

# Central Banks and Gold

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## Abstract

Central banks hold gold reserves that are designed to build confidence in fiat currency. This confidence is undermined if the price of gold falls significantly or rises significantly. Central banks thus have an incentive to manage the price of gold. Such management is evident in fixed gold prices in the early 20th century, in Central Bank Gold Agreements more recently and in the asymmetric correlation between monthly central bank gold reserve changes and gold price changes. The empirical analysis further analyzes gold lending by central banks, linkages between central banks, bullion banks and mining companies and the gold carry trade. We conclude that coordinated and shadowy gold operations by central banks are necessary for successful gold price and gold reserves management and demonstrate the power of market forces relative to central banks.

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\*Address: UWA Business School, 35 Stirling Highway, Crawley, Perth, WA6018, Australia. E-mail: [dirk.baur@uwa.edu.au](mailto:dirk.baur@uwa.edu.au) I would like to thank Isaac Miyakawa for excellent research assistance and Bron Suchecki for very important comments and feedback on an earlier version of this paper. I would also like to thank Ken Clements, Andrew Caminschi, Frank Liu, Marvin Wee, Michael Murach, Arman Eshraghi, Jianxin Wang, Talis Putnins, Michael Lucey, Fergal O'Connor and Gunter Schnabl for very valuable comments.

Gold is the 3rd largest reserve currency after the US dollar and the euro with the US holding the largest gold reserves at close to 70% of its FX reserves (e.g. World Gold Council, 2011 and 2013). More surprising perhaps, gold is also among the most heavily traded assets in the world. The London Bullion Market Association (LBMA) estimates the average daily turnover at \$240bn (LBMA, 2011) which is higher than the global daily turnover of any currency pair except for the dollar/euro, dollar/yen, dollar/sterling and dollar/Aussie dollar (Financial Times, 2011).<sup>1</sup> The World Gold Council (2011) also argues that the liquidity and depth of the gold market is no coincidence in the context of gold reserve holdings by central banks as a liquid market is essential for a reserve asset.

The current gold reserves of central banks indicate a significant role of gold. This role is not new. Central banks, monetary policy and the price of gold seem to have a long joint history as the price of gold was fixed to the US dollar for most of the 19th and 20th century. In the 20th century, gold was fixed at 20.67 US dollar until 1934 and at 35 US dollar until 1971.

This history of a tight connection between fiat currencies and the price of gold is possibly the basis for claims that the price of gold is controlled or managed still today. There is even an organization, the Gold Anti-Trust Action Committee (GATA), dedicated to the issue of gold price manipulation. An article in the Financial Times (Tett, 2011) summarizes the core argument by GATA and asserts that some of GATA's "points have at least a grain of truth". The "grain of truth" is related to the economic arguments underlying the manipulation claims, i.e. central banks control fiat money and the monetary system and thus have an interest in a relatively constant price of gold in particular a price of gold that does not rise by too much and too fast. In other words, gold is a currency that competes with other fiat currencies which is why central banks have an incentive to control or manage the price of gold.<sup>2</sup> Martenson (2012) emphasizes this point as follows "If gold were suddenly to spike up to \$5,000 an ounce, all sorts of troubling questions

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<sup>1</sup>See also World Gold Council (2011) Liquidity in the Global Gold Market.

<sup>2</sup>"The price of gold is largely determined by what people who do not have trust in fiat money system want to use for an escape out of any currency, and they want to gain security through owning gold. Now, if annual gold production and consumption amount to 2 percent of the world's stock, a change of 10 percent in the amount produced or consumed is not going to change the price very much. But attitudes about inflation will change it." (Fed, 1993 (Angell, FOMC meeting 5/ 18/ 1993)).

would emerge for people. Such as, is there something wrong with the dollar? Is the world falling apart? A rapid spike in the price of gold would certainly cause people to question the current state of the world of fiat money [...]. Doubts about the value of fiat money would particularly affect a country whose currency is a global reserve currency. Hence, the focus of manipulation is often on the US central bank.<sup>3</sup>

Similar conclusions can be drawn for fast rising interest rates, inflation rates or exchange rates. These economic series are determined or influenced by central banks and governments yet generally no one claims that these series are manipulated. This perhaps puzzling discrepancy is potentially due to the limited information provided by central banks regarding gold reserves lending and gold's global and supranational nature which makes uncoordinated and open management by any central bank difficult if not impossible.

But not only a historically high price of gold or a fast rising price of gold would be of central banks' concern, historically low gold prices or a fast falling price of gold would also be as it implies low valuations of central banks' gold reserves.<sup>4</sup>

This establishes a trade-off for central banks, i.e. prices should neither be too high nor too low, and provides incentives to manage the price of gold.

There are many official statements that illustrate that central banks acknowledge the role of gold for monetary policy and the existence of tools to manage the price. Two prominent examples are the following.

“There’s an interesting question here because if the gold price broke in that context, the thermometer would not be just a measuring tool. It would basically affect the underlying psychology. Now, we don’t have the legal right to sell gold but I’m just frankly curious about what people’s views are on situa-

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<sup>3</sup>The competition of gold with other currencies is loosely related to “Gresham’s Law”. When there are multiple currencies in an economy, Gresham’s law states that any circulating currency consisting of both “good” and “bad” money (both forms required to be accepted at equal value under legal tender law) quickly becomes dominated by the “bad” money. This is commonly stated as “Bad money drives out good”. In contrast, Rolnick and Weber (1986) theoretically investigated the possibility that bad money would drive good money to a premium rather than driving it out of circulation entirely.

<sup>4</sup>The introduction of the first Central Bank Gold Agreement was a reaction to deteriorating gold prices and gold reserve valuations (World Gold Council, 2011). Central Bank Gold Agreements will be analyzed in more detail below.

tions of this nature because something unusual is involved in policy here.”(Fed 1993 (Greenspan, FOMC meeting 5/ 18/ 1993)).

“We can hold the price of gold very easily; all we have to do is to cause the opportunity cost in terms of interest rates and U.S. Treasury bills to make it unprofitable to own gold. I don’t know how much change in the fed funds rate and the Treasury bill rate it takes to do that, but I’d sure like to find out.” (Fed, 1993 (Angell, FOMC meeting 5/18/1993)).

More recent statements by the former chairman of the US central bank, Ben Bernanke, draw a slightly different picture. When asked in 2011 whether gold is money he responded that gold is not money but an asset.<sup>5</sup> Two years later, in 2013 when again questioned about gold, Bernanke said that “Movements of gold prices don’t predict inflation very well.” and that “nobody really understands gold prices” (see Wall Street Journal, 2013). These statements do not acknowledge the role of gold as an alternative currency or money which is a key premise in the rationale for gold price management or manipulation.<sup>6</sup> A claim that gold is only an asset and does not possess any characteristics of an alternative currency is consistent with the view of manipulation advocates that gold has an important function in central bank decision making and that its role is systematically downplayed. In other words, if a central bank wanted to ensure that gold is not viewed as a thermometer for the value of fiat currency, it would try to decouple gold from the value of fiat currency or from consumer price indices. Finally, Bernanke’s statements do not explain why the “asset” gold is held in large quantities by the US government and why it is the 3rd largest reserve currency globally (World Gold Council, 2011).

