationary series. This conjecture is supported by formal unit root tests shown in Table 2. ADF, Phillips-Perron and KPSS tests point toward the presence of unit root in the log real gold price series; however, the first difference of the series is found to be stationary by these tests. Hence, we use log-difference of real gold price in our empirical exercise.

3.1 The baseline models

We experimented with various ARMA models to explain the log-difference of real gold price, denoted by . The autocorrelation function (ACF) and the partial autocorrelation function (PACF) suggested multiple lags. However, the baseline model for the conditional mean of the log-difference of real gold price was chosen on the basis of simultaneous

satisfaction of three model selection criteria – parsimony, lowest value of AIC and no significant autocorrelation in the residuals (see Table 3 for the Ljung-Box Q-statistics). The model we choose is AR (1, 2, 7, 11):

(1)

(0.49) (0.00) (0.00) (0.06) (0.00)

Next, we find that the squared residuals of the AR (1, 2, 7, 11) are highly autocorrelated, as evident from the significant Ljung-Box Q-statistics in Table 4. Moreover, the Lagrange Multiplier test, at 12 lags, in Table 5 strongly suggest the presence of ARCH effects in the residuals of the AR (1, 2, 7, 11) model. We then use a parsimonious GARCH (1, 1) specification for the conditional variance of the log-difference of the real gold price. With the GARCH (1, 1) as the conditional variance equation of the AR (1, 2, 7, 11) process of the maximum likelihood estimates we get are as follows:

(0.96) (0.00) (0.02) (0.08) (0.00)

(2)

(0.00) (0.00) (0.00)

where the conditional variance of is denoted by .

The Q-statistics of Table 6 and 7, suggest that the AR (1, 2, 7, 11)-GARCH (1, 1) specification for the conditional mean and variance of the log-difference of real gold price is appropriate. Moreover, the Lagrange Multiplier test, at 12 lags, in Table 8 shows no evidence of any ARCH effects in the residuals of our chosen model.

3.2 The effects of historical events on conditional mean of real gold price

We now extend our baseline AR (1, 2, 7, 11)-GARCH (1, 1) model with dummy variables indicating a specific historical event in order to analyze their effects on the conditional mean of log-difference of real gold price. Hence, our new model becomes:

(3)

where denotes the historical event under consideration. We run 30 regressions to test the effects of the 30 historical episodes on the conditional mean of the log-difference of real gold price. Table 9 shows the results of these regressions along with the Q-statistics for autocorrelations of residuals and squared residuals at some key lags and the ARCH Lagrange

Multiplier statistics at 12 lags. The tests ascertain that the regressions are statistically meaningful and can be used for the necessary inferences. The results show that only 5 of the 30 events had any significant effects on the mean of our dependent variable. These events are the Smithsonian Agreement, the IMF Gold Sales Program, the Introduction of Euro, the Iraq War and the US Occupation of Iraq. Except the Iraq War, all the other events had a positive impact on the mean, with the Smithsonian Agreement having the largest positive effect. The Iraq War had the largest effect on the mean and interestingly on the negative side. A steady buildup in gold prices in anticipation of a protracted war in Iraq and a surprisingly quick end to the major combat operations of the war was primarily responsible for this large negative impact of the war episode on the conditional mean of the log-difference of real gold prices.

3.3 The effects of historical events on conditional variance of real gold price

In order analyze the effects of specific historical events on the conditional variance of the log-difference of real gold price, we now extend our baseline AR (1, 2, 7, 11)-GARCH (1, 1) model with dummy variables in the variance equation. Hence the formal model becomes:

(4)

where denotes the historical event under consideration. As before, we run 30 regressions to test the effects of the 30 historical episodes on the conditional variance of the log-difference of real gold price. Table 10 reports the results of these regressions along with the Q-statistics for autocorrelations of residuals and squared residuals at some key lags and the ARCH Lagrange Multiplier statistics at 12 lags. Based on the results of these tests we can be confident of the validity of our regression results and hence proceed towards necessary statistically inferences. The results indicate that only 6 of the 30 events had any significant effects on the variance of our dependent variable. These events are the IMF Gold Sales Program, the Iranian Hostage Crisis, the Establishment of World Gold Council, the Dissolution of the USSR, the Passage of Taxpayers Relief Act by US Congress and the Introduction of Euro. Barring the Establishment of World Gold Council and the Dissolution of the USSR, the rest of the significant historical events affected the volatility of real gold price positively.

