Gold - Fundamental Drivers and Asset Allocation

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First draft: February 28, 2013

Abstract

In this paper we perform a theoretical and econometric analysis of the fundamental drivers of gold. We demonstrate that gold is significantly influenced by inflation changes, interest rates, currency changes and central bank reserve policies. A key finding is that the influence of the drivers varies through time, e.g. inflation is a major driver in the 1970s and in the late 2000s but not in the 1980s and 1990s. We also examine the role of gold in asset allocation and show that gold can significantly enhance the risk-reward ratio in a portfolio comprised of stocks, bonds and cash. We argue that there are several factors that have the potential to support a historically high price of gold.

Keywords: gold; fundamental drivers; risk factors; gold in asset allocation; gold standard

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Introduction

The repercussions of the subprime crisis in 2007 and the sovereign debt crisis which followed have increased the role of the government, fiscal and monetary policy. Gold may play a key part in this new environment because it is not dependent on any single government and does not require a credit rating. The sovereign debt crisis and Eurozone crisis in particular has highlighted the role of "safe assets" (e.g. see Gorton et al., 2012 and IMF, 2012). Gold is an almost natural candidate of a "safe asset" due to its store of value and safe haven properties. It may function as an anchor of stability for central banks, governments and individual investors. Despite its potentially stabilizing role, the price of gold is volatile and influenced by many "risk factors". One question that we address in this study is whether all these factors are indeed fundamental drivers or whether some drivers are, in fact, only coincidentally related to gold and the true driver is highly correlated with this variable.

We analyze these factors both theoretically and econometrically and show that gold is only influenced by some factors but not all. Some factors have an unconditional correlation with gold but this correlation is spurious in the sense that it disappears if the true drivers are included in the analysis. For example, inflation rates and interest rates are generally associated with changes in the price of gold. Since both inflation rates and interest rates are highly correlated it is not clear which of the two variables is more important and actually influences the price of gold. Furthermore, we distinguish between traditional drivers and new drivers which have only emerged recently.

There is a large and diverse literature on gold. The role of gold during the Gold Standard has been studied by Barsky and Summers (1988) and Bordo (1981) among others, the literature has analyzed gold as an investment asset (Conover et al., 2006, Jaffe, 1989 and Riley, 2010) , a portfolio diversifier (Davidson, Faff and Hillier, 2003 and Sherman, 1982), an inflation hedge (e.g. Beckmann and Czudai, 2013, Blose, 2010 and Ghosh et al., 2002), a currency hedge (e.g. Capie, Mills and Wood, 2005) and a safe haven

(e.g. Baur and Lucey, 2010 and Baur and McDermott, 2010). Psychological factors have been analyzed (e.g. Aggarwal and Lucey, 2007), the efficiency of the gold market (e.g. Aggarwal and Soenen, 1988), anomalies and seasonality of gold (e.g. Ball, Torous and Tschoegl, 1982 and Lucey and Tully, 2006), the volatility of gold (e.g. Batten, Ciner and Lucey, 2010 and Baur, 2012) and the co-movement of gold with other assets (e.g. Baffes, 2007 and Escribano and Granger, 1998). The role of central banks and gold is analyzed in Aizenman and Inoue, 2012) and gold and mining in Brennan and Schwartz (1985), Tufano (1996), Tufano (1998) and Twite (2002) among others.

We contribute to the literature with a broader analysis. Instead of focussing on merely one property of gold we analyze all (common) properties and the key drivers. We can thus identify differences among the drivers and assess their relative importance. We also examine the possibility that gold constitutes a single asset class and study the effects of an inclusion of gold on the efficiency of differently weighted equity-bond-cash portfolios.

We identify seven major drivers of gold: (i) inflation, (ii) currency changes, (iii) interest rates, (iv) commodity prices, (v) stock prices, (vi) safe haven demand (uncertainty) and (vii) central bank demand.

One important part of this study is the theoretical description and discussion of the drivers and their interactions with each other. For example, we demonstrate theoretically that inflation and currency changes have the same impact on the price of gold. Another example is the link of nominal and real interest rates with other variables. Nominal interest rates are strongly related to inflation rates, currency values and stock returns and it is not clear which economic variable is more important for the price of gold. Thus, a single variable focus, i.e. a univariate analysis, is neglecting all other factors and abstracting from their existence. We show that the isolated estimation leads to different estimates than a multivariate analysis which integrates all variables in one model and thus does not neglect the interaction of the drivers.

Our main findings can be summarized as follows: Gold is mainly influenced by "traditional" drivers like inflation, currency changes and interest rates and "new" drivers like

central bank gold demand. Another key finding is that the strength of the drivers changes significantly through time. For example, inflation has been an "active" driver in the 1970s and in the aftermath of the subprime crisis in 2007 but not during the "great moderation" in the 1980s and 1990s.

The remainder of this study is structured as follows. In the first section we analyze the drivers of gold. The analysis includes a thorough theoretical discussion of the drivers and their origin. The empirical part studies each driver separately and conditional on the other drivers. The time-varying importance of the drivers is also estimated. In the second section, we examine whether the characteristics of gold can be clearly distinguished from other commodities and whether gold constitutes a separate asset class. The third section evaluates the role of gold in asset allocation. What weight is adequate in a Markowitz-type mean-variance optimization framework? The role of gold is also assessed with alternative assumptions regarding expected returns, standard deviations (risk) and correlations of stocks, bonds, cash and gold. Finally, section IV summarizes the results and draws conclusions.

I Drivers of Gold

Gold is associated with many properties and drivers that potentially influence its value. This section first analyzes the key drivers theoretically, presents and discusses the evolution of the drivers graphically and then estimates the exposure of gold to these drivers econometrically.

A Theoretical Analysis

One important part of this section is the focus on the interaction among the drivers. We illustrate that several of the major drivers are related to each other and may compensate each other. Since the importance of the drivers may change through time it is crucial to complement an empirical analysis with a theoretical analysis to have intellectual tools to predict future changes of the price of gold.

There are "traditional" drivers related to the store of value and currency properties including (i) (consumer price) inflation rates, (ii) currency changes, (iii) interest rates and (iv) mining supply factors related to the price regime of gold. Other drivers have emerged only recently and can thus be labeled "new" drivers. These include (i) commodity and stock prices[1] related to investment diversification and portfolio protection demand, (ii) safe haven demand[2], (iii) emerging market central bank demand and (iv) momentum or speculative demand. We first discuss the traditional drivers followed by a discussion of the new drivers.

Gold has been used as a store of value and a means of exchange for centuries (see Jastram, 2009). In the more recent past, i.e. during the Gold Standard, gold was explicitly and directly linked to currencies and thus money. In fact, gold has desirable properties of money. It is durable, easily recognizable, storable, portable, divisible and easily standardized. Furthermore, changes in its stock are limited, at least in the short run, due to high costs of production. Because of these physical attributes it has emerged as one of the earliest forms of money (see Bordo, 1981). The store of value property is directly linked to two key drivers of gold, i.e. inflation and currency changes.[3] If gold is positively influenced by inflation and thus an inflation hedge (in the sense that it fully compensates investors for higher inflation), the price of gold co-moves with the rate of inflation. In other words, a 2% inflation rate leads to a 2% increase of the value of gold. The underlying economic mechanism can be easily explained with an example. If the price index consisting of goods and services increases by, say 2% per year, gold becomes relatively cheap compared to this index. As a consequence, the demand for gold will increase until the change of the price of gold equals the change in the price index.

This example can also be used to explain that gold is influenced by currency changes.

[1] Commodity and stock prices are also used as a proxy for economic growth and the business cycle.

[2] The timing of the safe haven demand can be clearly distinguished from the "investment diversification" or "portfolio protection". The safe haven demand occurs during or shortly after a crisis or crash while the other two demand types occur before the occurrence of a crisis or crash.

[3] Note that the store of value characteristic of gold holds in a Gold Standard system in which gold is directly linked to a certain amount of currency units under certain conditions. If there is no inflation, gold acts as a store of value in such a system. In a fiat money system gold is a store of value if its price in the fiat currency increases with the general price level or the items it is considered to be a store of value for.

If the value of gold in country A increased by 2%, gold has become more expensive in country A than in country B under the assumption that the exchange rate has not changed. Arbitrageurs will buy gold in country B and sell in country A changing the price of gold in at least one of the countries. This process will stop once the price of gold in both countries denominated in a common currency is equal. The price of gold can either adjust in local currency or through changes in the relative values of the currencies represented by changes in the exchange rate.[4]

Hence, the two properties of gold as an inflation hedge and a currency hedge are fundamentally similar.[5] The value of a currency either decreases through inflation or through a depreciation. In gold price terms, both inflation and currency depreciation increase the price of gold in local currency.[6]

The relationship between inflation and currency changes can also reveal two other properties of gold. Gold is a homogeneous and a global asset. If two countries have a fixed exchange rate, the prices can only adjust in local currency and not via the exchange rate. Hence, if the inflation rates differ in the countries with a fixed exchange rate, gold cannot be an effective (full) inflation hedge in both countries but only in one country.[7]

It is important to note that the inflation and currency relationship of gold is not exclusive to the US dollar. An inverse relationship between the value of the US dollar and the price of gold in US dollars does also exist for other currencies. For example, a depreciation of the euro will tend to increase the price of gold in euro. Hence, the

[4]Assume that at $t = 0$: 1,000 USD = 1oz gold, 1 USD = 1 AUD and 1000 AUD = 1oz gold. If the inflation rate in the US is 5%, the price of gold in USD rises to 1,050 USD at $t = 1$. At a constant exchange rate, gold is now more expensive in USD than in AUD. Hence, arbitrageurs will buy gold in Australia and sell gold in the US. If there is no exchange rate change, this trade will stop once the price of gold in USD is equal to the price of gold in AUD, i.e. 1,050 AUD = 1oz gold. Alternatively, the arbitrage opportunity will vanish if the USD depreciates. This happens if USD is exchanged for AUD to purchase gold in Australia to be sold in the US. More formally, the price of gold is equal in both countries if the exchange rate changes to 1.05 USD = 1 AUD. Gold in Australia is valued at 1,000 AUD which is equal to 1,050 USD. This example demonstrates that the properties of gold as an inflation hedge and currency hedge are linked.

[5]Interestingly, the literature has focused on these drivers separately but not analyzed these drivers jointly. For example, the inflation hedge property is analyzed by Blose (2010) and Ghosh, Levin,MacMillan and Wright (2002) and the currency hedge property is studied by Capie, Mills and Wood (2005) and Sjaastad (2008).