Bernanke’s statements point to the scarcity of research on the role of gold for central banks and is one of the motivations for this paper. Another motivation is to better understand and possibly resolve the many conspiracy theories about gold. “Conspiracy” is arguably a strong word but its usage has some justification in the context of central

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<sup>5</sup>During his monetary policy report to Congress in July 2011 Bernanke responded to the question “Is gold money?” with “No. It’s an asset.” (e.g. see Forbes 7/13/2011).

<sup>6</sup>If the price of gold was indeed manipulated in the 1980s and 1990s so that it did not increase with the general price level, the manipulation would be the basis for Bernanke’s argument that gold “does not predict inflation very well.”

bank gold reserves and the price of gold.<sup>7</sup> Conspiracy implies a “secret plan” and some coordination or collusion which is necessary to manage the price of gold effectively.<sup>8</sup> If central banks acted on their own and disclosed their plans to sell or buy gold, the price of gold would potentially move against the central banks interest. The Central Bank Gold Agreements are an implicit acknowledgement of this issue.

Incentives play a major part in economics and also in the analysis of gold price management and potential manipulation. The organisation that advocates the “conspiracy” and “manipulation” theories, GATA, and many other individuals and websites may have altruistic interests but also have incentives to advertise their theories and make profits. For example, some groups or individuals and their associated websites and newsletters have a large number of paying subscribers. In addition, if the price of gold is indeed suppressed and the true price is significantly higher, stopping the suppression would lead to significant profits for those who hold large amounts of gold.

To the best of our knowledge this is the first academic study on the management of the gold price and central bank gold reserves. In addition, since gold is a currency, it is also the first academic study on foreign exchange intervention with a focus on gold.<sup>9</sup>

The paper is structured as follows: First, we describe the background of gold prices and potential gold price management. Second, we study direct channels of management based on central bank gold reserves changes and find only weak evidence for a price impact of gold reserve changes. Third, we study indirect channels of management - gold lending - i.e. price patterns that do not directly and immediately result from central banks’ actions. Remarkably, both the relatively stable gold price regime in the 1980s and the 1990s and the bull market in the 2000s can be fully explained with the gold carry trade based on central bank gold lending. The stable gold price period can result from an “active” gold carry trade whilst the bull market can result from an unwinding of the carry trade. The

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<sup>7</sup>Tett (Financial Times, 2011) asks if there is a shadowy plot behind gold.

<sup>8</sup>A more recent example of secret gold transactions involved the Bank for International Settlements and a gold swap (Financial Times, 2010).

<sup>9</sup>There seems to be only one recent paper on gold reserve holdings and central banks (Aizenman and Inoue, 2012). Aizenman and Inoue (2012) aim to explain gold reserve holdings of central banks whilst this paper aims to analyze the influence of central banks on gold prices.

analysis of gold lending emphasizes the power of the market relative to central banks and an asymmetry in relation to upside price management versus downside price management.

Finally, we summarize the main findings and draw conclusions.

## 1 Background

The role of gold as a monetary anchor has been the basis for an official gold price fixing and thus price management, intervention and “manipulation” by central banks for decades. Figure 1 illustrates that the price of gold was maintained by monetary authorities at predetermined levels until 1968 followed by a two-tier London market establishing a free market for individuals and a central bank “market” with a gold price set at 35 US dollars per troy ounce.

When the US dollar’s convertibility into gold (at 35 US dollars) was suspended in 1971 the two-tier market became one global market for gold. As the London fix would now be free of any central bank intervention an afternoon (second) fix was introduced in an effort to attract investors from the United States (O’Callaghan, 1991).<sup>10</sup>

< Insert 1 about here >

The objective of central banks to maintain a predetermined level of the gold price during the gold standard and the Bretton Woods system represents gold price management and can be seen as the basis and the precursor of any gold price management in the post-1971 era. However, the 40-year price history of gold from 35 US dollars in 1971 to more than 1,900 US dollars in 2011 is not compelling evidence for any gold price management and clearly not suppression. Even though the suspension of the Bretton Woods gold standard meant that gold lost its pivotal role in the international monetary system (O’Callaghan, 1991) gold still plays an important role as a relative benchmark for fiat money. For example, the depreciation of the US dollar (euro, yen, Swiss franc) is associated with a

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<sup>10</sup>Until 2014, the gold fixing happened twice a day by teleconference with five banks: Bank of Nova Scotia-ScotiaMocatta, Barclays Bank, Deutsche Bank AG, HSBC Bank USA and Societe Generale. The fixings were used to determine prices globally (e.g. see Brown (Reuters), 2013).

higher price of gold in US dollar (euro, yen, Swiss franc) *ceteris paribus*.<sup>11</sup> This benchmark role provides incentives for governments and central bankers to control and eventually influence the price. The benchmark may be particularly important in times of economic or financial crisis.<sup>12</sup>

Central Bank Gold Agreements (CBGA) are alternative evidence for intervention and also include the implicit acknowledgement that central bank gold sales affect prices. This means that central banks aim to provide a support or a floor for gold prices emphasizing that they are also concerned about negative gold price changes. The implied price impact of central bank gold sales should lead to a positive relationship between gold reserve changes and the price of gold. This relationship is tested statistically below. The first Central Bank Gold Agreement, also known as the Washington Agreement on Gold, was announced on 26th September 1999. It followed a period of increasing concern that uncoordinated central bank gold sales were destabilising the market, driving the gold price sharply down (World Gold Council<sup>13</sup>). The first CBGA restricts annual sales to 400 tons and total sales over the five year period to 2,000 tons.<sup>14</sup>

The first CBGA coincides with the creation of the European Central Bank and the euro. Despite an apparent trend among European central banks to sell gold, the ECB had decided to hold 15% of its foreign exchange reserves in gold (World Gold Council, 2010).<sup>15</sup>

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<sup>11</sup>A regression of changes in the monthly gold price (denominated in US dollars) on changes in a trade-weighted index of the US dollar yields a coefficient estimate of  $-0.93$  and is not statistically different from  $-1$ .

<sup>12</sup>Speck (2010) argues that gold is manipulated in such periods since its price is not stable during the entire turmoil or crisis period. An alternative explanation is that the safe haven character of gold is short-lived and that investors start to sell gold as soon as the uncertainty associated with the shock is resolved.

<sup>13</sup><http://www.gold.org/reserve-asset-management/central-bank-gold-agreements>

<sup>14</sup>The “Joint Statement on gold” ECB Press Release (26 September 1999) states: In the interest of clarifying their intentions with respect to their gold holdings, the undersigned institutions make the following statement: Gold will remain an important element of global monetary reserves. The undersigned institutions will not enter the market as sellers, with the exception of already decided sales. The gold sales already decided will be achieved through a concerted programme of sales over the next five years. Annual sales will not exceed approximately 400 tons and total sales over this period will not exceed 2,000 tons. The signatories to this agreement have agreed not to expand their gold leaseings and their use of gold futures and options over this period. This agreement will be reviewed after five years. Source: [www.ecb.europa.eu/press/pr/date/1999/html/pr990926.en.html](http://www.ecb.europa.eu/press/pr/date/1999/html/pr990926.en.html)

<sup>15</sup>Jean-Claude Trichet, the second ECB governor listed three points in support of the ECB’s decision: Firstly, gold plays a *de facto* role in the international monetary system. It is one of the elements on which confidence in the currency is based, particularly in the eyes of public opinion. It is often viewed as the ultimate reference asset. Secondly, putting no gold in the ECB reserves could be seen as a challenge *vis a vis* almost all central banks who hold gold in their reserves. Thirdly, including gold in the ECB’s reserves

Central banks also manage their gold holdings and implicitly the price of gold by lending out fractions of their gold reserves. Management through lending may be more effective as the gold is not sold and the power of the central bank to act in the future is not reduced. Greenspan stated “central banks stand ready to lease gold in increasing quantities should the price rise.” (Greenspan, 1998) Whilst this statement may be true, the demand side is not taken into account. For example, if gold is in a strong bull market, a central bank may stand ready to lease gold but it is not clear who (and in increasing quantities) would want to borrow gold in times of rising gold prices. This issue points to an asymmetry of the abilities of central banks to manage rising gold prices versus falling gold prices. Whilst falling gold prices can be counteracted with gold purchases increasing gold reserve holdings, rising gold prices can only be counteracted with gold sales decreasing gold reserve holdings. Since central bank gold holdings are finite, there is a clear limit of gold sales defined by the gold reserve holdings.