4. Discussion and Conclusion

Our empirical exercise in the foregoing section has yielded some interesting results. Like any other commodity prices, gold prices are quick to respond to world events. However, some of these historical events stand out, in the sense that they have had significant impact on the conditional mean and volatility of real gold prices. Out of the 30 events considered in our exercise, only 5 of them significantly affected the mean of the log-difference of real gold price, 6 events had a major impact on the volatility and among these 2 events (the IMF Gold Sales Program and the Introduction of Euro) affected both the mean and volatility of real gold price in monthly frequency. Both the IMF Gold Sales Program and the Introduction of Euro affected the mean and volatility positively. After the collapse of the Bretton Woods system as IMF sold its gold, market participants absorbed this gold in order include this asset as part of their investment portfolio as a hedge against other assets, which were denoted in their respective currencies that were then on without any real anchor. Indeed the gold price dynamics seems to suggest that despite the collapse of the Bretton Woods system, market participants continued to view gold as the unofficial anchor for their assets. Moreover, a wider ownership of gold, post the official sector sales, increased the depth, tradability and liquidity of the world gold market thereby positively impacting the mean and variance of gold prices. Similarly, the birth of Euro was seen by market participants as the birth of a currency with a potential to be an alternative to the dollar. This naturally brings the possibility of a transition (gradual or drastic) of the dominant currency status away from dollar and towards the Euro, leading to a positive impact on the mean and volatility of gold, which is often seen as an anchor during uncertainties of monetary transitions.

When it comes to the positive impact on the mean of real gold price, the case of the long US occupation of Iraq in order to combat its insurgency problem and bring back a semblance of political stability in that country can be well understood. What is surprising, though, is the negative effect of the Iraq War on the mean of real gold price. It must be noted that the preparation of the Iraq War started in mid-2002 and one of the major reasons for the start of the Iraq War was the adoption of the November 2002 UN Security Council Resolution finding Iraq in breach of past UN resolutions prohibiting stockpiling and importing weapons of mass destruction (WMDs). Hence, the market participants were anticipating a determined and well-armed Iraqi army and a long and destructive conflict in Iraq. All this time, investors were flocking towards gold as a safe haven and gold prices were rising steeply until February 2003. However, just after the beginning of the Iraq War in mid-March 2003, it was evident that Iraqi army was in total disarray in the face of the US offensive and there was no use of

WMDs in the conflict. Realizing a surprisingly quick end to the war, gold prices started to fall in March and April 2003. Although, the prices recovered in May and June 2003 and started their upward movement from August 2003 onwards, after a brief fall in July 2003, it was albeit at a much flatter rate. The largest positive impact on the mean of real gold price; however, came during the period of the Smithsonian Agreement. This was probably due to the fact market participants, given the worldwide circulation of dollars and the US gold reserve, were anticipating one more round of devaluation of dollar against gold and possibly a collapse of the Bretton Woods system itself.

The Iranian Hostage Crisis led to the possibility of a conflict with a very determined and audacious adversary in the Middle-East, with a potential for escalation into a much wider conflict, given Iran's oil and gas reserve and its geographical closeness to major oil and gas suppliers of the world and the erstwhile USSR. This episode, expectedly, increased gold price volatility. The passage of Taxpayers Relief Act by the US Congress allowed US Individual Retirement Account holders to invest in gold bullion of purity 99.5% and above for their accounts. This law brought in a new set of institutional investors with large sums of money under their management into the gold market. Moreover, movement of large sums of money in and out of the gold market in order to book trading profits is expected to cause increased gold price volatility. Finally, we observe that the two historical events, namely, the Establishment of World Gold Council and the Dissolution of the USSR reduced gold price volatility. World Gold Council was established by some of the leading gold mining companies of the world with an aim to manage the world gold supply chain and stimulate world gold demand. High volatility of prices is detrimental to production planning and supplier profits, as among other things, it raises gold hedging costs. Hence, as a supplier consortium World Gold Council is expected to manage the global gold supply chain and the global gold marketing campaigns with an intention to minimize gold price volatility and ensure a steady appreciation of gold prices. The Dissolution of the USSR left the world with the only real superpower, the US. This was likely to reaffirm the monetary hegemony of the US dollar and reduce the likelihood of a monetary transition in the world and the consequent attractiveness of gold as an anchor asset. Hence, we would expect this event to reduce gold price volatility.

