

# OXFORD ECONOMICS

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## The impact of inflation and deflation on the case for gold

A report commissioned by the  
World Gold Council  
July 2011



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ECONOMICS

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## Foreword

Two crises, unprecedented central bank intervention and deep and prolonged recessions, followed by a brittle recovery have left the global economy facing a complex inflation/deflation paradox. For many developing economies, high inflation is an ongoing reality, while the threat of protracted low growth, low inflation or even deflation looms over developed markets, fuelling uncertainty for investors and savers.

The World Gold Council has therefore commissioned Oxford Economics to conduct this independent, proprietary research using their respected Global Model, to explore the performance of gold and other assets in various economic situations and examine gold's role within in an efficient investment portfolio in divergent economic scenarios.

This research from Oxford Economics makes a valuable contribution towards the World Gold Council's own fundamental research for investors, supporting the findings from recent reports on gold as a tail risk hedge and gold versus the broader commodities complex, which can be found at [www.gold.org](http://www.gold.org).

## Executive Summary

- Since 2007 the world has seen a period of considerable economic and financial volatility, during which gold has performed strongly with its price more than doubling. This performance has prompted some reappraisal of gold's properties as an investment vehicle.
- Over the very long-term gold tends to hold its value in real terms, but short-run factors can move gold away from its long run equilibrium for extended periods. These factors include financial stress, political turmoil, real interest rates, inflation, central bank activity and the US dollar exchange rate.
- To begin our investigation into gold, we estimate an equation to explain gold price movements over the 1976-2010 period. The modelling approach suggests that all of the factors outlined above are significant short-run influences on the gold price and that shocks to the gold price tend to wear off relatively slowly. The equation also highlights the fact that whilst the current price of gold is comparatively high, the adjustment back to equilibrium could take place via a rise in the general price level, rather than a fall in the nominal value of gold.
- Using the estimated equation and Oxford Economics' Global Model, we examine the performance of gold relative to other assets from 2011-2015 over a number of variant economic scenarios. We find that while other assets outperform gold in the baseline scenario, gold performs relatively strongly in a high inflation scenario and also does comparatively well in a deflation scenario derived from a wave of defaults in the 'peripheral' eurozone countries. This is because such a deflation scenario includes a sharp rise in financial stress.
- The scenario analysis confirms gold's properties as a hedge against extreme events; properties that may be especially valuable given the considerable uncertainties still facing the world economy.
- The study then goes on to examine gold's place in an efficient investment portfolio using optimisation techniques and different assumed long-run returns for gold, equities, bonds, cash and property. We find that because of its lack of correlation with other financial assets, gold has a useful role to play in stabilising the value of a portfolio even if the conservative assumption of a modest negative real annual return is made.
- We find gold's optimum share of a portfolio to be around 5% in a base long-term case for the UK featuring 2.25% growth and 2% annual inflation. This is higher than levels found in typical mainstream investment portfolios, although this may be in part because the analysis does not include other assets such as index-linked bonds, foreign securities and other commodities.
- Varying the economic assumptions can imply higher allocations for gold. Gold's optimal share rises in a more inflationary scenario, as well as for more risk-averse investors in a limited growth and lower inflation scenario, thanks to its low correlation with other assets.

## 1 Introduction

Since 2007 the world has seen a period of striking economic and financial volatility, featuring the deepest recession since the 1930s and steep declines in the value of many financial assets – both traditional ones such as equities and newly developed ones such as mortgage-backed securities. Against this background, however, gold has performed strongly with its price roughly doubling since the global financial crisis began in mid-2007.

Gold's performance in this period has sparked something of a reappraisal of its characteristics as an asset and led some to revisit its proper place in investors' portfolios. As a store of value which is relatively immune to inflation, financial crises and credit default, gold has been used for centuries to protect individuals' wealth. These special properties are borne out in the recent performance of gold, and investors may continue to value them given the significant uncertainties still facing the global economy.

At the time of writing, the world economy faces concerns over sovereign creditworthiness, the impact of loose monetary policy including quantitative easing on medium-term inflation, and the possible effects of unrest in the Middle East on global oil markets. There are also longer-term structural issues looming large such as the future of the US dollar as a reserve currency and the ongoing shift in the balance of economic power and wealth from the western 'developed' countries to the rapidly growing emerging economies such as China and India.

The purpose of this study is to examine in detail gold's properties as an asset and its likely performance relative to other assets in a variety of different economic scenarios. By building on existing studies of the determinants of the gold price and combining this with our own quantitative analysis in the framework of the Oxford Global Macroeconomic Model, we have examined in detail gold's properties as an asset and its likely performance relative to other assets in a variety of different economic scenarios. The ongoing uncertainty surrounding many aspects of the global economy (as noted above) makes it especially appropriate that a wide range of alternative scenarios be covered. We seek to test gold's resilience as an asset in the face of possible shocks including high inflation, financial crises and deflationary conditions and also seek to assess its proper place in a long-run investment portfolio under different economic conditions.