Gold is also used as collateral. The “central bank of central banks”, the Bank for International Settlements (BIS), accepts gold as collateral in gold swaps (BIS, 2010 and Farchy and Blas, 2010).<sup>16</sup>

The lack of research on gold price and gold reserves management of central banks is in stark contrast to a strand of literature that is closely related to gold price management - exchange rate or currency management. Exchange rate management is performed both openly and secretly (e.g. see Bhattacharya and Weller, 1997, Dominguez, 1998 and Sarno and Taylor, 2001). It is possible for a country to intervene unilaterally but it is generally more effective if the intervention is coordinated. Obviously, the scale is different and potentially more complex as foreign exchange involves two countries and currencies and not multiple countries as in the case of gold.

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would be a way of diversification of portfolios, which is a good tool to reduce the global risk. So gold has a role to play.(World Gold Council, 1998)

<sup>16</sup>It is noteworthy that the swaps are part of the entry “Gold bars held at central banks”. The statistic increased from Special Drawing Rights (SDR) millions 22,616.5 in 2009 to SDR 41,596.9 in 2010 (page 163, BIS, 2010).

## 2 Analysis of Management

This section focuses on central bank gold reserves and gold price management. Whilst we prefer the word “management” for its more neutral usage compared to “manipulation” and “intervention” the words do essentially not differ in their meaning, i.e. all words are about “control” and “influence”.

However, there seems to be no agreement on a definition of market manipulation (see Putnins, 2013). Common words with respect to the manipulation of prices are “artificial”, “abnormal” and “intent”. Putnins (2013) distinguishes between direct and indirect evidence of manipulation. The former is based on the study of known manipulation cases whilst the latter is based on the study of abnormalities in prices. In the context of the gold market, the CBGA is an agreement with the objective (“intent”) to ensure that the price of gold does not significantly fall. This is direct evidence of management, intervention or manipulation. Changes in gold reserve holdings are also related to direct evidence but the “intent” may be unknown. Changes may be motivated by gold reserves management or by gold price changes and thus intervention. This is analyzed in Section 2.1. Section 2.2 studies indirect evidence based on central bank gold lending.

Figure 2 presents the evolution of the price of gold and shows that there are two bull markets, one spanning the period from 1968 until September 1980 and the other one lasting from 2003 until 2011. Moreover, there is a third and rather long episode in which the price of gold remained in relatively narrow bands between the early 1980s until the year 2000. We identified these three periods since a successful suppression and thus manipulation of the gold price can only have occurred in the 1980 - 2000 period in which the price was relatively stable.<sup>17</sup>

< Insert 2 about here >

A strong bull market, similar to the one between 2003 and 2011, is not consistent with a successful suppression of the price of gold. Moreover, some authors use the relatively

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<sup>17</sup>A manipulation is defined as “successful” if the price of gold is relatively stable, i.e. the price does not increase by too much over a certain period of time. In contrast, a price manipulation could also be labelled “successful” if the price of gold increased significantly. It could be argued that the price would have risen even more without the manipulation.

stable price of gold in the 1980s and 1990s (around 300 US dollar) as an indication for a price suppression and identify the 400 US dollar price as an upper-price barrier (see Speck, 2010). However, it is well known that assets exhibit price barriers or thresholds and that these are often the result of psychological factors rather than manipulation (see Aggarwal and Lucey, 2007).

Following the high inflation era in the 1970s and early 1980s and the relatively high gold price, central banks may indeed have had an incentive to stabilise the price of gold. Similarly, after 20 years of stable gold prices and low inflation rates labelled the “great moderation” incentives to suppress the price may have disappeared. This argument explains both the relatively stable price of gold in the 1980s and 1990s and the 2004 - 2011 bull market. However, we show below that there are alternative and less vague explanations.<sup>18</sup>

## 2.1 Central Bank Reserves

Salant and Henderson (1978) analyzed the effects of anticipations of government sales of gold. They illustrated that market anticipations of governments selling a portion of these stocks at an unpredictable time exerted a significant negative influence on the gold price.<sup>19</sup> It can be argued that this negative influence resulted in the first central bank gold agreement (CBGA) in 1999.

This section does not analyze the anticipations of gold reserve changes but actual gold reserve changes of central banks. However, it is important to mention that large gold reserve holdings do not only generate confidence per se but also public knowledge about the ability to sell gold and thus to influence the price. In fact, the mere anticipation of such an event by investors could depress the price of gold or cap the price at some level. And the larger the gold reserves of central banks are the larger the effect could be. Salant and Henderson (1978) cite a reference to the “sword of Damocles” over large gold holdings to

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<sup>18</sup>Section 2.2 provides new evidence for gold price suppression between 1980 and 2000.

<sup>19</sup>When the Bank for International Settlements retrospectively announced a gold swap (see BIS, 2010 and Farchy and Blas, 2010) it caused the price of gold to fall since the swap was interpreted as a potential future sale. The swap was apparently not interpreted as evidence that gold would be increasingly used as collateral increasing the demand and thus the price of gold.

describe such effects. The removal of the “sword” is analyzed below with the first Central Bank Gold Agreement (CBGA) in 1999.

Figure 3 displays the relationship between total (world aggregate) central bank gold reserves and the price of gold. The graph illustrates that there is no clear and consistent relationship between the two series for the 1968- 2015 period. There are periods in which a positive correlation can be identified, e.g. between 1996 and 2000 and between 2009 and 2011. However, there are also periods in which the correlation is negative, e.g. between 2002 and 2008 and between 2012 and 2015. Varying correlation patterns can also be identified between US central bank gold reserves and the price of gold but the gold reserve changes only vary by 600m troy ounces of gold over the entire period of analysis compared to about 8,000m troy ounces globally. Between 1973 and 2016 the change in US gold reserves is even smaller and less than 100m troy ounces of gold. The large drop in gold reserves from 11,700m ounces to less than 11,200m ounces in 1973 emphasizes two alternative explanations. Either the US central bank reserve system wanted to profit from rising prices by selling gold reserves or they wanted to counter the strong price increase.