In addition, we compare our results with those obtained from tests that endogenously determine breaks in mean and variance using methods proposed by Bai and Perron (2003) and Inclan and Tiao (1994) respectively. The Bai and Perron (2003) procedure identified structural break dates (see Table 11) in the log-difference of real gold price are February

1980, March 1987, April 1994, May 2001, and August 2008. The February 1980 date coincides with the concluding period of the IMF gold sales program. Around the March 1987 break date we saw a number of historical events relevant to the world gold market occur, which include the establishment of the World Gold Council and the Black Monday stock market crash. And around May 2001, we saw the September 11th terrorist attack and the war in Afghanistan. The August 2008 date is close to beginning of the first round of Quantitative Easing. It is important to note that we could not find the historical importance of the April 1994 break date and except the IMF Gold Sales Program, all the remaining break dates identified by the Bai and Perron (2003) procedure do not correspond with the historical events that were identified by our empirical exercise as significant influencers on the conditional mean of real gold price.

The Inclan and Tiao (1994) procedure detects 7 changes in the volatility of real gold prices (see Table 12), which are April 1972, November 1974, August 1979, March 1980, March 1983, November 2005 and February 2009. Several historical events occurred around these identified break dates. These include the Smithsonian Agreement, the Legalization of Private Ownership of Gold of All Forms in the US, the Iranian Hostage Crisis, the Iranian Nuclear Crisis and the first round of Quantitative Easing. Barring the Iranian Hostage Crisis, none of the other identified break dates were found to be significant changers of the conditional volatility in our empirical exercise. We could not find the historical significance of the March 1983 break date.

Finally, we note that the endogenous break point tests of mean and volatility seems to suggest that although the three rounds of Quantitative Easing and the Operation Twist were individually not found to be significant in our empirical exercise, the entire episode of monetary expansion that started in the late 2008 with the first round of Quantitative Easing may have been important movers of mean and volatility of real gold price.

To conclude, we find that the US economy and the current dollar-based monetary system is still the main driver of the mean and volatility of real gold prices. Our empirical exercise in this paper finds that the mean and variance of real gold prices have undergone significant changes primarily when the historical events in question either reinforced or challenged the economic dominance of the US and the role of dollar in the global monetary system.

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Appendix

Table 1

Historical events.

	Event	Period
1	Suspension of dollar's convertibility into gold	August – November 1971
2	The Smithsonian Agreement	December 1971 – January 1973
3	End of the Bretton Woods fixed exchange rate system	March 1973 onwards
4	Private ownership of gold of all forms legal in the US	December 1974 onwards
5	Gold futures trading begins in the US	February 1975 onwards
6	IMF gold sales program	June 1976 – May 1980
7	Iranian hostage crisis	November 1979 – January 1981
8	US Gold Commission rejects return to gold standard	March 1982
9	Establishment of World Gold Council	January 1987 onwards
10	Black Monday stock market crash	October 1987
11	Gulf War	August 1990 – February 1991
12	Dissolution of the USSR	August 1991 – December 1991
13	Passage of Taxpayers Relief Act by US Congress	August 1997 onwards
14	The introduction of Euro	January 1999 onwards
15	Central Bank Gold Agreements	September 1999 onwards
16	September 11th Terrorist Attack	September 2001
17	War in Afghanistan	October 2001 – December 2001
18	Shanghai Gold Exchange begins operation	October 2002 onwards
19	Iraq War	March – April 2003
20	US occupation of Iraq	May 2003 – December 2011
21	Launch of SPDR Gold Trust ETF	November 2004 onwards
22	Iran nuclear crisis	January – December 2006
23	The Great Recession	December 2007 – June 2009
24	QE1	November 2008 – August 2010
25	IMF gold sales	February – December 2010
26	Central banks become net purchasers of gold	January 2010 – December 2015
27	QE2	August 2010 – June 2011
28	S&P's lowering of long-term US credit rating	August 2011 onwards
29	Operation Twist	September 2011 – June 2012
30	QE3	September 2012 – October 2014