[6]The "parity conditions" such as Purchasing Power Parity and the International Fisher Effect imply that a currency with a higher inflation relative to another currency will depreciate.

[7]Since inflation rates differed (and continue to differ) widely within the Eurozone in the past, gold was, by definition, not an inflation hedge in all Eurozone member states at all times.

main reason for this negative relationship is not that gold is priced in US dollars but that arbitrage implies an equal price of gold across countries. Hence, if the euro depreciates relative to the US dollar, gold becomes relatively cheap. Arbitrage will increase the price of gold in euro to eliminate the price difference.

Interest rates do also potentially influence the price of gold. High interest rates increase the opportunity cost of holding gold, also known as the "cost of carry" (e.g. Blose, 2010), and will therefore tend to reduce the price of gold. However, since interest rates generally co-move with inflation rates, high interest rates imply high inflation rates and the latter tend to increase the price of gold. These two effects are combined in the real interest rate, i.e. the difference between nominal interest rates and the inflation rate. The real interest rate therefore represents the net effect of the two drivers. It is obvious that a macroeconomic regime in which the nominal interest rate is below the inflation rate, i.e. negative real interest rates, can be expected to exert a particularly strong influence on the price of gold.

The drivers described and discussed above can be considered "traditional" drivers.

New drivers are mainly related to an increased role of gold in portfolio allocation especially as a "diversifier" due to its low correlation. Gold has emerged as an asset used for portfolio diversification and portfolio protection in recent years possibly due to studies that emphasized these characteristics for commodities in general (e.g. see Erb and Harvey, 2005 and Gorton and Rouwenhorst, 2006) and for precious metals in particular (Hillier, Draper and Faff, 2006). Gold has been a store of value and thus a safe haven for a long time. However, more recently the safe haven property is defined in a narrower sense and associated with adverse financial market conditions (e.g. see Baur and McDermott, 2010).

Emerging markets, in particular China, have accumulated large FX reserves with very low but increasing gold holdings relative to industrial countries like the US and major European countries. Central bank diversification demand of these emerging markets may have driven the price of gold in recent times.

Emerging market investment (or consumption) demand, especially in countries in

which gold plays a large cultural role like in India, can also influence the price of gold.[8]

These new drivers, like the "traditional" drivers, are interconnected which implies that an isolated analysis may be misleading. For example, if the safe haven demand is analyzed from a US investor or US dollar perspective, the safe haven effect may be underestimated in times in which both the US dollar and gold both act as safe haven assets. The US dollar has been a safe haven asset in the past and also acted as such during the global financial crisis (see Mundell, 1999 and Fratzscher, 2009). If both gold and the US dollar increase in value, the price increase of gold in US dollar is partially compensated by the appreciating US dollar. This effect is related to the inverse relationship between the price of gold and the currency in which gold is denominated.

Large swings in the US dollar or exchange rate volatility may increase the desire of emerging market central banks to diversify their US dollar reserves to reduce the exposure to one currency. Hence, currency movements and central bank demand for gold may be related. Again, focussing on only one component can lead to incorrect conclusions. Feedback effects may also play an important role. There may be a significant feedback effect from past price changes on the price of gold and changes in the correlation of gold with equities. If, for example, the gold-equity correlation increases due to increased investment demand for gold, the higher correlation diminishes the positive diversification effect and may lead to lower future demand for gold as a diversifier. Similarly, if market participants use gold as an indicator of volatility and uncertainty, positive price movements may be self-enforcing.[9]

[8]Consumption or jewelery demand is not available on a monthly basis which is used below. We thus use emerging market stock indices as a proxy for the increasing prosperity of a region or country and associated demand for gold. The World Gold Council provides data on gold demand including jewelery. Special data on India and China are included in World Gold Council (2013) for example.

[9]Tkacz (2007) analyzes the role of gold as an indicator of inflation. Theories about the manipulation of the gold price are related to a feedback effect and justified with the argument that central banks do not have an interest in high gold prices since they may signal future inflation or a decreasing value of the currency or money thereby threatening the role of the central bank and the government.

B Descriptive Analysis

This section analyzes the drivers empirically by describing their properties and their relationship with gold through time. The data is mainly obtained from Thompson Reuters Datastream and supplemented with data from the International Monetary Fund's International Financial Statistics and Bloomberg. We obtained more than 500 different time-series that were considered as potential drivers. The sample period starts in 1968 and ends in January 2013. Monthly data was used since time-series data of a major driver represented by consumer price indices is only available on a monthly basis. Since this study is concerned with a long-term perspective of gold and its drivers, a monthly frequency appears to be a perfect mix between annual or quarterly data with lower volatility but a lower number of observations and a daily frequency with a relatively large number of observations and increased statistical power but with a higher volatility.

Figure 1 presents the price of gold and the US consumer price index from 1968 to 2013. The graph shows that the price of gold increased from a value around 40 US dollars in 1968 to more than 1,800 US dollars in 2011 and was worth around 1,600 US dollar in January 2013. The price of gold fluctuated significantly in this 40-year time period. It reached values around 700 US dollar in 1980 but fell significantly after that and remained around 400 US dollars or below for the rest of the 1980s, in the 1990s and the beginning of the 2000s. Gold started to increase significantly around 2004 from 400 US dollars to more than 1,800 US dollars in 2011. Since the graphical presentation of the two time-series, gold and the US consumer price index, exhibit similar relative values in 2013 but a higher relative starting point of the US CPI, it can be derived that the price of gold has increased by more than the US CPI. Hence, gold has acted as an inflation hedge for this 40-year time-period.[10] However, the fluctuations of the price of gold show that gold has not been an inflation hedge at each point in time. Since gold did not yield positive returns in the 1980s and the 1990s it did not fully compensate for a constantly rising price level in this period. So where does the variation come from or why is gold not an inflation

[10] Gold has also acted as a hedge for a much longer time period as shown in Jastram (2009).

hedge at all times? One explanation is that gold reacts or perhaps overreacts to significant changes in inflation and the risk of prolonged high inflation rates. Since the 1970s can be characterized by such an inflation regime a higher price of gold is justified. The lower value of gold in the 1980s and 1990s is consistent with this explanation since this period is represented by relatively low inflation rates and the perception that inflation does not pose a serious risk to financial and economic stability. The period is also labeled the "great moderation" and reflects a fundamental change in inflation expectations. Figure 2 presents the dynamic relationship of the price of gold and a global consumer price index. The graph shows that gold (denominated in US dollars) provided a lower level of protection against global consumer price changes than against the US consumer price index.

*** Insert Figure 1 about here ***

*** Insert Figure 2 about here ***

Figure 3 presents the ratio of the price of gold in US dollar relative to the US consumer price index. This ratio analysis provides the real price of gold and shows that the real price reached its highest level in the year 1980 and was not higher at the end of the sample despite the considerable price increase between 2004 and 2013. The time-series plot of the ratio also suggests that the real price of gold fluctuates around a constant.

*** Insert Figure 3 about here ***

Figure 4 presents the evolution of the price of gold and the trade-weighted value of the US dollar through time and the dynamic relationship between the two series. The time-series plot of the US dollar value shows a slightly decreasing value of the US dollar over the sample period relative to an increasing price of gold over the same period. This

negative relationship is also apparent in several shorter periods, especially between 1996 and 2006 in which the evolution of the price of gold is u-shaped while the evolution of the value of the US dollar exhibits an inverted u-shape. The inverse relationship is consistent with the theoretical prediction that a depreciation (appreciation) of a currency tends to increase (decrease) the price of gold in that currency.

*** Insert Figure 4 about here ***

Figure 5 displays the third potential driver, a broad commodity index. The Figure shows the evolution of the Goldman Sachs Commodity Index (GSCI) which includes precious metals with a weight around 5% . The graph illustrates a relatively low degree of co-movement consistent with the hypothesis that gold is independent of the business cycle. However, the graph also reveals that the co-movement intensified in the early 2000s. [11]

*** Insert Figure 5 about here ***

Figure 6 shows the evolution of the price of gold with a global equity index and an emerging equity index. Both indices are Morgan Stanley Composite Indices (MSCI) denominated in US dollars. The Figure shows that the correlation of gold returns with global equity returns is around zero due to prolonged periods of inverse price movements between 1980 and 2000 and most notably between 1995 and 2002. This finding also illustrates that gold does generally not co-move with the business cycle. The inverse price movements of gold and stock markets are also evident during stock market crashes and periods of financial turmoil. This finding represents the safe haven property of gold. Figure 7 provides a more focussed graphical analysis and shows that the price of gold did

[11] This increased co-movement or correlation may be due to the "financialization" of commodities. Baur (2013) analyzed changes in the degree and the structure of dependence of gold with the GSCI due to "financialization" and found a decoupling of gold with the GSCI for extreme changes of gold.

not fall during the crash in October 1987, in response to the terrorist attacks on September 11, 2001 and during the outbreak of the global financial crisis in October 2008.[12] The graphical representation of the price of gold and the MSCI Emerging Market index shows no or less pronounced inverse price movements.

*** Insert Figure 6 about here ***

*** Insert Figure 7 about here ***

Related to the safe haven property is the belief that the gold price increases with uncertainty or its proxy volatility. Figure 8 shows that empirically there is only weak evidence for this relationship. Uncertainty is represented by the implied volatility index VIX. Apart from the period initiated by the US subprime crisis in 2007 until 2012 including the sovereign debt crisis there is evidence of an inverse or negative relationship strongly rejecting the belief that gold increases with stock market uncertainty.[13] The weak empirical evidence could be related to the fact that the VIX is a rather narrow measure of uncertainty and does, for example, not include political uncertainty.

*** Insert Figure 8 about here ***

The level of interest rates determines the opportunity cost of holding an asset. The higher the interest rate the higher is the opportunity cost, all else equal, and thus the cost of carry. Since holding gold does not provide dividend or interest payments, this opportunity cost may be particularly high. We thus expect an inverse relationship between the level of interest rates and the price of gold. Figure 9 shows an inverse relationship over

[12] The graph is taken from Baur and McDermott (2013). The graph includes the price of the US 30-year Treasury bond for comparison of two potential safe haven assets, i.e. gold and US Treasury bonds.

[13] This finding is not related to the empirical observation reported in Baur (2012) that the volatility of gold increases more in response to positive shocks than to negative shocks. The volatility of gold returns therefore display a different reaction to signed shocks than the volatility of equity returns.

the entire sample period from 1968 until 2013. The cost of carry hypothesis is particularly evident between 2008 and 2012 in which the interest rate is essentially zero and the price of gold increased considerably from around 600 to more than 1,800 US dollars. However, the late 1970s exhibit a different pattern. Historically high interest rates coincide with historically high gold prices. This positive relationship suggests that other factors may be at play. Inflation rates were very high in that period and may explain the high gold price. This finding suggests that real interest rates drive the price of gold or the combined effect of nominal interest rates and inflation rates. The Figure also contains a plot of the gold price and the US real interest rate and indeed shows that periods of low real interest rates consistently coincide with periods of high gold prices and vice versa.