< Insert Figure 3 about here >

< Insert Figure 5 about here >

The varying levels of correlations between the price of gold and government gold reserves through time demonstrates that there is an asymmetry between gold reserve reductions and gold reserve increases. The observed relationship suggests that the market can absorb all sales without any price obvious impact whilst purchases are not absorbed and have the expected positive price effect. This empirically observed asymmetry is also consistent with the ability of central banks to stop a negative price trend and create a floor through gold purchases and the inability to stop a positive price trend and create a ceiling through gold sales due to the finite gold reserves.<sup>20</sup> To summarize, central banks have incentives to manage and control the price in both directions but have limited resources to enforce the latter creating an asymmetry.

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<sup>20</sup>We show below that gold lending is not effective in such circumstances either.

The positive correlation between 1996 and 2000 coincides with several announcements of major (mainly European) central banks to sell gold culminating in the first central bank gold agreement signed in September 1999. The central bank of the Netherlands, Switzerland and the UK had all announced an intention to sell significant fractions of their gold reserve holdings. For example, The UK government announced on 7 May 1999 to sell gold and reinvest the proceeds in foreign currency deposits and in June 1999, the Swiss National Bank (SNB) announced that half of its 2590 tonnes of gold reserves were no longer required for monetary purposes. These announcements had an effect on the price of gold as illustrated in Figure 4.

< Insert Figure 4 about here >

The negative price effect led to concerns that the fall in the price of gold would further reduce the value of the reserve holdings (Alchemist, 2003). The fact that the mere announcements of future sales led to the fall in the price is consistent with the predictions of Salant and Henderson (1978). Furthermore, the relatively small drop in the price could be explained with a reduction in uncertainty and the removal of the “sword of Damocles” over large gold reserves.

To deal with this and other prospective sales of gold reserves, a consortium of central banks - including the European Central Bank and the Bank of England - were pushed to sign the Washington Agreement on Gold in September 1999, limiting gold sales to 400 tonnes per year for 5 years. This triggered a sharp rise in the price of gold, from around US\$260 per ounce to around \$330 per ounce before the price fell again into 2000.

The graph illustrates a clear positive correlation between central bank gold reserves and the price of gold over the 2-year period but also demonstrates that the correlation can break down due to announcements as observed in early to mid 1999.

Another explanation for non-positive correlations could be that the price is managed or that other factors dominate central bank gold reserve changes.

Theoretically, we expect a positive or zero correlation between gold price changes and gold reserve changes if the price of gold is managed or suppressed through central bank

gold sales. A negative correlation is not consistent with gold price management through central bank gold sales. However, it would be consistent with gold reserves management, i.e. selling gold reserves when prices rise and buying gold reserves when prices fall.

To account for different gold price regimes and to focus on regimes of rising prices and regimes of falling prices we use quantile regressions with relative gold price changes ( $\Delta P$ ) as the dependent variable and changes in reserves as independent variables ( $\Delta Res$ ). If central bank gold sales (purchases) are intended to slow rising (falling) prices, gold reserve changes should lead to decreasing gold prices changes, respectively.

$$Q(\Delta P_t|\tau) = \alpha(\tau) + \beta(\tau)\Delta Res_t + \gamma(\tau)\mathbf{X}_t + \epsilon_t \quad (1)$$

where  $Q(\Delta P_t|\tau)$  denotes the conditional quantile  $\tau$  of gold price changes,  $\Delta Res_t$  are the changes in gold reserve holdings and  $\mathbf{X}$  is a matrix of control variables consisting of relative changes of US dollar, US CPI and the VIX. These variables are among the most important on a long list of national and international factors. The US dollar is not only a reserve currency but also the currency in which gold is generally denominated. The US CPI is a proxy for global consumer price inflation and thus controls for gold's role as a store of value and the VIX accounts for the safe haven property of gold. The null hypothesis of a positive price impact of gold reserve changes is  $H_0 : \beta(\tau) > 0$  and the alternative hypothesis is  $H_1 : \beta(\tau) \leq 0$ . A zero or negative price impact is consistent with gold price management and gold reserves management.

Since central banks are particularly concerned with extreme gold price movements, the null and alternative hypotheses can be focussed on the lower (e.g. 5% and 10% quantile) and upper quantiles (e.g. 90% and 95% quantiles) whilst the intermediate quantiles (e.g. between 20% and 80%) are not of particular interest to central banks.

$H_0 : \beta(\tau) > 0$  for  $\tau < 0.2$  and the alternative hypothesis is  $H_1 : \beta(\tau) \leq 0$  for  $\tau < 0.2$

and

$H_0 : \beta(\tau) > 0$  for  $\tau > 0.8$  and the alternative hypothesis is  $H_1 : \beta(\tau) \leq 0$  for  $\tau > 0.8$

The asymmetry in the ability of central banks to manage rising prices versus falling prices leads to an additional hypothesis that the lower quantile effects are smaller than the upper quantile effects, i.e.  $H_0 : \beta(\tau_1) < \beta(\tau_2)$  where  $\tau_1$  are selected lower quantiles (e.g. 5%, 10%, 15%) and  $\tau_2$  are selected upper quantiles (e.g. 85%, 90%, 95%).

The coefficient estimates for world central bank gold reserve holdings are presented in Figure 6 and contain the least-squares coefficient estimate (red solid line) and its 95% confidence interval (red dashed lines) and the quantile-dependent coefficient estimates (black dots) and their respective confidence interval. The least-squares estimates show a negative but statistically insignificant relationship. The quantile regression coefficients illustrate that there is considerable variation around the mean with larger negative values for the most extreme lower quantiles, zero coefficient estimates for intermediate quantiles and negative coefficients for high quantiles except for the most extreme upper quantiles for which the estimates turn positive. The coefficient estimates are not statistically different from zero within a two-sided test but the lower quantile estimates are statistically significantly different from being positive rejecting the null hypothesis for lower quantiles. In addition, the variation across quantiles is also economically significant as the coefficient estimates vary between  $-2$  and  $2$ . The large coefficient estimates in the lower quantiles indicate that central banks increase their gold reserves in strongly falling gold price regimes. In contrast, the positive coefficient estimates for extreme upper quantiles indicates that central bank gold reserve changes exhibit a price impact in strongly rising gold price regimes. This asymmetry is consistent with the theoretical considerations that central banks can enforce a price floor but not a price ceiling.

The fact that statistical significance is weak in general (despite relatively large coefficient estimates and thus economic significance) can be explained economically since central banks will sell or buy gold in a way that minimizes the price impact on gold. Given that the analysis is based on monthly data, it is not surprising that the effect is small as changes in reserves will be smoothed over several days, weeks or months.

Alternatively, we have also estimated a vector autoregressive (VAR) model to further study the dynamics between gold reserve holdings and the price of gold. The estimation results show that lagged changes in gold reserves negatively influence the price of gold

on average but there is no effect from the price of gold on gold reserve holdings. All coefficient estimates are statistically insignificant. The VAR estimates support the quantile regression results qualitatively and provide additional information about the dynamics of the relationships.

< Insert Figure 6 about here >

The simple OLS estimates of gold price changes regressed on US gold reserves changes yield a negative coefficient estimate whilst the multivariate OLS estimates lead to a positive coefficient. The corresponding quantile regressions yield similar estimates as the simple OLS model across all quantiles and positive and increasing coefficients for the multivariate OLS specification across quantiles. However, only the highest quantiles are statistically significant. The difference between the simple and multivariate regressions confirms the role of the selected control variables but also indicates that they are strongly related to gold reserve changes and thus not merely control variables. Changes in the US dollar influence the price of gold but may also be correlated with gold reserve changes. The same relationship holds for changes in CPI whilst changes in the VIX can be assumed to play a minor role for changes in gold reserve holdings.