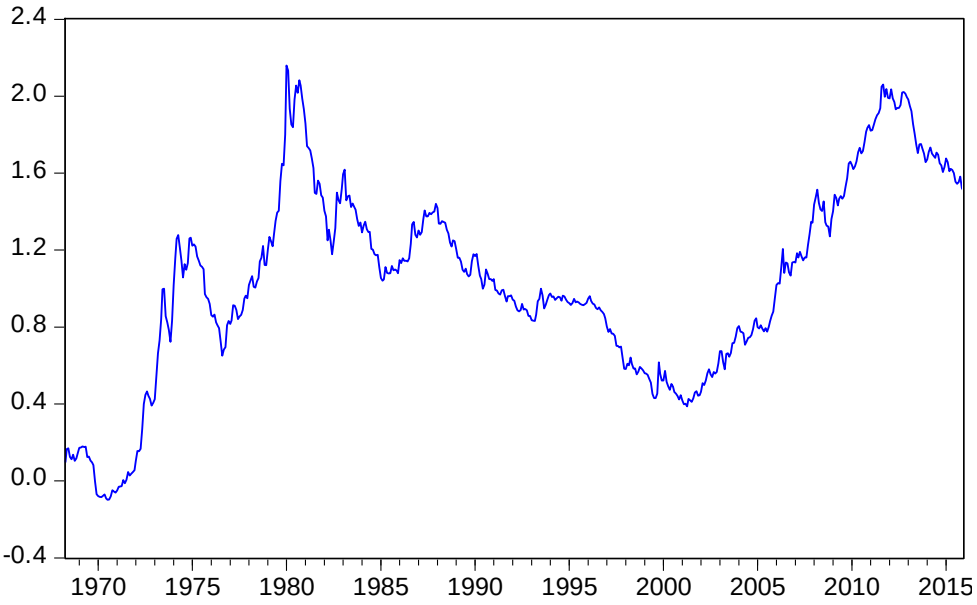

Fig. 1. Logarithm of Real Gold Price: April 1968 – December 2015

Table 2

Unit root tests for logarithm of real gold price

	ADF t-stat	PP Adj. t-stat	KPSS LM-stat
Levels	-1.728223	-1.833195	0.637963[a]
First differences	-16.36725[*]	-18.06809[*]	0.158750[b]

[a] Null hypothesis of stationarity is rejected at 5% level of significance.

[*] Null hypothesis of a unit root is rejected at 1% level of significance.

[b] Failed to reject the null hypothesis of stationarity.

Table 3

Q-stats for AR (1, 2, 7, 11) residuals

Lag	Q-statistics
1	0.0004
2	0.0640
3	2.2751
4	2.3190
5	2.6047
6	3.8990
7	4.0091
8	7.1378
9	10.291[*]
10	11.559[*]

11	11.559
12	11.961
13	13.086
14	15.370
15	15.375
16	15.788
17	15.979
18	19.466
19	21.457
20	22.244
21	23.409
22	23.431
23	23.442
24	24.185

* Significant at 10% level.

Table 4

Q-stats for AR (1, 2, 7, 11) sqrd.-residuals

Lag	Q-statistics*
1	38.365
2	52.965
3	64.101
4	82.571
5	94.431
6	108.40
7	112.39
8	115.97
9	117.95
10	121.91
11	129.54
12	132.46
13	134.89
14	141.37
15	142.32
16	143.66
17	145.67
18	147.93
19	148.80
20	149.66
21	151.39
22	151.82

23	151.95
24	152.94

* All Q-statistics values are significant at 1% level.

Table 5

ARCH-LM Test for Heteroskedasticity

LM statistic	61.81128*

* Significant at 1% level.