*** Insert Figure 9 about here ***

Figure 10 focuses on central bank foreign exchange (FX) reserve holding changes as drivers of the price of gold. Central bank FX reserves may be correlated with the price of gold due to the desire to diversify the reserves. The graph representing aggregate central bank FX reserves and the price of gold identifies a strong relationship especially in the second part of the sample. Low central bank gold reserves may also indicate the potential for future demand. The central banks of China and India are good examples of this potential. China is expected to reduce its exposure to US dollar reserves and diversify its holdings by selling US dollar reserves for gold. India officially increased its gold reserves in 2009. There is a large potential of increased central bank gold demand in general due to the relatively low gold holdings of these countries compared with their industrialized counterparts like the US, Germany and France.[14] In fact, Figure 10 shows that central bank gold demand increased for the first time in 2009 after a long period of declining demand. This trend is strongly associated with the price of gold.

[14]For example, China officially only holds 2% of its reserves in gold compared to 70% for the US, Germany, Italy and France (see World Gold Council, 2013).

*** Insert Figure 10 about here ***

Finally, Table I presents the correlation matrix of the potential drivers analyzed and discussed above and demonstrates that many of the drivers are correlated with each other. Due to these correlations, an isolated, univariate, analysis may be misleading as will be shown in detail below.

*** Insert Table I about here ***

There are other potential drivers and risk factors that have not been analyzed so far. There are different specific reasons for this but one major common feature is the non-availability of adequate empirical data to analyze the importance of these drivers. For example, jewelery demand or dental demand for gold may play a role but the data is only available at a quarterly frequency and for a rather limited number of years. A sound statistical analysis is thus not possible. Other potential drivers are demand due to the introduction of exchange-traded funds on gold. This may have facilitated an increased investment demand for gold but not necessarily caused it.

Another important question, which can be indirectly analyzed, is whether the significant price increase between 2005 and 2011 has attracted momentum investors which increased the demand for gold without fundamental reasons but only for speculative reasons. If this is true and led to an overvaluation of gold, the price of gold should have increased significantly relative to other assets like oil, global equity and other assets. Figure 12 displays the ratio of the price of gold with the spot price of oil and the MSCI World equity index. The time-series plots show that the price of gold has not significantly increased relative to these assets in recent years.

*** Insert Figure 12 about here ***

The role of the price of gold for the future demand of gold is closely linked to the mining of gold. The higher the price of gold, the more profitable is an extraction of gold. However, a high price of gold can also be due to high costs of gold mining. Since a higher rate of extraction of gold may coincide with an increased investment demand due to high gold returns in the recent past, it would be important to disentangle the two effects. However, time-series data limitations on the mining of gold restrains us from such an analysis.

The analysis above demonstrated that there is significant variation in the role of the potential drivers. For example, real interest rates seem to affect the price of gold only in periods of negative real interest rates, i.e. in the late 1970s and in the aftermath of the financial crisis of 2007 and 2008. Similarly, high inflation expectations were more important in the 1970s and most recently but not during the "great moderation" in the 1980s and 1990s. Stock market valuations changed considerably and may have resulted in diversification or insurance demand for gold, e.g. in the immediate aftermath of a financial crisis. Finally, emerging markets have become important for the gold market only recently.

This variation of the relevance of the drivers for the price of gold justifies a more rigorous dynamic analysis. Therefore, the next section performs an econometric analysis based on the whole sample period but also on four sub-samples, i.e. the 1970s, 1980s, 1990s, 2000s to identify any time-variation in the drivers relevance.

C Econometric Analysis

In this section we analyze the drivers of gold econometrically, i.e. we regress the changes of the gold price on changes of the drivers identified and described above. We analyze each driver separately and then jointly thereby fully accounting for the interdependence with other drivers. More specifically, we estimate the following model:

$$\Delta P_{\text{Gold},t} = \alpha + \sum_{i=1}^{K} \beta_i \Delta X_{i,t} + e_{i,t} \tag{1}$$

where X_i is a potential "driver" or "risk factor" of gold and Δ denotes the relative change of the variable. To identify the isolated importance of each driver we first regress gold price changes (log-changes) ΔP_{Gold} on each potential driver separately, i.e. estimate a constrained version of equation (1) K times.[15] In a second step the model is estimated (without constraints) for all drivers K jointly. The second step reveals the relative importance of the drivers and thus a bias if a specific driver is omitted.[16] We consider different time-series data for each driver. For example, consumer price inflation may be most adequately captured by US consumer price inflation, world consumer price inflation or sub-categories of world consumer price inflation like "agricultural & raw materials" or "food & commodities".

Table II presents the estimation results for each driver.

*** Insert Table II about here ***

The table contains the potential gold price driver (e.g. inflation), the data used to represent the driver (e.g. US CPI or World CPI), the coefficient estimate, the t-statistic, the statistical significance represented by the p-value, the variation of the gold price that is explained by the driver and the number of observations.

The estimation results show that many of the drivers are statistically significant given by absolute t-statistics greater than two and p-values smaller than 0.1. For example US CPI is highly significant with a t-statistic of 3.56 and a p-value of 0.00. The variation that is explained by US CPI is 2.3% represented by R squared. World CPI Food &

[15] Constrained estimation means that β_i is set equal to zero for all drivers K except one.

[16] An "omitted variable bias" can be described as follows. Assume that gold is affected by the following factors and factor loadings:

$$\Delta_{\text{Gold}} = 1\Delta_{\text{CPI}} - 1\Delta_{\text{US\$}} + 0.25\Delta_{\text{CB reserves}} + 0.1\Delta_{\text{IR}} + \varepsilon \tag{2}$$

If this model is estimated without inclusion of all variables, the result is an "omitted variable bias". If, for example, US dollar changes ($\Delta_{\text{US\$}}$ are not included in the regression model it is likely that the other coefficient estimates are biased. If interest rates and CPI changes are assumed to be positively correlated and CPI is excluded in the regression, the bias may be most severe for the coefficient which estimates the interest rate effect. A Monte Carlo simulation indicates that the interest rate effect is estimated with a coefficient of around 1 compared to the true (full model) coefficient of 0.1. Hence, the coefficient may be severely biased if CPI is part of a true model but such a model is not estimated.

Commodities is also highly significant and explains 3.3% of the variation of the gold price. However, the coefficient estimate of the World CPI is smaller than one and implies that gold does not fully hedge against World CPI changes while this is true for the US CPI with a coefficient larger than one.

According to the estimation results, the US dollar is also an important driver. The coefficient estimate of -0.92 represents the expected negative relationship between the price of gold in US dollars and the value of the US dollar. We included an alternative currency for comparison. The coefficient estimate for the Swiss Franc is positive which is related to the fact that gold is denominated in US dollars and not in Swiss Franc. A fraction of the positive relationship could also be related to the fact that the Swiss Franc is viewed as a safe haven currency.

The estimation results also show that commodity prices have a strong effect on the price of gold. The strongest influence has the GSCI Precious Metals Index, followed by Silver and the broad commodity index CRB spot.

The influence of the stock market as a driver shows that the type of equity index that is used has a strong influence on the effect. For example, while the Dow Jones Industrial average and the S&P500 display coefficient estimates close to zero, the coefficient estimates for the MSCI World, MSCI World ex USA and MSCI Emerging Markets exhibit positive coefficients and thus represent a positive co-movement of the equity indices with the price of gold. This finding suggests that gold is independent of the business cycle in most industrial countries but depends to some degree on the business cycle in emerging market economies. In an investment context, the results imply that gold is only an unconditional hedge[17] for rather narrow equity market indices like the US indices but not for broader indices as represented by the MSCI family.

The estimation results for uncertainty proxied by the VIX, interest rate changes and central bank FX reserve and gold reserve changes show no statistically significant influence with two exceptions. Aggregate central bank FX reserve and Indian gold reserve

[17]Baur and Lucey (2010 distinguish a hedge from a diversifier and a safe haven. A hedge asset is uncorrelated with another asset.

changes exhibit a significant positive effect on the price of gold. This result demonstrates the importance of central bank FX reserves for the price of gold and also identifies econometrically the role of the Indian central bank gold reserves.

Table III presents the estimation results of a model in which all potential drivers can simultaneously and jointly influence the price of gold. We selected the variables with the highest statistical or economic significance based on the univariate regression results and the theoretical analysis of the drivers performed above.

*** Insert Table III about here ***

The multivariate estimation results include the US CPI, the US dollar, the S&P Commodity index, World FX reserves, the MSCI World equity index, Indian gold reserves and the US benchmark interest rate. The table shows that all drivers are statistically significant except for the MSCI World equity index. The multivariate results confirm the theoretical relationship between a univariate analysis and a multivariate analysis. The coefficient estimates are smaller in a multivariate model than in the univariate model consistent with the hypothesis that the unconditional estimates are biased due to the exclusion of other variables that are important co-drivers of the price of gold. For example the coefficient for US CPI changes is estimated at 1.47 in the multivariate framework and at 2.64 in the univariate framework. A smaller effect is also estimated for the equity index. The MSCI World equity index is a significant driver in a univariate context but statistically and economically insignificant in a multivariate context. Hence, if all relevant factors are included, there is no evidence that gold moves in tandem with global equity markets.

Finally, table IV presents the multivariate estimation results for four sub-samples. The sub-sample analysis is designed to examine whether the influence of a specific driver is stable through time. As discussed above, we use the 1970s, the 1980s, the 1990s and the 2000s including the period until January 2013 as four sub-samples. The economic justi-

fication for this partitioning is the different economic, financial and monetary conditions in these periods. Inflation rates, interest rates, equity markets and the gold price differ markedly in some periods and exhibit similar changes or characteristics in other periods.