It is noteworthy that the quantile regression model also provides information about the volatility of the gold price as small changes (centre of the distribution) and large positive and negative price changes (upper and lower quantiles) are all explicitly modelled. The negative coefficient estimates in lower quantiles and upper quantiles of gold price changes imply that gold reserve changes are used to counter large price movements decreasing the volatility. The results are confirmed by another model that regresses absolute gold price changes on gold reserve changes and the control variables. The resulting negative coefficient estimate of the gold reserve changes for high quantiles (but not the most extreme quantiles) implies that gold reserves changes decrease the volatility of the gold price in certain regimes.

The results demonstrate that central bank gold reserve changes have a different impact in falling gold price regimes and rising gold price regimes consistent with the theory described above. The statistically insignificant results are due to the monthly frequency

of gold reserves that make it impossible to identify the daily price impact. However, the results suggest that central banks purchase gold in falling gold price environments and sell gold in rising gold price environments consistent with both gold price management and gold reserves management. In other words, the price impact is mainly hidden consistent with the objective of non-visibility of central bank market interventions to avoid counter-acting market activity. The findings also show that the gold market is liquid as it can absorb large demand and supply shocks.<sup>21</sup> The identified asymmetry of gold price intervention, i.e. that central banks can enforce a price floor but not a price ceiling, suggests that for rising gold prices central banks rather engage in gold reserves management than price management.

## 2.2 Gold Lending

The previous section analyzed direct intervention in the gold market through sales and purchases of gold and thus changes in central bank gold reserves. This section studies an indirect intervention through gold lending (also called “gold leasing”). The indirect form is more sustainable as lending does not imply an actual sale of gold reserves. In addition, such lending need not be disclosed (see IMF, 2004). Since gold does not pay any interest there is an incentive to lend gold.<sup>22</sup> Figure 7 shows the 1-month and 6-month gold lease rates from 1989 until 2015 obtained from the London Bullion Market Association (LBMA).<sup>23</sup> The high lease rates until around the year 2000 point to a very active leasing market with significant fractions of gold reserve holdings lent out. The subsequent decline of gold lease rates to values around and below zero points to a rather inactive leasing market with only small amounts of gold reserves lent out. The negative rates following the Global Financial Crisis imply that gold lenders would not receive but pay interest.

< Insert Figure 7 about here >

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<sup>21</sup>The World Gold Council (2011) mentions explicitly that the liquidity and non-visibility offered by gold is a main factor in gold’s popularity among central banks and its status as the 3rd largest reserve currency after the US dollar and the euro.

<sup>22</sup>It is often stated that gold does not pay any interest. It is noteworthy that money or cash does not pay any interest either if it is not lent. Storing gold or money in a safe or a vault does not provide any income.

<sup>23</sup>Le and Zhu (2013) analyse the risk premia in gold lease rates and Barone-Adesi et al. (2010) study the link between the gold lease rate and the convenience yield.

The very low (close to zero) interest rates are an important observation in the context of a famous quote by the former Fed chairman Allan Greenspan that “[...] central banks stand ready to lease gold in increasing quantities should the price rise” (Greenspan, 1998). The quote does not mention the potential costs of leasing gold if the lease rate is low or even negative. Clearly, in a negative leasing rate regime, it would be very costly to lease gold in increasing quantities. This demonstrates that the asymmetry in the ability of central banks to manage the price of gold through gold reserve changes<sup>24</sup> also holds for gold lending. But why did lease rates decline and fluctuated around zero for most of the time from the early 2000s onwards? Interactions among central banks, bullion banks and mining companies and the evolution of the price of gold can explain the history of gold lease rates. In an active lending market, central banks lend gold to bullion banks which lend the borrowed gold to mining companies which in turn sell the borrowed gold to finance the mining operations and eventually pay back their gold loan with future gold production. The sale of gold by the mining companies creates a direct link between central bank gold lending and the increased supply of gold. If bullion banks do not lend the gold to mining companies but instead sell the borrowed gold and use the proceeds to invest in higher yielding bonds or assets, bullion banks engage in a gold carry trade. The gold carry trade implies that bullion banks hold a short position in gold and thus have an interest in a constant or decreasing price of gold. A numerical example illustrates this gold carry trade. The bullion bank borrows 10,000 ounces of gold for \$1,000 per ounce (\$10m) at a lease rate of 2% p.a. and immediately sells the gold for \$10m. The bank invests the proceeds at 4% p.a. After one year the investment matures and the bank receives \$10m x (1 + 4%) = \$10.4m and pays back its gold loan of 10,000 ounces plus 2% or 200 ounces of gold interest.<sup>25</sup> If the price of gold did not change over the course of the year, the bank pays 10,200 ounces x \$1,000 = \$10.2m and makes a profit of \$0.2m. If, however, the price increased by 2% to \$1,020 over the year, the bank would have to pay 10,200 ounces x \$1,020 = \$10.404m and incur a loss of -\$0.004m. More formally, the no-arbitrage condition is  $(i_{USD} - i_{gold}) = GOFO$  where GOFO is the gold forward rate.

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<sup>24</sup>Central banks can manage falling gold prices by purchasing gold and financing such purchases with fiat currency but they cannot sell gold in excess of their gold reserve holdings.

<sup>25</sup>Central banks have an incentive to receive payment in US dollars and not in gold ounces as payment in ounces would increase gold reserves and thus provide public information about gold lending.

Empirically, the condition can be tested as follows:

$$\Delta s_{G1,t,t+1} = \alpha + \beta(i_{USD,t} - i_{gold,t}) + \epsilon_{t,t+1} \quad (2)$$

where  $\Delta s_{G1,t,t+1} = s_{G1,t+1} - s_{G1,t}$  and  $s$  is the price of gold (1 ounce) in US dollar. Uncovered interest rate parity (UIP) holds if  $\alpha = 0$  and  $\beta = 1$ . The equation implies that a low (high) gold interest rate (leasing rate) relative to a US dollar interest rate leads to an appreciation (depreciation) of the US dollar to Gold (1 ounce) exchange rate or simpler, the price of gold.

Table 1 presents the results for 3-month, 6-month and 12-month interest rate differentials using US dollar LIBOR and the gold lease rate for the full sample period (Panel A) and two sub-sample periods presented in Panel B (1989-2000) and Panel C (2001-2015). The sub-samples are motivated by the relatively constant price of gold until 2000 and the bull market from 2001 until 2011.

< Insert Table 1 about here >

The coefficient estimates for the full sample period indicate that UIP did not hold on average as both coefficients are significantly different from 0 and 1, respectively. The results also show that the gold carry trade was not profitable for most interest rate differences as the highly significant  $\alpha$  dominates the  $\beta$  for interest rate differences that are not too large, e.g. do not exceed 8% in the case of 12-months lease rates. The appreciation of the price of gold is often too large to be compensated by the profits obtained through borrowing gold and investing in US dollars.