Table 6

Q-stats for AR (.)-GARCH (1, 1) residuals

Lag	Q-statistics
1	0.8485
2	0.9926
3	4.2287
4	4.6593
5	5.2272**
6	5.5705*
7	5.7312
8	7.9546*
9	9.3650*
10	10.677*
11	12.259*
12	13.552*
13	13.675
14	14.261
15	14.276
16	15.631
17	15.631
18	16.403
19	16.660
20	16.959
21	16.987
22	16.987
23	17.602
24	17.888

** Significant at 5% level. * Significant at 10% level.

Table 7

Q-stats for AR (.)-GARCH (1, 1) sqrd.-residuals

Lag	Q-statistics
1	0.5260
2	1.8976
3	1.9410
4	12.115**
5	12.700**
6	12.720**
7	12.832*
8	13.511*
9	13.594
10	13.733
11	14.009
12	15.055
13	15.070
14	15.715
15	16.137
16	17.904
17	17.936
18	18.003
19	18.047
20	18.058
21	18.127
22	18.577
23	18.580
24	18.681

** Significant at 5% level. * Significant at 10% level.

Table 8

ARCH-LM Test for Heteroskedasticity

LM statistic	16.68142*

* Insignificant.

Table 9

Effects of historical events on conditional mean.

									Correlogram of residuals		Correlogram of squared residuals		
									Q(12)	Q(24)	Q(12)	Q(24)	LM
.00	.26[a]	-.12[b]	.08[c]	.13[a]	.01	.00[a]	.13[a]	.84[a]	13.3	17.7	15.1	18.7	16.7
-.00	.25[a]	-.13[b]	.07	.12[a]	.04[a]	.00[a]	.13[a]	.84[a]	11.4	16.2	15.4	19.8	16.5
.00	.26[a]	-.12[b]	.08[c]	.13[a]	-.01	.00[a]	.13[a]	.84[a]	12.5	16.9	14.7	18.5	16.3
.01	.26[a]	-.12[b]	.08[c]	.13[a]	-.01	.00[a]	.13[a]	.83[a]	11.0	15.8	14.5	18.4	16.0
.01	.26[a]	-.12[b]	.08[c]	.13[a]	-.01	.00[a]	.13[a]	.83[a]	11.3	16.0	14.6	18.3	16.1
-.00	.26[a]	-.13[b]	.08[c]	.14[a]	.02[a]	.00[a]	.13[a]	.83[a]	11.2	15.4	15.1	19.0	16.5
.00	.27[a]	-.12[b]	.08[c]	.13[a]	.03	.00[a]	.13[a]	.84[a]	12.6	16.8	14.8	18.3	16.6
.00	.27[a]	-.12[b]	.07[c]	.13[a]	-.14	.00[a]	.13[a]	.83[a]	12.4	17.5	15.1	18.4	16.3
.00	.26[a]	-.12[b]	.08[c]	.13[a]	-.00	.00[a]	.13[a]	.84[a]	12.2	16.6	14.9	18.5	16.5