*** Insert Table IV about here ***

Table IV confirms and supports the results obtained with the descriptive analysis. The influence of the drivers changes significantly across the four sub-periods. The most notably variation is entertained by changes in the CPI, the US dollar and commodity prices. The CPI exhibits a positive influence in the 1970s and in the 2000s but a negative influence on the price of gold in the 1980s and the 1990s. The influence of the US dollar declines in each decade from -1.12 in the 1970s to -0.5 in the 2000s. Gold was strongly affected by changes in commodity prices in the 1980s and 1990s but less so in the 1970s and the 2000s. The influence of the nominal interest rate is positive in the 1970s and negative in the other periods. Hence, nominal interest rates reduced the inflation effect in the 1970s and potentially strengthened it in the 2000s. This is consistent with the finding that negative real interest rates are an important driver of the price of gold as discussed in the descriptive analysis. Such negative real interest rates existed in the 1970s when inflation rates and interest rates were very high and in the period following the global financial crisis in 2007 and 2008, a period characterized by historically low interest rates. Central bank FX reserves and central bank gold holdings also show some variation through time and the positive effect of the Indian central banks' gold holding changes suggests that future central bank demand may be an important driver for the price of gold.

Our analysis of the price of gold and its fundamental drivers illustrate that the price of gold varies significantly through time. When inflation rates are high or the expected future inflation is high the inflation driver is "active" and tends to increase the price of gold. Similarly, if interest rates are low the opportunity cost of holding gold is negligible

which positively affects the price of gold. When both the inflation driver is active and the nominal interest rate is low, the impact on the price of gold is even stronger. If FX reserves of emerging central banks continue to grow or if the confidence in the stability of the US dollar falls, it will support a relatively high price of gold.

II Gold as an Asset Class

In this section we analyze the role of gold as a single asset class. There are three generally accepted asset classes: equity, fixed income (bonds) and cash. Commodities, real estate, collectibles and derivatives may constitute additional asset classes.[18] Commodities, in particular commodities futures, including precious metals have been discovered only relatively recently as an investment class (e.g. see Erb and Harvey, 2006, Georgiev, 2001, Gorton and Rouwenhorst, 2006 and Idzorek, 2007).

Greer (1997) defines an asset class as a "set of assets that bear some fundamental economic similarities to each other, and that have characteristics that make them distinct from other assets that are not part of that class." This definition is consistent with stocks and bonds as separate asset classes. Commodities bear some similarities (e.g. pay no dividend or interest) and are therefore distinct from stocks and bonds.

Can gold be clearly distinguished from commodities or are there too many similarities to justify the treatment of gold as an asset class on its own?

Gold may constitute a separate asset class because it is viewed as a currency alternative and held by major central banks as part of their currency reserves. This property makes gold distinct from other asset classes, namely equity, bonds and cash, and also other commodities and precious metals like silver or platinum.

There are several other properties of gold. Some of them are not specific to gold but to precious metals in general: (i) gold is not tied to the economic cycle, (ii) gold is not spent and consumed[19], (iii) gold has no nationality and is not susceptible to any government

[18] Horvitz (2000) argues that the "[...] elegant simplicity of a three-class system has now been degraded into a complex array of [...] categories [...]".

[19] Jewelery can be viewed as consumption but this type of consumption does not imply that the good

action, hence no rating is required as for government bonds, (iv) gold is less susceptible to adverse storage conditions than agricultural commodities, (v) gold can be reused and recycled, (vi) transportation and storage of gold is relatively cheap compared to most other commodities.[20]

To provide a more formal analysis we study the co-movement of gold with several asset class factors to determine the dependence or independence of gold. We follow the approach of Sharpe (1992) who proposed an asset class factor model to determine an asset's association with a specific asset class. We consider a broad commodity index, the precious metals silver, palladium and platinum and oil. If the "beta" or co-movement of gold with the asset class factors differs significantly, i.e. a large fraction of the movement in gold prices cannot be explained by changes in a factor, there is formal evidence that gold constitutes an asset class on its own. An alternative hypothesis is that gold co-moves with other commodities in the mean but decouples from cyclical commodities when these commodities are significantly different from the mean.

We estimate the following model

$$r_{\text{gold},t} = \alpha + \beta_1 f_{1,t} + \beta_2 f_{2,t} + ... + \beta_K f_{K,t} + e_{i,t} \tag{3}$$

where $r_{\text{gold},t}$ denotes the return of gold and f_i represents the log-change of the asset class factor i between t and $t-1$. The equation is different from equation (1) above since it focusses on asset classes and thus excludes factors like consumer price changes (CPI), currency changes and uncertainty. The estimation results reveal that around half of the variation of the gold price is not explained by these asset class factors. In particular, the results reveal that gold is primarily related to silver but not to commodities in general. The estimate for the commodity index factor is slightly positive (0.073) and the estimate for the silver factor is 0.397 and highly significant. Silver explains 49% of the variation of the gold price but only 0.5% is explained by the broad commodity index despite its

disappears. It can be stored and used at a later stage.

[20]Physical investment in gold and the necessary storage is relatively cheap compared to the storage of energy commodities like oil or agricultural commodities like wheat.

significant coefficient estimate of 0.073. The inclusion of alternative precious metals like palladium and platinum, and oil as a proxy for energy commodities in general yields a similar qualitative result, i.e. a large fraction of gold price movements remains unexplained. This result lends support to the hypothesis that gold constitutes an asset class on its own since it is driven, to a large extent, by gold-specific factors.

III Gold in Asset Allocation

The econometric analysis performed in previous sections demonstrated that gold is related to fundamental drivers, or risk factors, but that analysis does not directly provide details about the performance of gold in a portfolio consisting of stocks, bonds and cash. In this section we first study the role of gold in asset allocation using historical data and then perform a theoretical analysis with different assumptions about future average asset returns, volatilities and correlations. The basis for the theoretical analysis is the unpredictability of the future which implies that future returns, volatility and correlations are unknown. Historical returns may be an adequate description of future returns depending on the choice of the sample period which is the basis for predictions into the future. The assumptions about future returns, volatilities and correlations entertained in the theoretical section are grounded in the econometric analysis of the drivers and thus combine the different parts of this study.

A Historical data

The diversification of risk may be the only "free lunch" in economics and finance (e.g. see Jaffe, 1989). The diversification benefits are determined by the correlation of the assets. The lower the correlation of an asset with another, the larger is the possible reduction in risk.[21] Hence, one major factor in the inclusion of gold in a portfolio consisting of, say stocks and bonds, is its correlation with these assets. The correlation and the volatility

[21]The risk of a portfolio P consisting of two assets i and j is given by $\sigma^2(R_{P,t}) = \sigma^2(R_{i,t}) + \sigma^2(R_{j,t}) + 2\rho(R_{i,t}, R_{j,t})\sigma(R_{j,t})\sigma(R_{j,t})$ where R denotes the return of an asset, σ^2 (σ) denotes the volatility (standard deviation) and ρ represents the correlation coefficient. The equation shows that a positive correlation yields a higher risk of the portfolio $\sigma(P)$ than a zero or negative correlation.

(risk) of the assets determine the risk of the portfolio while the asset-specific returns determine the portfolio return.

Table V presents the average returns, standard deviations and correlation coefficients (in matrix form) for gold, different equity indices, 10-year US government bonds and T-bills for monthly data between 1968 and 2013. The table consists of five panels. The first panel presents the estimates for the full period followed by the estimates for four sub-samples, ie. the 1970s, 1980s, 1990s and the 2000s. The full sample results show that the correlation coefficient of gold with equity is zero for the S&P500 and positive for the broader indices representing global and emerging equity markets. The correlation coefficients of gold with Treasury bonds and bills is negative. The correlation estimates indicate that gold can play an efficiency-enhancing role, i.e. gold can reduce the risk of a portfolio for a given target return of the portfolio.

*** Insert Table V about here ***

However, the sub-period estimates also reveal that the correlations fluctuate significantly through time. For example, the correlation of gold with the S&P500 is negative in the 1970s and 1990s and positive in the 1980s and in the 2000s. The mean return and standard deviations also vary substantially in each decade. These results suggest that gold is a particularly good diversifier of a portfolio in some periods.

A more technical issue entails the calculation of the "efficient frontier" and the question what the optimal mean-variance efficient weight of gold in a diversified portfolio consisting of equity, fixed income (government bonds) and cash is? We calculated the mean-variance efficient weights for increasing target returns using the returns, risk and correlations presented in Table V.[22] Due to the high average return of gold and the relatively poor performance of the equity indices, the optimal weight of gold is monotonically increasing with the target return and reaches 100% for a maximal return under the assumption that

[22]The concept of mean-variance efficient portfolios is introduced by Markowitz (1952).

short-selling is not possible.

Since this large weight is due to the specific performance of gold between 2004 and 2011 we obtain a longer annual data set starting in 1928 and ending in 2010. The longer data set provides potentially more representative equity return and correlation estimates. The mean returns for stocks, bonds and gold are 11.31%, 5.28% and 4.92%, respectively. This alternative data set yields more conservative estimates of the optimal mean-variance efficient weights of gold in a mean-variance efficient, diversified, portfolio.

Figure 12 shows the optimal weights for different target returns.[23] The graphical representation of the weights for equity, bonds, bills (cash) and gold shows that the weight of gold varies between zero and 15%. More specifically, the weight of gold increases to its maximum of 15% for target returns between 4% and 7% and then decreases for target returns between 7% and 11.3%. Cash is only included in portfolios with relatively low target (required) returns whilst the weight of bonds increases for intermediate returns and decreases for target returns between 7% and 11.3%. Finally, the weight of stocks monotonically increases and reaches 100% for the maximum target return.

*** Insert Figure 12 about here ***

The calculations are easily summarized: gold is included in a mean-variance efficient portfolio. It is important to add that this result does not suggest a tactical allocation, i.e. the inclusion of gold in some periods and the exclusion in other periods, but a strategic allocation.[24]

The above analysis is based on a large amount of data and a long time-series. The findings are thus more reliable than comparable studies that used shorter sample periods. However, the calculations do not reveal under which alternative assumptions gold will enhance the efficiency of a portfolio. For example, the analysis does not show how the efficiency changes with lower or higher equity - gold correlations. The next section ad-

[23]The analysis is performed in R. The code and the data can be obtained from the authors.
[24]The safe haven effect of gold implies a tactical allocation.

dresses this issue and also discusses the role of the fundamental drivers for the correlation of gold with other assets.

B Theoretical Analysis

There is no theory about correlations and volatilities (see Erb and Harvey, 2006). In addition, historical returns may be misleading. Thus, to evaluate the role of gold in asset allocation, it is important to consider different scenarios thereby accounting for the fact that the price of gold considerably varied in the last 40 years. The descriptive and econometric analysis stressed that gold is influenced by several factors whose influence varies through time. In addition, the correlation between gold and other assets, the volatility of gold returns and returns itself vary. It is thus crucial to understand the correlation dynamics and use an adequate correlation estimate in an asset allocation context. We agree with Erb and Harvey (2006) that a forward-looking asset allocation analysis may be more useful than an analysis that tells an "investor what the investor should have done in the past".