The sub-sample analysis further shows that only the first sub-sample (1989-2000) was profitable for investors that employed the carry trade. Panel B shows that the  $\beta$  coefficient estimates dominate the  $\alpha$  coefficients. In contrast, in the second sub-sample (2001-2015) carry trade strategies would have led to losses since all coefficient estimates are positive implying an appreciation of the price of gold for all interest rate differences. The full sample and sub-sample results are expected given the evolution of the gold price. The gold price was relatively stable in the first sub-sample providing a perfect ground for the

carry trade whilst the second sub-sample can be characterized by a strong bull market implying losses due to an appreciation of the funding currency gold.<sup>26</sup>

The gold carry trade is conditional on a stable (non-increasing) price of gold. Hence, banks involved in the carry trade have an interest in a relatively constant price of gold with low volatility. Similar to the “classical” carry trade involving currencies, there is also a self-enforcing mechanism that tends to render the gold carry trade profitable. In periods of falling gold prices, the demand to borrow gold and thus lease rates will be relatively high resulting in additional selling pressure on the price of gold and increasing the gains with the gold carry trade. In contrast, in periods of rising gold prices, the demand to borrow gold and thus lease rates will be relatively low and potentially even negative (see Figure 7) and investors will unwind their carry trades increasing the price of gold further.

Consequently, relatively stable gold prices can be the result of gold lending by central banks and subsequent gold sales by gold miners and bullion banks. In fact, since gold reserves are finite gold sales would reduce the reserves and thus reduce a central banks ability to influence the price of gold in the future. Moreover, due to the Central Bank Gold Agreement (CBGA) that restricts the sale of gold<sup>27</sup>, gold lending may be the only alternative and need not be disclosed by central banks (see IMF, 2004).<sup>28</sup>

The strong gold price increase between 2003 and 2011 is evidence that the gold price was either not suppressed or that such suppression was not successful in holding the price relatively constant. Whilst the direct channel of management does not offer any explanation why central banks would have ended their attempts to suppress the price of gold, the indirect channel represented by the gold carry trade offers such an explanation. It is possible that banks involved in the carry trade were surprised by an unexpected gold price increase which led them to buy back gold to close their short positions. This may have led to a short squeeze potentially explaining the initial phase of the strong price increase between 2003 and 2011. Whilst gold borrowing can be considered low risk in a stable, low volatility price regime, gold borrowing can be considered high risk in a bull market ren-

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<sup>26</sup>The first sub-sample results are consistent with a common effect in currency markets known as the “forward premium puzzle” (e.g. see Boudoukh et al., 2013).

<sup>27</sup>E.g. see World Gold Council website: Government Affairs - Central Bank Gold Agreements.

<sup>28</sup>Speck (2010) provides statistics of gold lending for the central banks of Portugal and Switzerland and estimates the amount of gold lent by the Deutsche Bundesbank.

dering the gold carry trade too risky. The spike in lease rates around the global financial crisis in 2008 also suggests that central banks became aware of (increased) counterparty risk and thus demanded compensation for increased risk (see Key, 2009).<sup>29</sup> Information about mining companies' hedging activities provides additional empirical evidence. Quarterly hedge book data<sup>30</sup> reveals that miners hedged their exposure during the relatively stable gold price episode between 1987 and 2001 and reduced that hedging activity during the gold bull market between 2002 and 2013.

Similarly, the gold mining companies' borrowing from central banks or bullion banks to finance their production is only efficient in stable gold price regimes. If the gold price is expected to increase significantly this financing option becomes too expensive and the demand for gold borrowing decreases. The lower demand leads to falling lease rates and thus reduced gold lending of central banks potentially reinforcing any momentum in prices.

This perspective illustrates the interdependence of central banks, gold mining companies, bullion banks and the price of gold and emphasizes that an isolated analysis is misleading.

To summarize, central bank gold lending enables the gold carry trade and gives bullion banks an interest in a constant price of gold, i.e. there is a rationale for gold price stabilization or suppression. Central banks therefore do not directly influence the price of gold but indirectly through the anticipated gold transactions of the bullion banks. Whilst it is impossible to identify if the motivation of central bank gold lending is to enable the carry trade with the intent to indirectly influence the price of gold or if the motivation of the lending is to make a profit on the otherwise non-interest bearing gold reserves there are strong arguments for the latter. If central banks know that they cannot "lease gold in increasing quantities should the price rise" because the market conditions imply no demand for borrowed gold, they will not attempt to influence the price through gold leasing.

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<sup>29</sup>The negative correlation between lease rates and the price of gold during the global financial crisis clearly indicates that there is no effect in lease rates related to the safe haven property of gold.

<sup>30</sup>The data is obtained from GFMS.

### 3 Summary and Concluding Remarks

This paper is motivated by claims that central banks manipulate the price of gold and by the under-researched and under-estimated role of gold for central banks and monetary policy.

The theoretical arguments for central bank gold price management are based on the connection of gold with fiat currency. Gold reserves are designed to build confidence in fiat currency. This confidence would be jeopardized if the price of gold increased by too much which is the theoretical basis for control and management of the price. There is also an incentive for central banks to control the downside of gold prices and thus preserve the value of their gold reserves. The Central Bank Gold Agreement is clear acknowledgement of central banks' potential price impact and evidence of coordinated and mostly hidden price and reserves management. In addition, the European Central Bank's gold reserves and recent increases of emerging market central banks' gold reserve are further evidence of the role of gold in central bank monetary policy beyond the "legacy" gold holdings of the US and many, mostly European central banks.

Furthermore, the gold lending activities of central banks implicit in the gold leasing rate establish a link between central banks, bullion banks and gold mining companies and imply an indirect and transferred gold price management. Gold lending is the basis for the gold carry trade which is profitable in stable gold price regimes and provides market-based incentives to stabilize or control the gold price. In other words, the gold carry trade represents a market-driven suppression of the gold price based on the gold lending of central banks. Whilst there are strong economic arguments for central bank gold price management following the high inflation episode and the rising price of gold in the late 1970s it is less clear why central banks would have ended such strategies rather abruptly in the 2000s. In contrast, the unwinding of the gold carry trade in the early 2000s offers an explanation for the significant price change between 2003 and 2011. Remarkably, whilst central bank gold lending can stabilize gold prices and the gold carry trade is creating a self-sustaining environment, gold lending is not effective in rising gold price regimes as in such regimes there is no market-based borrowing demand and the creation of such a

demand would be too costly. This asymmetry in the ability to influence the price of gold does not only apply to gold lending but also to actual gold reserve sales and purchases. The empirical analysis of global central bank gold reserves changes illustrates that central banks can enforce a price floor but not enforce a price ceiling.

There is also an explanation for the apparent lack of transparency regarding central bank gold reserve management including gold lending. If central banks disclosed planned gold reserve changes or gold lending activities, they would provide signals to the market that would make the changes more costly or increase the volatility and uncertainty in the gold market. The disclosure of the Bank for International Settlements about a gold swap in 2010 and a subsequent fall in the price of gold is a good example for the effects of such announcements.

This study demonstrated that central banks have an economic interest in gold prices and directly and indirectly influence the price of gold. It also illustrated that central banks can only stabilize a falling gold price but not a rising gold price and that the stabilization can only work if it is hidden from the public and coordinated among central banks.