.00	.26[a]	-.12[b]	.08[c]	.13[a]	.03	.00[a]	.13[a]	.84[a]	13.8[c]	18.2	15.0	18.6	16.6
.00	.26[a]	-.12[b]	.08[c]	.13[a]	-.00	.00[a]	.13[a]	.84[a]	13.6[c]	17.9	15.0	18.7	16.7
.00	.26[a]	-.12[b]	.08[c]	.13[a]	-.00	.00[a]	.13[a]	.84[a]	13.5[c]	17.8	15.1	18.7	16.7
-.00	.26[a]	-.12[b]	.07[c]	.12[a]	.01	.00[a]	.13[a]	.84[a]	14.9[c]	19.1	15.5	19.5	17.3
-.00	.25[a]	-.13[b]	.07	.12[a]	.01[b]	.00[a]	.13[a]	.84[a]	14.5[c]	18.6	15.8	20.0	17.9
-.00	.26[a]	-.12[b]	.07	.12[a]	.01	.00[a]	.13[a]	.84[a]	13.3	17.6	14.0	17.7	15.7
.00	.26[a]	-.12[b]	.08[c]	.13[a]	.02	.00[a]	.13[a]	.84[a]	13.5[c]	17.5	15.0	18.6	16.6
.00	.26[a]	-.12[b]	.08[c]	.13[a]	-.00	.00[a]	.13[a]	.84[a]	13.5[c]	17.8	15.0	18.7	16.7
-.00	.26[a]	-.12[b]	.07[c]	.12[a]	.01	.00[a]	.13[a]	.84[a]	13.3	17.6	14.4	18.0	16.0
.00	.27[a]	-.11[b]	.08[c]	.13[a]	-.06[b]	.00[a]	.12[a]	.84[a]	12.8	16.9	15.4	18.8	17.0
-.00	.25[a]	-.13[a]	.06	.11[a]	.02[a]	.00[a]	.13[a]	.84[a]	12.3	16.5	13.4	16.9	15.0
-.00	.26[a]	-.12[b]	.08[c]	.13[a]	.00	.00[a]	.13[a]	.84[a]	13.3	17.6	14.8	18.4	16.5
.00	.26[a]	-.12[b]	.08[c]	.13[a]	.00	.00[a]	.13[a]	.84[a]	13.5[c]	17.9	15.0	18.7	16.7
.00	.26[a]	-.12[b]	.08[c]	.13[a]	-.00	.00[a]	.13[a]	.84[a]	13.5[c]	17.9	15.0	18.6	16.6
-.00	.26[a]	-.13[b]	.07	.12[a]	.02	.00[a]	.13[a]	.84[a]	14.2[c]	18.5	15.0	18.9	16.5
-.00	.26[a]	-.12[b]	.07	.12[a]	.01	.00[a]	.13[a]	.83[a]	13.1	17.4	15.1	18.8	16.5
.00	.26[a]	-.12[b]	.08[c]	.13[a]	-.00	.00[a]	.13[a]	.84[a]	13.8[c]	18.0	15.2	18.8	16.8
-.00	.26[a]	-.12[b]	.07[c]	.12[a]	.02	.00[a]	.13[a]	.84[a]	12.6	16.9	15.0	18.8	16.6
.00	.26[a]	-.12[b]	.07[c]	.13[a]	-.01	.00[a]	.13[a]	.84[a]	13.4[c]	17.6	14.8	18.5	16.3
.00	.26[a]	-.12[b]	.08[c]	.13[a]	-.01	.00[a]	.13[a]	.84[a]	14.2[c]	18.7	14.9	18.6	16.3
.00	.26[a]	-.12[b]	.07[c]	.12[a]	-.01	.00[a]	.13[a]	.84[a]	13.0	17.3	15.3	18.9	16.9