For example, if inflation is expected to increase, the price of gold will go up, bond prices will go down and stock prices may be unaffected or decrease due to a higher discount rate. Hence, the future correlation between stocks, bonds and gold can be assumed to be negative and zero, respectively. The same assumption can be justified for a scenario in which expected inflation is low: the price of gold will fall, bond prices will go up and stock prices may be either unaffected or increase.

Table VI illustrates the influence of an inclusion of gold in a portfolio on the return to risk ratio. The table includes the return-risk ratio of differently weighted stock-bond-cash-gold portfolios under alternative correlation scenarios. We use very conservative gold return and volatility assumptions to stress the benefits of an inclusion of gold even for relatively unfavorable properties of gold.

*** Insert Table VI about here ***

The calculations demonstrate that the return-risk ratios increase with the inclusion of gold even for positive stock-gold correlations. This finding shows that the inclusion of gold is enhancing the efficiency of a portfolio, i.e. it is either increasing the return for a given level of risk or decreasing the risk for a given level of return.[25]

IV Summary and Concluding Remarks

In this study we have identified fundamental drivers of gold and performed a theoretical, a descriptive and an econometric analysis. We have also studied the question whether gold can be considered an asset class on its own and analyzed the role of gold in asset allocation. We contribute to the literature with a study of the most important drivers and describe and discuss the similarities and differences of the drivers. This is an important part of the identification of the key drivers. For example, both inflation and currency changes are considered drivers of gold but the underlying economic reason for this is the same: a change in the value of a currency through inflation or through a devaluation of the currency changes the price of gold in that currency. Our econometric analysis suggests that inflation is one of the major drivers in the 1970s and most recently, between 2003 and 2013 but not in the 1980s and 1990s, i.e. during the "great moderation". In contrast, currency changes exhibit a more stable but generally weaker influence compared to inflation. Interest rates especially low nominal and negative real interest rates also play a key role in the determination of the price of gold. Finally, we find econometric evidence that central bank foreign exchange reserve and central bank gold reserve changes display a clear positive impact on the price of gold. These findings allow a clear conditional prediction. If one of the major drivers is "active", for example expected future inflation is high, it will support the price of gold. If many drivers are active simultaneously it is likely that they support a historically high price of gold. Finally, an analysis of gold relative to other assets revealed that gold is not overpriced despite its strong price increase mainly between 2002 and 2012.

[25] A similar qualitative result is reported in Hillier, Draper and Faff (2006) and Jaffe (1989).

There are several potential drivers that have not been formally analyzed in this study due to the non-availability of adequate empirical data. However, these additional drivers most likely have a positive impact on the price of gold. For example, if gold is indeed underrepresented in typical portfolios potentially due to its poor performance in the 1980s and 1990s (e.g. see Riley, 2010), there is increased demand for gold in the future. The sovereign debt crisis, the Eurozone crisis and related discussions about "safe assets" may also support the price of gold. Furthermore, it can be presumed that the possibility of a currency war will positively influence the price of gold. Finally, the fact that gold is viewed as an alternative currency may be the ultimate driver of gold in an environment of high levels of sovereign debt.

Even if the price of gold will be below its historical record in the near future, there is no reason to assume that gold will not act as a safe haven and thus a type of portfolio insurance. A lower price of gold would also lower the cost, or premium, to insure and protect a portfolio including financial and real assets.

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Figure 1: Gold and US consumer price index (CPI)

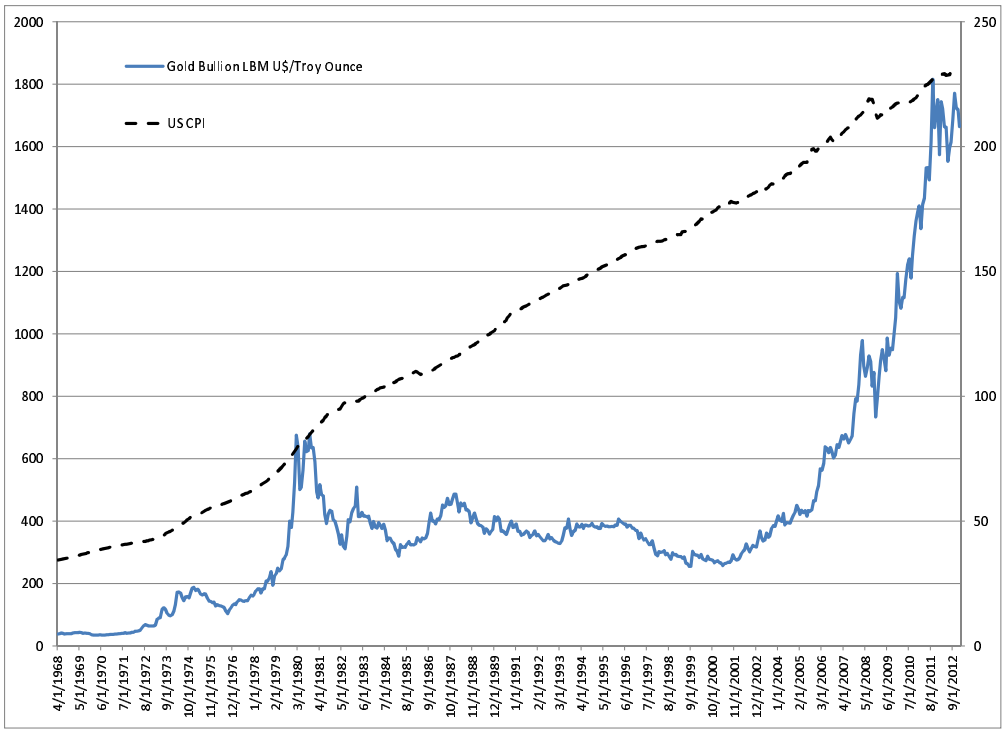


Figure 2: Gold and World consumer price index (CPI)

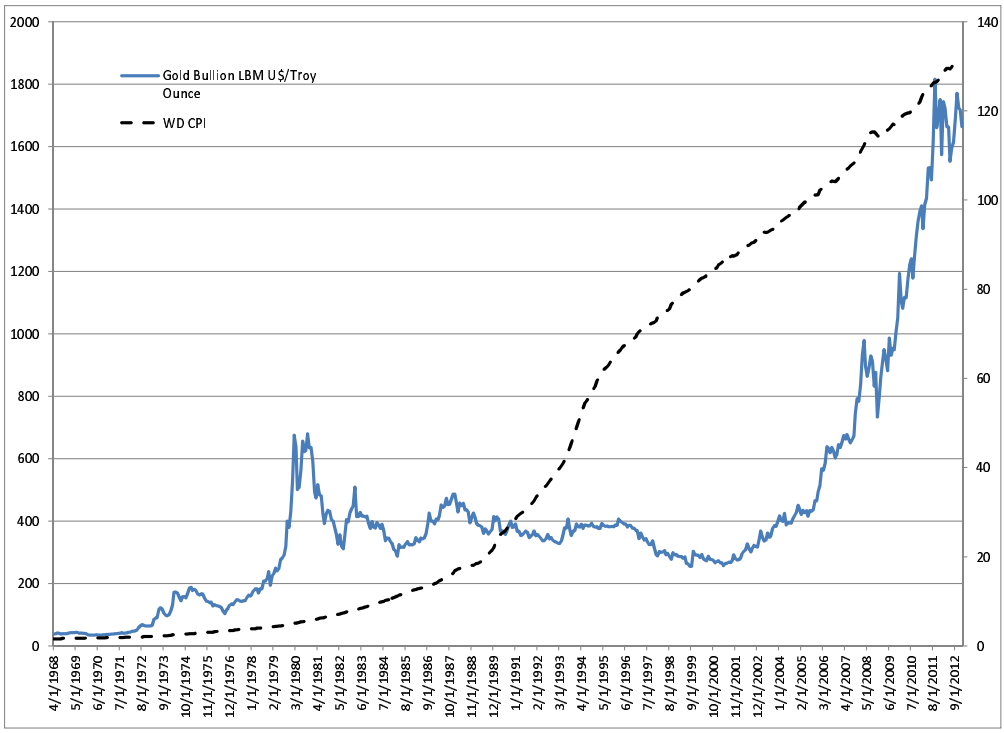


Figure 3: Ratio: Gold and US consumer price (CPI)

Figure 4: Gold and US dollar

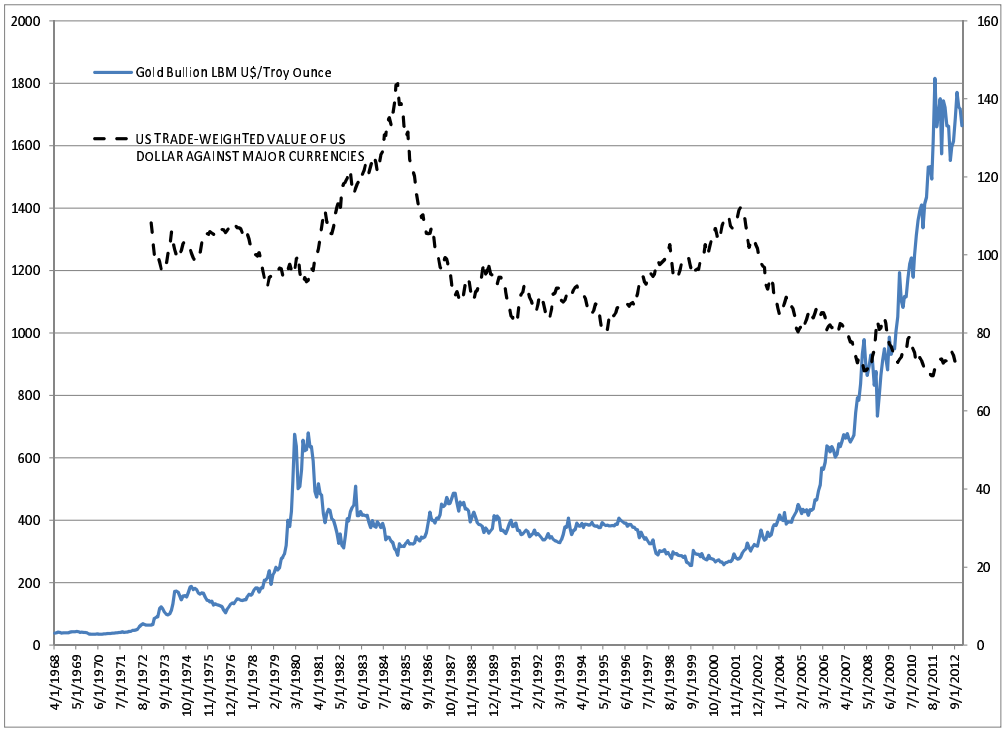


Figure 5: Gold and broad commodity index (GSCI)