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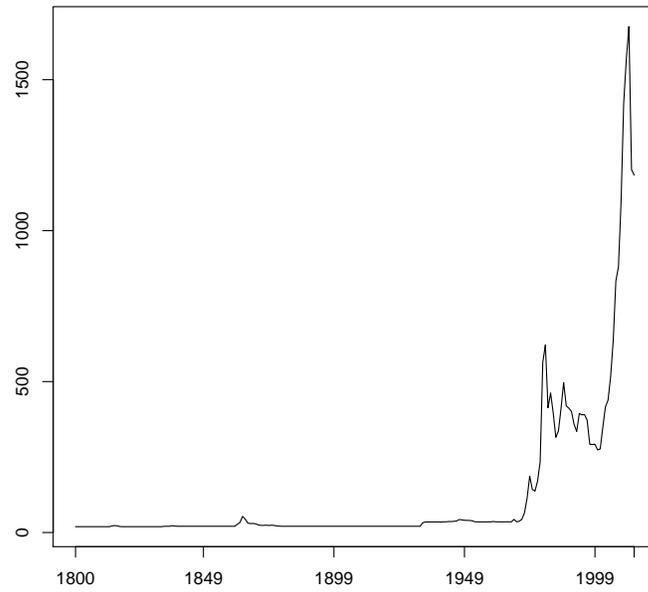
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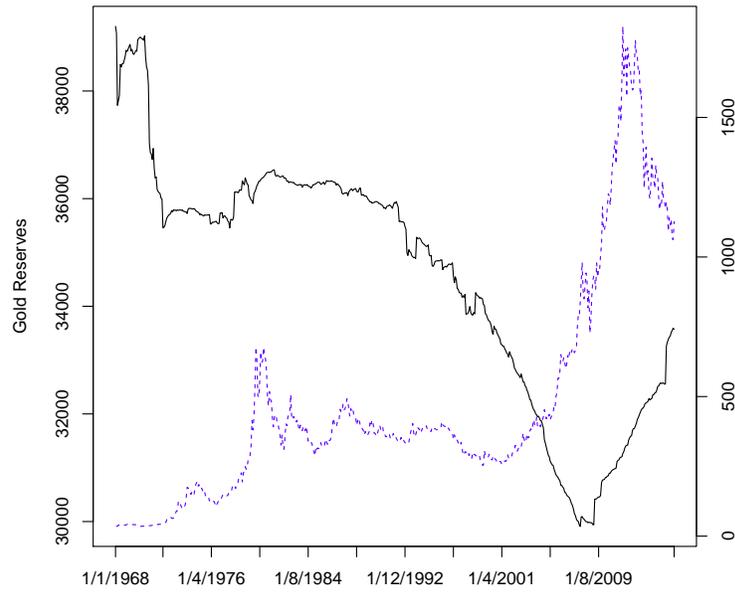
**Figure 1: Price of Gold (Two Centuries)**



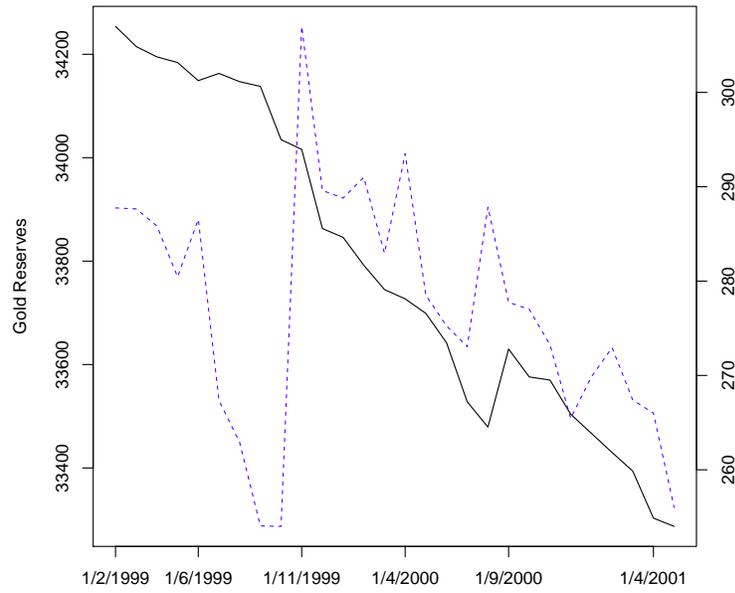
**Figure 2: Price of Gold (1968 - 2016)**



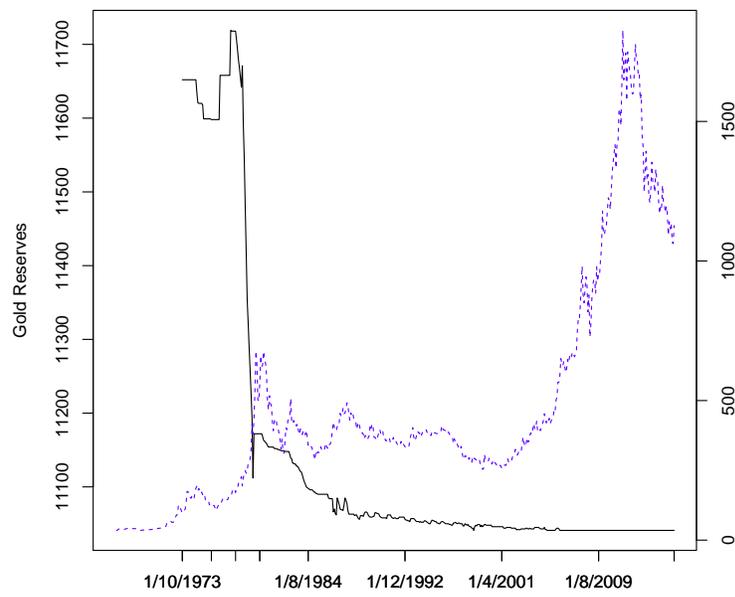
**Figure 3:** World Central Bank Gold Holdings (in tonnes) and the Price of Gold



**Figure 4:** World Central Bank Gold Holdings (in 1m troy ounces) and the Price of Gold in 1999 and 2000



**Figure 5:** US Central Bank Gold Holdings (in 1m troy ounces) and the Price of Gold



**Figure 6:** Quantile Regression Results: Gold Price changes on World Central Bank Gold Holding changes

Model:  $Q(\Delta P_t|\tau) = \alpha(\tau) + \beta(\tau)\Delta Res_t + \gamma(\tau)\mathbf{X}_t + \epsilon_t$