[a] Significant at 1% level. [b] Significant at 5% level. [c] Significant at 10% level.

Table 10

Effects of historical events on conditional variance.

									Correlogram of residuals		Correlogram of squared residuals		
LM									Q(12)	Q(24)	Q(12)	Q(24)	
-.00	.26[a]	-.12[b]	.08[c]	.13[a]	.00[a]	.11[a]	.86[a]	.00	12.1	15.9	15.4	19.5	17.0
-.00	.25[a]	-.12[a]	.07[c]	.13[a]	.00[a]	.11[a]	.86[a]	.00	10.7	14.7	16.7	20.6	18.0
-.00	.26[a]	-.12[b]	.07[c]	.13[a]	.00[b]	.12[a]	.85[a]	-.00	12.6	16.8	15.7	19.5	16.8
-.00	.26[a]	-.12[b]	.07[c]	.13[a]	.00[a]	.12[a]	.85[a]	-.00	12.2	16.5	15.8	19.6	16.8
-.00	.26[a]	-.12[b]	.07[c]	.13[a]	.00[a]	.12[a]	.85[a]	-.00	12.2	16.4	15.8	19.6	16.9
-.00	.27[a]	-.12[b]	.08[c]	.13[a]	.00[a]	.11[a]	.84[a]	.00[b]	12.5	16.0	10.2	13.6	11.8
.00	.26[a]	-.11[b]	.08[c]	.14[a]	.00[a]	.11[a]	.84[a]	.00[b]	12.2	16.6	14.4	18.7	15.8
.00	.27[a]	-.12[b]	.08[c]	.13[a]	.00[a]	.13[a]	.82[a]	.01	13.6	18.5	17.0	21.0	18.5
-.00	.26[a]	-.12[b]	.07[c]	.14[a]	.00[b]	.13[a]	.77[a]	-.00[b]	10.2	13.8	14.1	17.1	14.8
.00	.26[a]	-.12[b]	.08[c]	.13[a]	.00[a]	.13[a]	.84[a]	-.00	13.5[c]	17.8	15.0	18.6	16.6
-.00	.26[a]	-.12[b]	.08[c]	.13[a]	.00[a]	.12[a]	.85[a]	-.00[c]	13.1	17.3	14.8	18.6	16.5
.00	.26[a]	-.11[b]	.08[c]	.14[a]	.00[a]	.12[a]	.84[a]	-.00[a]	11.7	15.9	15.0	18.6	16.6
-.00	.27[a]	-.12[b]	.09[b]	.12[a]	.00[b]	.13[a]	.85[a]	.00[b]	14.6[c]	20.0	15.9	20.2	18.1
-.00	.27[a]	-.12[b]	.09[b]	.12[a]	.00[a]	.13[a]	.84[a]	.00[b]	14.5[c]	19.9	16.1	20.5	18.1
.00	.26[a]	-.12[b]	.08[c]	.13[a]	.00[a]	.13[a]	.84[a]	.00	13.7[c]	18.3	15.4	19.1	17.0
.00	.27[a]	-.12[b]	.08[c]	.13[a]	.00[a]	.12[a]	.84[a]	-.00	13.6[c]	18.4	15.2	18.9	16.8
.00	.26[a]	-.12[b]	.08[c]	.13[a]	.00[a]	.13[a]	.84[a]	-.00	13.7[c]	18.2	15.0	18.7	16.5
.00	.26[a]	-.12[b]	.08[c]	.12[a]	.00[a]	.13[a]	.84[a]	.00	13.8[c]	18.4	15.1	18.8	16.7
.00	.27[a]	-.12[b]	.08[c]	.13[a]	.00[a]	.13[a]	.84[a]	.00	13.5[c]	17.9	15.1	18.6	16.7
.00	.27[a]	-.12[b]	.08[c]	.12[a]	.00[a]	.13[a]	.84[a]	.00	13.8[c]	18.4	15.3	19.0	16.9
.00	.26[a]	-.12[b]	.08[c]	.13[a]	.00[a]	.13[a]	.84[a]	.00	13.8[c]	18.4	15.1	18.8	16.7
.00	.28[a]	-.12[b]	.08[c]	.13[a]	.00[a]	.12[a]	.85[a]	.00	13.2	17.7	15.5	19.4	17.2
.00	.26[a]	-.12[b]	.08[c]	.13[a]	.00[a]	.13[a]	.83[a]	.00	13.7[c]	18.0	14.6	18.3	16.2
.00	.27[a]	-.12[b]	.08[c]	.13[a]	.00[a]	.13[a]	.84[a]	-.00	13.1	17.8	14.7	18.3	16.3
.00	.27[a]	-.12[b]	.08[c]	.13[a]	.00[a]	.13[a]	.83[a]	-.00	13.3	17.7	14.5	18.2	16.0
.00	.26[a]	-.12[b]	.08[c]	.13[a]	.00[a]	.13[a]	.84[a]	.00	13.6[c]	18.0	15.2	18.8	16.8
.00	.26[a]	-.12[b]	.08[c]	.12[a]	.00[a]	.13[a]	.84[a]	.00	13.8[c]	18.3	15.9	19.6	17.7
.00	.26[a]	-.12[b]	.08[c]	.13[a]	.00[a]	.13[a]	.84[a]	-.00	13.4[c]	17.6	15.1	18.7	16.8
.00	.26[a]	-.12[b]	.08[c]	.12[a]	.00[a]	.13[a]	.84[a]	-.00	13.5[c]	17.8	15.1	18.8	16.8
.00	.26[a]	-.12[b]	.07[c]	.13[a]	.00[a]	.13[a]	.84[a]	-.00	13.2	17.1	15.1	18.6	16.8

[a] Significant at 1% level. [b] Significant at 5% level. [c] Significant at 10% level.

Table 11

Bai and Perron (2003) identified breakpoints.

Number of Breaks	F-statistic	Critical Value
5	3.93**	3.91
Breakpoints		
February 1980		
March 1987		
April 1994		
May 2001		
August 2008		

** Significant at 5% level.

Table 12

Inclan and Tiao (1994) identified breakpoints.

Number of Breaks	Level of Significance
7	5%
Breakpoints	
April 1972	
November 1974	
August 1979	
March 1980	
March 1983	
November 2005	
February 2009	

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