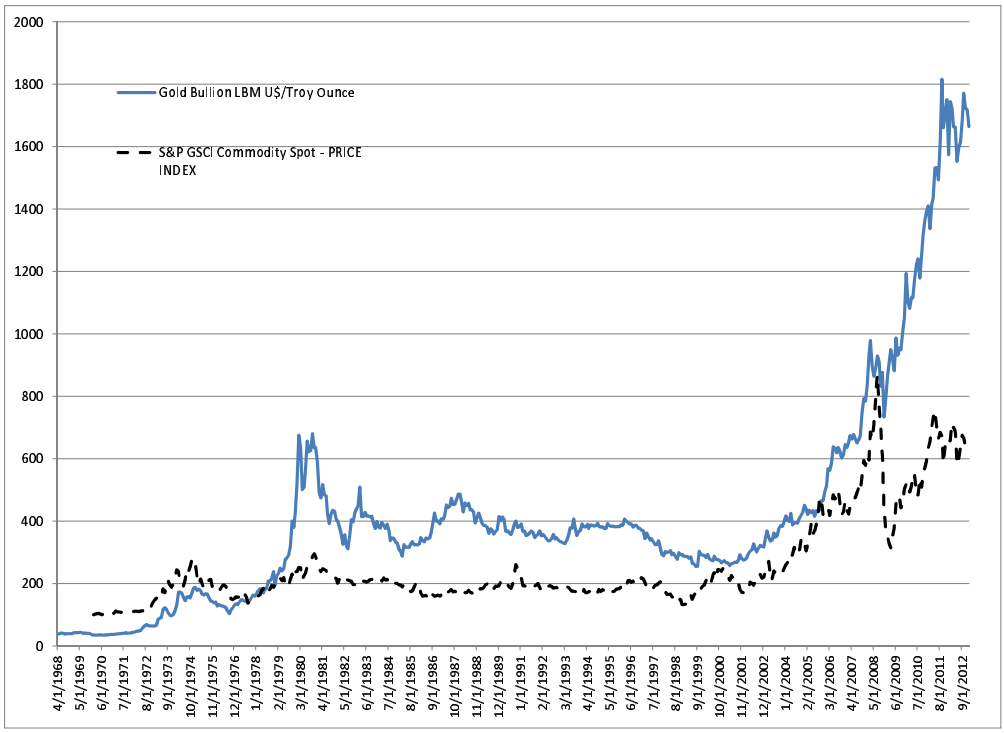
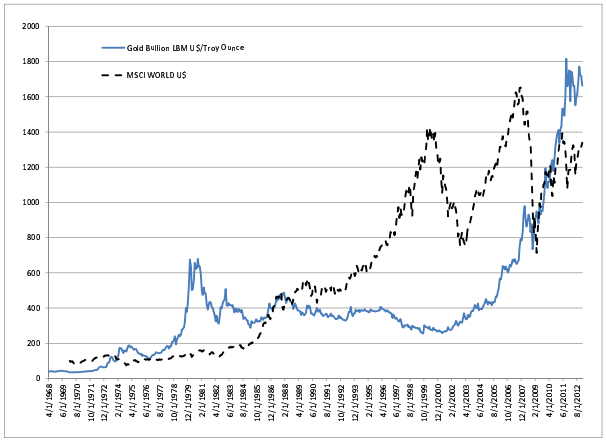


Figure 6: Gold and MSCI World and Emerging Market stock indices



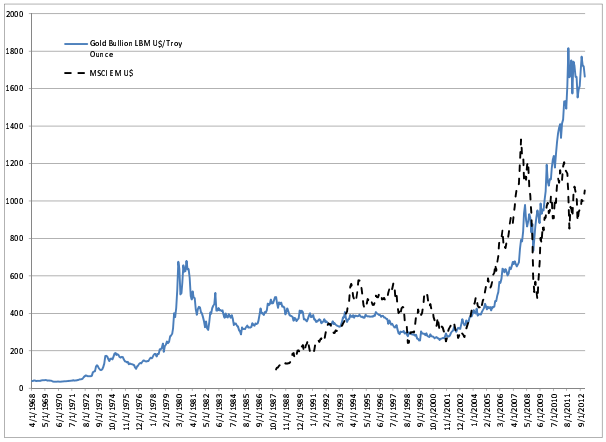


Figure 7: Graphical analysis of crash/ period of financial turmoil: October 1987, September 11, 2001 and Global financial and economic crisis 2008 (Source: Baur and McDermott, 2013)

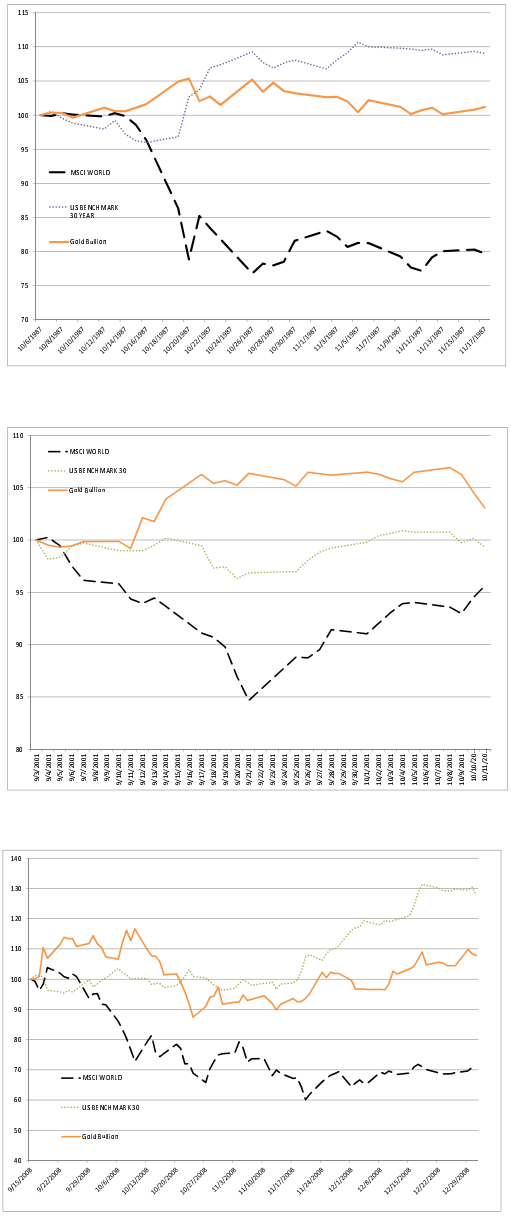


Figure 8: Gold and US stock market (implied) volatility (VIX)

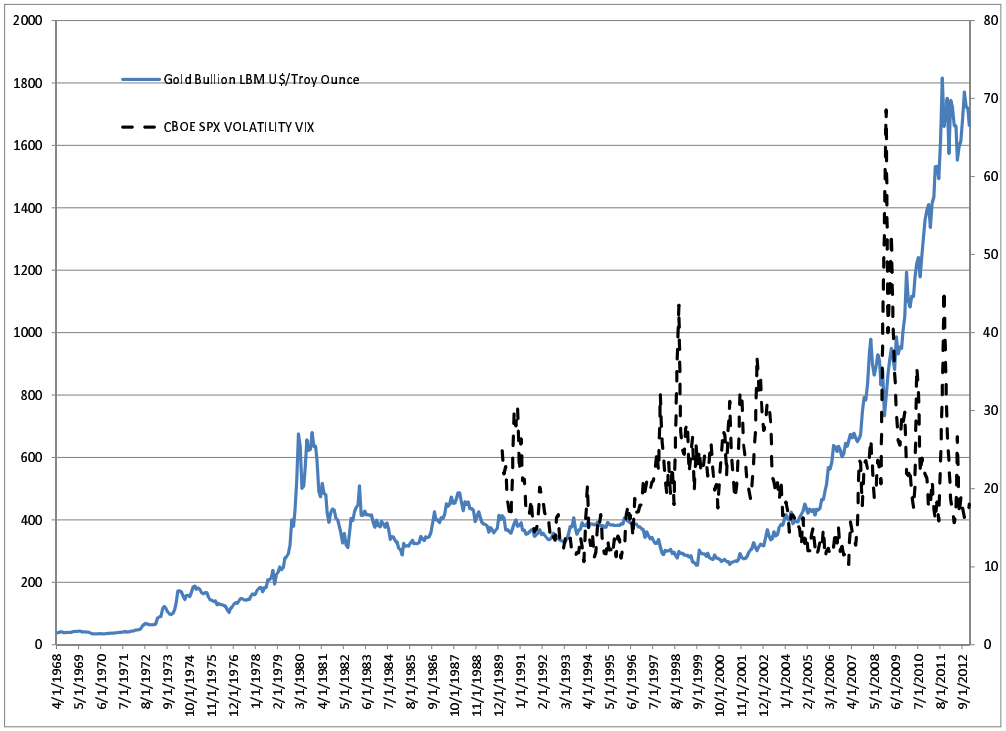
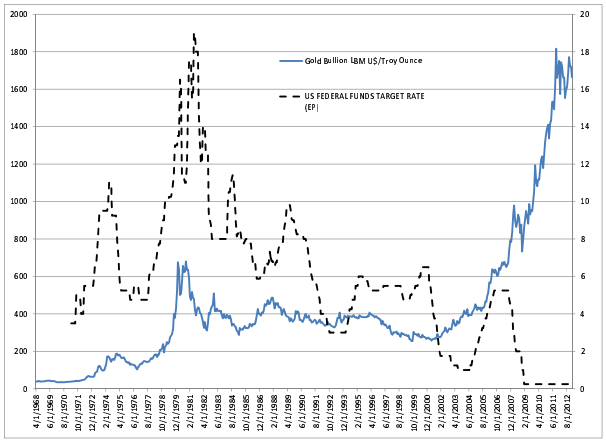


Figure 9: Gold and nominal US interest rate (top graph) and real US interest rate (bottom graph, smoothed 12-month moving average representation of real interest rate)