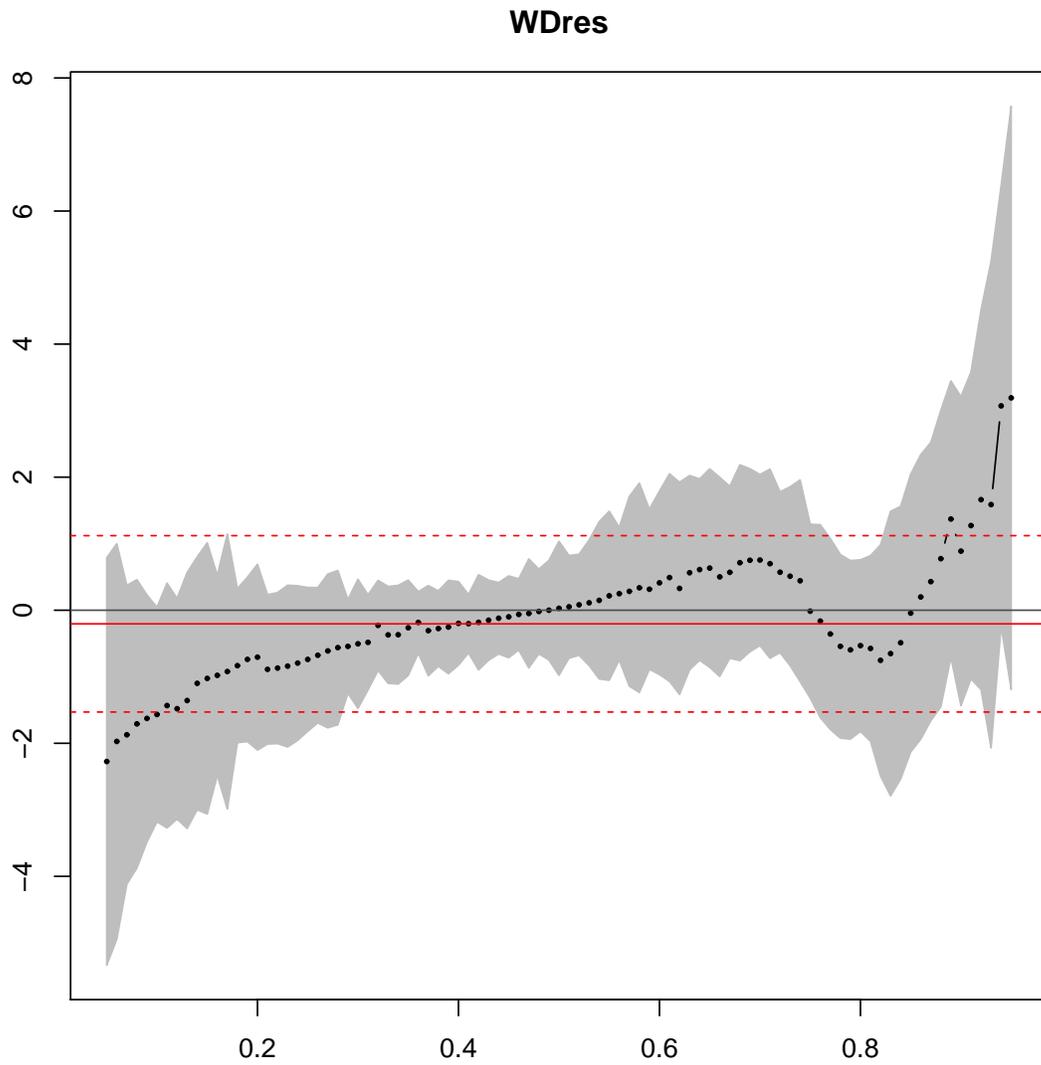
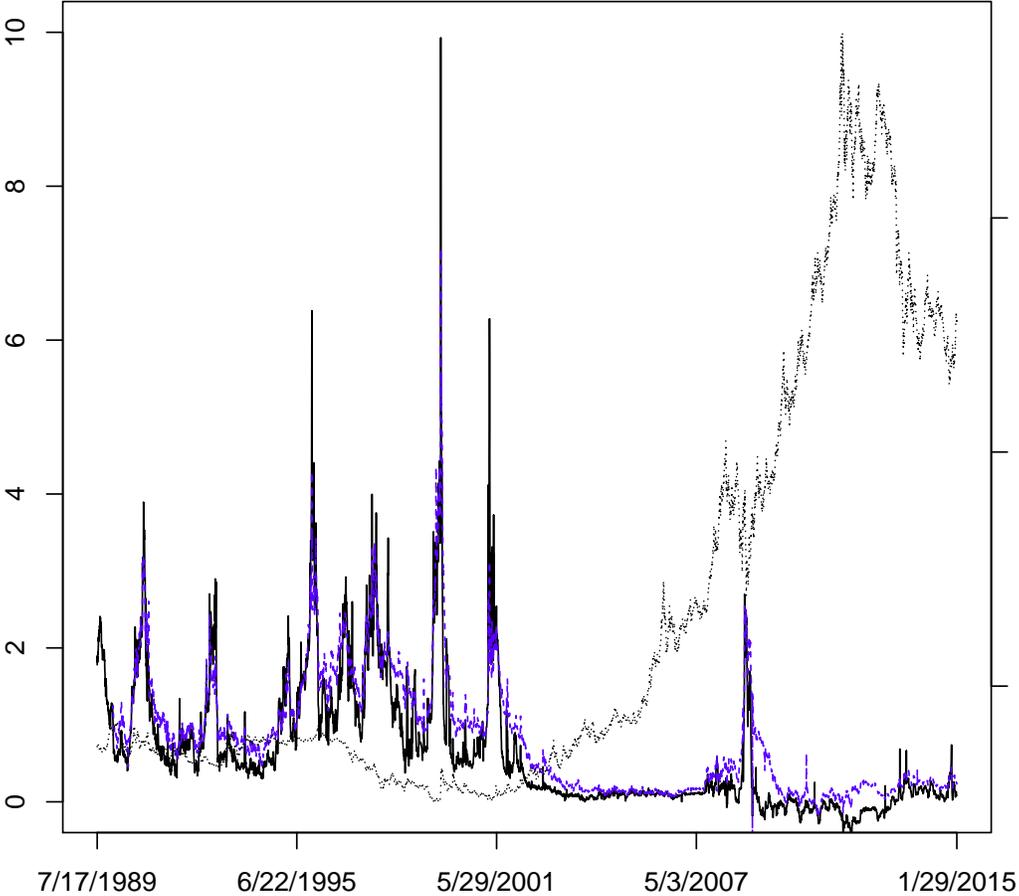


Figure 7: Gold Lease Rates (1-month and 6-months) and the Price of Gold



**Table 1:** Interest rates and the future price of gold  
 Model:  $\Delta P_{Gold,t+k} = \alpha + \beta(i_{USD,t} - i_{Gold,t}) + \epsilon_{t+k}$

**Panel A: Full sample period (1989 - 2015)**

	coeff	std. err	t-stat	p-value	R squared
constant	0.02	0.00	13.64	0.00	
lease rate 3 months	-0.26	0.04	-5.85	0.00	0.01
constant	0.04	0.00	19.29	0.00	
lease rate 6 months	-0.54	0.06	-8.57	0.00	0.01
constant	0.10	0.00	27.55	0.00	
lease rate 12 months	-1.20	0.09	-12.90	0.00	0.03

**Panel B: Sub-sample period (1989 - 2001)**

	coeff	std. err	t-stat	p-value	R squared
constant	0.01	0.00	2.96	0.00	
lease rate 3 months	-0.30	0.07	-4.45	0.00	0.01
constant	0.02	0.00	5.84	0.00	
lease rate 6 months	-0.74	0.08	-9.11	0.00	0.03
constant	-0.00	0.00	-0.54	0.59	
lease rate 12 months	-0.50	0.09	-5.50	0.00	0.01

**Panel C: Sub-sample period (2002-2015)**

	coeff	std. err	t-stat	p-value	R squared
constant	0.01	0.00	7.36	0.00	
lease rate 3 months	0.90	0.08	11.35	0.00	0.04
constant	0.03	0.00	9.14	0.00	
lease rate 6 months	1.99	0.11	17.56	0.00	0.09
constant	0.06	0.00	14.64	0.00	
lease rate 12 months	3.58	0.17	21.47	0.00	0.13