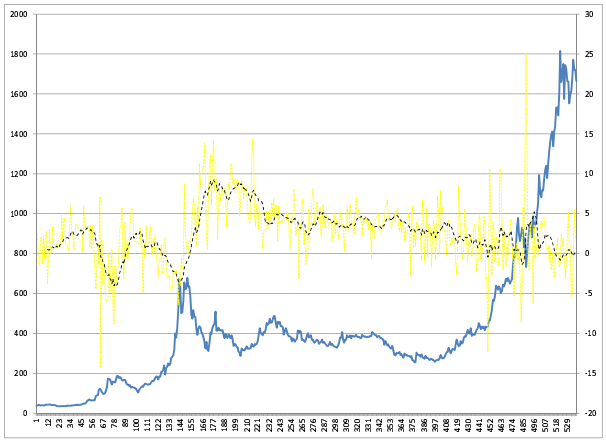
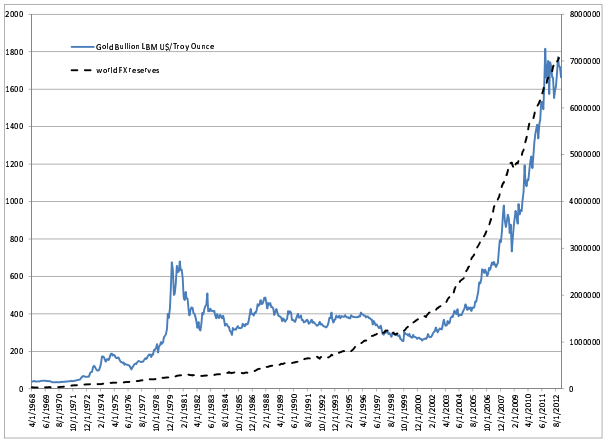


Figure 10: Gold and Aggregate Central Bank FX reserves (top graph) and Gold Reserves (bottom graph)



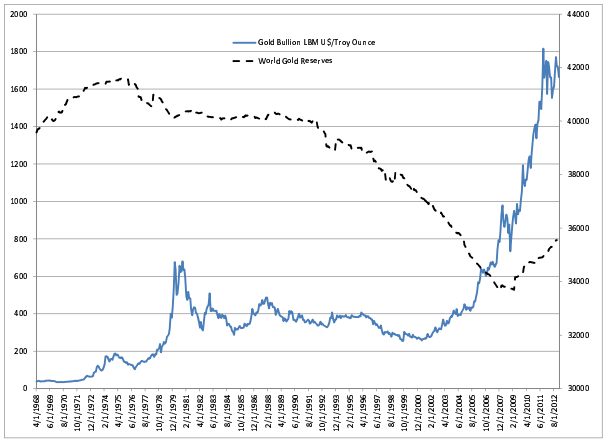
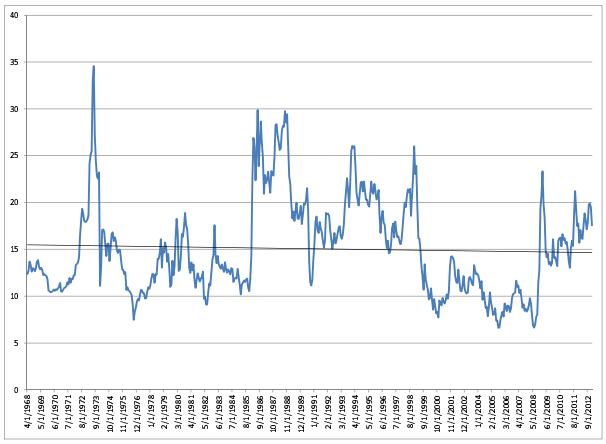


Figure 11: Gold Ratios: Gold relative to the price of oil (top graph); gold relative to the MSCI World equity index (bottom graph)



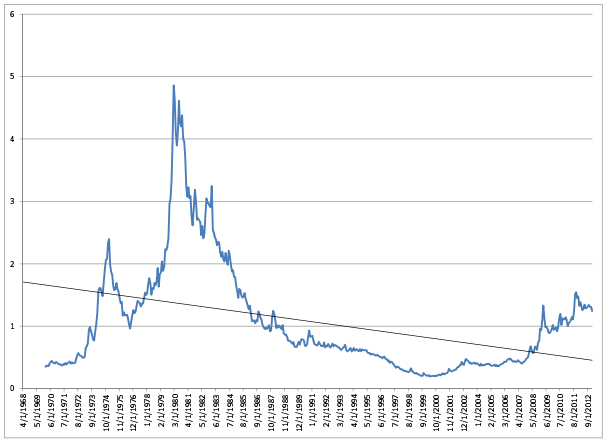


Figure 12: Asset allocation: Mean-variance efficient weight of gold in diversified portfolio

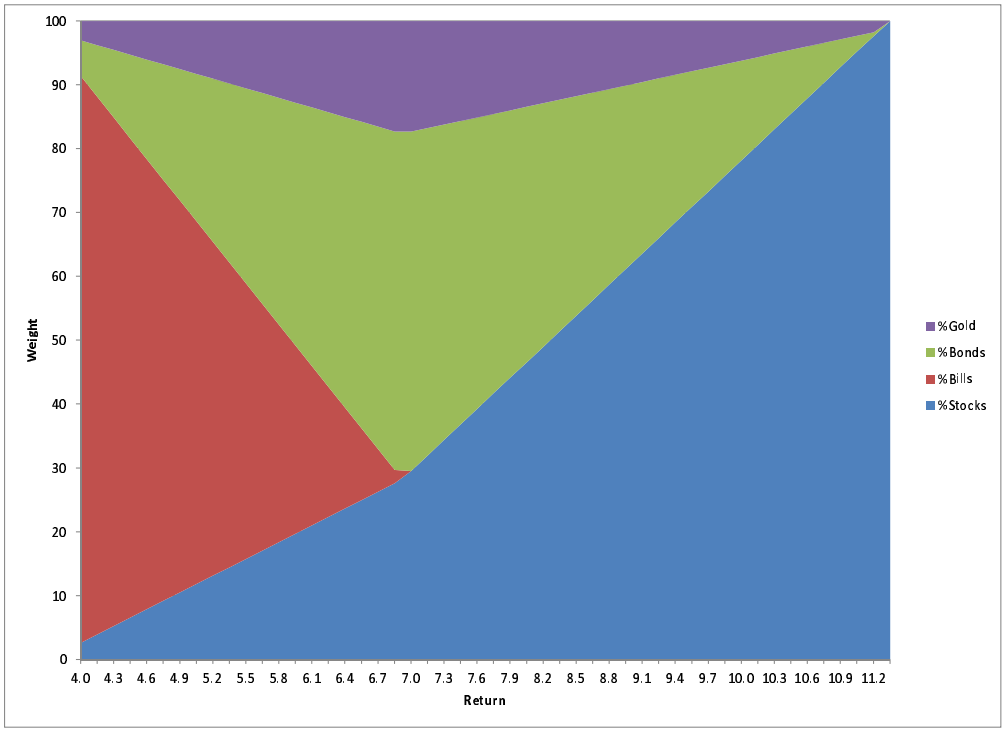


Table I: Unconditional correlations

	gold	US CPI	W CPI	US dollar	commodity	MSCI W	MSCI EM	VIX	IR	FX reserves	gold reserves
gold	1.000	0.152	0.059	-0.269	0.273	0.121	0.160	0.042	0.002	0.116	-0.034
US CPI		1.000	0.260	-0.057	0.389	0.055	0.283	-0.106	0.175	-0.016	0.021
W CPI			1.000	-0.038	0.077	-0.003	0.136	-0.065	0.028	-0.028	0.038
US dollar				1.000	-0.195	-0.209	-0.085	0.058	-0.043	0.088	0.025
commodity					1.000	0.234	0.333	-0.212	0.137	0.019	0.011
MSCI W						1.000	0.747	-0.619	-0.061	0.062	0.045
MSCI EM							1.000	-0.524	0.023	0.203	0.005
VIX								1.000	0.116	-0.095	-0.030
IR									1.000	0.145	-0.055
FX reserves										1.000	-0.012
gold reserves											1.000

Table II: Estimation Results: Univariate Regressions

This table reports the univariate regression results where log-changes of the gold price is the dependent variable and the potential driver of gold is the regressor variable.

Model: $\Delta P_{\text{Gold},t} = \alpha + \beta \Delta X_t + e_t$

	Drivers	Coeff.	t-stat.	p-value	R^2	obs.
inflation	US CPI	2.6352	3.56	0.00	0.023	534
	World CPI	0.3360	1.36	0.18	0.003	534
	World CPI - Agricultural & raw materials	0.1088	1.45	0.15	0.004	534
	World CPI - Food & Commodities	0.3187	4.27	0.00	0.033	534
currency	US trade-weighted index	-0.9202	-6.09	0.00	0.072	478
	Swiss Franc trade-weighted index	0.7086	4.94	0.00	0.051	454
commodity	CRB Spot Index	0.5753	6.86	0.00	0.081	534
	S&P GSCI Commodity Index	0.2455	5.91	0.00	0.064	513
	Silver (troy ounce)	0.4073	22.06	0.00	0.487	512
	S&P GSCI Precious Metals	0.8010	43.27	0.00	0.797	476
	S&P GSCI Non-Precious Metals	0.1736	4.13	0.00	0.036	464
stock markets	Dow Jones IA	-0.0314	-0.58	0.56	0.001	534
	S&P 500 Composite	0.0042	0.08	0.94	0.000	534
	MSCI World	0.1529	2.73	0.01	0.014	513
	MSCI World ex USA	0.2154	4.47	0.00	0.037	513
	MSCI Emerging Markets	0.0866	2.53	0.01	0.021	297
uncertainty	CBOE VIX	0.0125	0.84	0.40	0.003	272
interest rates	US Fed. Funds Target Rate	0.0012	0.04	0.96	0.000	500
	6 month eurodollar	0.0130	0.38	0.70	0.000	502
	US Treasury 10-year	0.0380	0.74	0.46	0.001	535
central bank	Total Foreign Exchange Reserves	0.3567	2.73	0.01	0.014	533
	Total Gold Reserves	-1.1478	-0.83	0.41	0.001	533
	Brazil	-0.0162	-0.87	0.39	0.001	530
	Russia	-0.0867	-0.79	0.43	0.003	209
	India	0.2527	2.21	0.03	0.009	530
	China	-0.0256	-0.34	0.74	0.000	382
	Italy	0.0523	0.31	0.76	0.000	530
	Germany	0.0499	0.31	0.76	0.000	530
	France	0.0798	0.50	0.62	0.000	530
	Australia	0.0408	0.57	0.57	0.001	530
	UK	0.0325	0.25	0.80	0.000	530
	US	-0.2719	-0.53	0.60	0.001	530

Table III: Estimation Results: Multivariate Regressions

This table reports the multivariate regression results where log-changes of the gold price is the dependent variable and potential drivers of gold are the regressor variables.

Model: $\Delta P_{\text{Gold},t} = \alpha + \sum_{i=1}^{K} \beta_i \Delta X_{i,t} + e_{i,t}$

Drivers	**Coeff.**	**t-stat.**	**p-value**	R^2	**obs.**
US CPI	1.4717	1.84	0.07	0.167	466
US$ trade-weighted index	-0.8077	-5.35	0.00		
S&P Commodity Index	0.2051	4.38	0.00		
World FX reserves	0.6436	3.51	0.00		
MSCI World	-0.0002	0.00	1.00		
India Gold Reserves	0.2349	2.13	0.03		
US Fed. Funds Target Rate	-0.0481	-1.79	0.07		

Table IV: Estimation Results: Multivariate Regressions - sub-sample analysis

This table reports the multivariate sub-sample regression results where log-changes of the gold price is the dependent variable and potential drivers of gold are the regressor variables.

Model: $\Delta P_{\text{Gold},t} = \alpha + \sum_{i=1}^{K} \beta_i \Delta X_{i,t} + e_{i,t}$

	Drivers	**Coeff.**	**t-stat.**	**p-value**	R^2	**obs.**
1970s	Constant	-0.0520	-2.26	0.02	0.280	76
	US CPI	8.6323	3.01	0.00		
	US$ trade-weighted index	-1.1185	-1.63	0.10		
	S&P Commodity Index	0.2146	1.69	0.09		
	World FX reserves	0.9682	1.99	0.05		
	MSCI World	0.3596	1.67	0.09		
	World Gold Reserves	-3.6279	-0.74	0.46		
	India Gold Reserves	-0.0551	-0.08	0.94		
	US Fed. Funds Target Rate	0.1718	1.18	0.24		
1980s	Constant	0.0096	1.05	0.29	0.358	111
	US CPI	-3.8371	-2.27	0.02		
	US$ trade-weighted index	-0.8437	-3.31	0.00		
	S&P Commodity Index	0.5632	4.50	0.00		
	World FX reserves	0.3052	0.90	0.37		
	MSCI World	0.0376	0.29	0.78		
	World Gold Reserves	-1.5996	-0.20	0.84		
	India Gold Reserves	-0.2541	-0.59	0.55		
	US Fed. Funds Target Rate	-0.1387	-2.10	0.04		
1990s	Constant	-0.0048	-0.69	0.49	0.092	111
	US CPI	-0.1672	-0.07	0.95		
	US$ trade-weighted index	-0.6232	-2.80	0.01		
	S&P Commodity Index	0.0656	0.84	0.40		
	World FX reserves	0.3611	1.46	0.15		
	MSCI World	-0.0157	-0.19	0.85		
	World Gold Reserves	0.4461	0.33	0.74		
	India Gold Reserves	-0.1896	-0.77	0.44		
	US Fed. Funds Target Rate	-0.0440	-0.53	0.60		
2000s	Constant	0.0009	0.13	0.90	0.188	141
	US CPI	1.0931	0.66	0.51		
	US$ trade-weighted index	-0.4901	-2.09	0.04		
	S&P Commodity Index	0.1801	2.15	0.03		
	World FX reserves	0.3675	0.81	0.42		
	MSCI World	-0.0993	-1.14	0.26		
	World Gold Reserves	-1.8342	-0.93	0.36		
	India Gold Reserves	0.2866	2.79	0.01		
	US Fed. Funds Target Rate	-0.0266	-0.97	0.33		

Table V: Asset allocation: Returns, Risk and Correlations

	Full period: 1968 - 2013							
						Correlations		
	Return	**Std. Dev.**	**Gold**	**SP500**	**MSCI World**	**MSCI EM**	**US bonds 10y**	**US T-bills 3m**
Gold	8.45	5.72	1.00	0.00	0.12	0.20	-0.03	-0.08
SP500	6.11	4.54		1.00	0.89	0.46	-0.17	-0.02
MSCI World	6.03	4.49			1.00	0.75	-0.18	-0.03
MSCI EM	7.09	5.99				1.00	-0.09	-0.03
US bonds 10y	6.27	3.87					1.00	0.13
US T-bills 3m	5.32	3.17						1.00

	1970s							
						Correlations		
	Return	**Std. Dev.**	**Gold**	**SP500**	**MSCI World**	**MSCI EM**	**US bonds 10y**	**US T-bills 3m**
Gold	24.31	7.19	1.00	-0.03	0.11	0.24	0.05	0.22
SP500	1.85	4.42		1.00	0.90	0.39	-0.29	-0.13
MSCI World	3.26	4.07			1.00	0.66	-0.29	-0.17
MSCI EM	11.21	5.43				1.00	-0.06	-0.28
US bonds 10y	8.06	2.65					1.00	0.13
US T-bills 3m	6.28	1.77						1.00

	1980s							
						Correlations		
	Return	**Std. Dev.**	**Gold**	**SP500**	**MSCI World**	**MSCI EM**	**US bonds 10y**	**US T-bills 3m**
Gold	-4.91	6.30	1.00	0.12	0.28	0.19	-0.21	-0.32
SP500	10.49	4.67		1.00	0.81	0.28	-0.23	-0.18
MSCI World	13.60	4.20			1.00	0.73	-0.31	-0.31
MSCI EM	20.97	6.07				1.00	-0.18	-0.26
US bonds 10y	10.31	3.50					1.00	0.17
US T-bills 3m	8.82	2.83						1.00

	1990s							
						Correlations		
	Return	**Std. Dev.**	**Gold**	**SP500**	**MSCI World**	**MSCI EM**	**US bonds 10y**	**US T-bills 3m**
Gold	-3.76	3.52	1.00	-0.12	-0.01	0.14	0.05	-0.12
SP500	14.55	3.58		1.00	0.80	0.41	-0.26	0.02
MSCI World	9.13	4.03			1.00	0.83	-0.22	-0.12
MSCI EM	-0.76	7.10				1.00	-0.09	-0.20
US bonds 10y	5.32	1.34					1.00	-0.01
US T-bills 3m	4.85	1.22						1.00

	2000s							
						Correlations		
	Return	**Std. Dev.**	**Gold**	**SP500**	**MSCI World**	**MSCI EM**	**US bonds 10y**	**US T-bills 3m**
Gold	13.70	4.77	1.00	0.05	0.14	0.28	-0.04	-0.03
SP500	0.09	5.12		1.00	0.97	0.74	-0.08	-0.04
MSCI World	-0.06	5.25			1.00	0.84	-0.09	-0.03
MSCI EM	-0.79	5.25				1.00	-0.11	-0.06
US bonds 10y	2.64	2.07					1.00	0.12
US T-bills 3m	2.10	1.96						1.00

Table VI: Asset allocation: Theoretical analysis - inclusion of gold in selected equity-bond-cash portfolios

This table presents the effect of changes in the allocation of gold in a portfolio comprised of equity, bonds, cash and gold. The weights of gold vary between 0 and 0.2 under different equity-gold return correlation scenarios (0, 0.1 and −0.1). Equity-bond and bond-gold return correlations are assumed to be zero.

	equity	bonds	cash	gold	portfolio return	equity-gold correlation	portfolio risk	return-risk ratio
return (in %)	**8**	**4**	**2**	**4**				
risk (std. dev.) (in %)	**4**	**3**	**1**	**4**				
weights	1	0	0	0	8.0	0.05	4.00	2.00
weight gold = 0.00	0.9	0.1	0	0	7.6	**0.05**	3.61	2.10
	0.8	0.2	0	0	7.2	0.05	3.26	2.21
	0.7	0.3	0	0	6.8	0.05	2.94	2.31
	0.6	0.4	0	0	**6.4**	0.05	2.68	**2.39**
weight gold = 0.05	0.95	0	0	0.05	7.8	0.05	3.83	2.04
	0.85	0.1	0	0.05	7.4	0.05	3.44	2.15
	0.75	0.2	0	0.05	7.0	0.05	3.09	2.27
	0.65	0.3	0	0.05	6.6	0.05	2.78	2.38
	0.55	0.4	0	0.05	**6.2**	0.05	2.53	**2.45**
weight gold = 0.1	0.9	0	0	0.1	7.6	0.05	3.66	2.08
	0.8	0.1	0	0.1	7.2	0.05	3.28	2.20
	0.7	0.2	0	0.1	6.8	0.05	2.93	2.32
	0.6	0.3	0	0.1	6.4	0.05	2.63	2.43
	0.5	0.4	0	0.1	**6.0**	0.05	2.40	**2.50**
weight gold = 0.2	0.8	0	0	0.2	7.2	0.05	3.38	2.13
	0.7	0.1	0	0.2	6.8	0.05	3.00	2.26
	0.6	0.2	0	0.2	6.4	0.05	2.67	2.39
	0.5	0.3	0	0.2	6.0	0.05	2.40	2.50
	0.4	0.4	0	0.2	**5.6**	0.05	2.21	**2.53**
weight gold = 0.1	0.9	0	0	0.1	7.6	**0.1**	3.70	2.05
	0.8	0.1	0	0.1	7.2	0.1	3.32	2.17
	0.7	0.2	0	0.1	6.8	0.1	2.97	2.29
	0.6	0.3	0	0.1	6.4	0.1	2.67	2.40
	0.5	0.4	0	0.1	**6.0**	0.1	2.43	**2.47**
weight gold = 0.2	0.8	0	0	0.2	7.2	0.1	3.45	2.09
	0.7	0.1	0	0.2	6.8	0.1	3.08	2.21
	0.6	0.2	0	0.2	6.4	0.1	2.74	2.33
	0.5	0.3	0	0.2	6.0	0.1	2.47	2.43
	0.4	0.4	0	0.2	**5.6**	0.1	2.27	**2.47**
weight gold = 0.1	0.9	0	0	0.1	7.6	**-0.1**	3.54	2.15
	0.8	0.1	0	0.1	7.2	-0.1	3.16	2.28
	0.7	0.2	0	0.1	6.8	-0.1	2.81	2.42
	0.6	0.3	0	0.1	6.4	-0.1	2.52	2.54
	0.5	0.4	0	0.1	**6.0**	-0.1	2.30	**2.61**
weight gold = 0.2	0.8	0	0	0.2	7.2	-0.1	3.14	2.29
	0.7	0.1	0	0.2	6.8	-0.1	2.77	2.45
	0.6	0.2	0	0.2	6.4	-0.1	2.45	2.61
	0.5	0.3	0	0.2	6.0	-0.1	2.19	2.74
	0.4	0.4	0	0.2	**5.6**	-0.1	2.03	**2.76**