The paper is organised as follows. In Section 2 we look at the key determinants of the gold price, using historical analysis. In Section 3, we present a model that explains movements in historical gold prices, investigate the key drivers of the price of gold (in both the short run and long run) and estimate an equation to explain movements in the gold price over the recent past.

Section 4 combines the newly estimated equation with the Oxford Global Macroeconomic Model to compare the performance of gold and other financial assets (cash, equities, gilts and property) in a variety of possible scenarios incorporating different inflation outlooks. Our scenario analysis considers four possible outcomes: (i) a baseline featuring a gradual recovery in the global economy with comparatively low rates of inflation, (ii) moderate deflation, where a eurozone sovereign debt crisis triggers a second global recession leading to deflation, (iii) stagflation, and (iv) very high inflation, where inflation rates approach 10% in the developed world. Our scenario selection is designed to cover possible futures for the global economy that incorporate some of the currently identified major risks to the global economy.

Finally, in Section 5 we use optimisation techniques to examine how gold might best fit into a benchmark investment portfolio given its particular characteristics and the range of possible future scenarios for the global economy. We elaborate three different long-term scenarios (baseline, higher inflation and low growth low inflation), and using assumptions about long-term asset returns and volatility we examine how gold's place in an efficient portfolio varies across the different scenarios. This section is constructed from the perspective of

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a UK investor in order to utilise the long run of historical asset returns data (going back to 1971) available for the UK. Section 6 presents a short conclusion.

The study and its results are subject to some limitations. Although the methodology used in this study was quantitatively rigorous, the approach taken to modelling the price of gold and constructing the scenarios was macroeconomic. As a result, the key drivers of the price of gold in the equation are macro variables, such as economy-wide interest rates and financial stress, rather than micro level variables of supply and demand, such as the mine supply of gold.<sup>1</sup> In addition, the optimisation analysis utilises a relatively simple model, which does not include all possible financial assets, allow for all possible constraints investors may face, or cover all the possible motivations and characteristics of investors. As such, the results are intended to be largely illustrative, outlining gold's special properties as an asset, examining gold's likely relative performance against other assets in changing economic circumstances and indicating the course that investors' allocations to gold might best take under different economic scenarios.

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<sup>1</sup> From a modelling perspective, using the macroeconomic approach means that we are unable to fully account for how micro developments, such as an increase in the cost of mining, will impact the price. Coupled with this it seems likely that increasing demand in the Far East and rising production costs will have a significant positive impact on the price over the medium term, which we are not able to fully capture in our model.

## 2 Determinants of the price of gold

### 2.1 The distinctive properties of gold

Gold has been used as a store of value and form of currency since ancient times. Since the seventeenth century it has been formally traded over the counter in London and by the nineteenth century it underpinned the largest fixed exchange rate system the world has ever known (the Gold Standard). In the twentieth century it was again used as the backbone to a formal exchange rate mechanism (Bretton Woods) but the collapse of the system in the early 1970s left the price to float freely for the first time in over 250 years.

Gold's historical popularity as a currency and a store of value has sprung in part from a number of peculiar properties not fully shared with competing assets. In contrast to other commodities, gold does not perish or degrade over time, giving it unique properties as a very long-term store of value. Gold mined today is interchangeable with gold mined many hundreds of years ago.

The supply of gold has also been relatively fixed for the last century, with annual mine production a small share of the total stock of gold outstanding and with a limited ability for annual production to rise in response to changes in the gold price. This marks it out from other commodities where substantial supply responses to price changes are possible, at least over the medium term.

Another important attribute of gold is its relatively less prominent use for industrial purposes, compared to other commodities including precious metals such as silver and platinum. Only around 10% of gold demand in 2010 came from such industrial uses<sup>2</sup> with the balance coming from jewellery and investment demand. As a result, gold prices lack the strong link to the economic cycle that other commodities have and gold has thus often exhibited low or even negative correlations with these and other financial assets.<sup>3</sup>

Gold is also unusual among financial assets in not delivering a yield, e.g. a dividend or coupon as paid by equities and bonds and this can be seen a disincentive to hold gold; however, gold has a significant advantage compared to some other financial assets which is its lack of default risk.

These factors give gold an unusual set of behavioural characteristics compared to other financial assets, which will be examined in more detail below.

### 2.2 Gold and the general price level

Despite the many different institutional settings (such as the Gold Standard, the Bretton Woods system and from 1971 a free floating price for gold) and the migration of gold from use as an everyday currency to an investment vehicle, the long run purchasing power of gold has remained remarkably stable over time.<sup>4</sup> In the 1830s the price of gold in 2010 dollars was around US\$450 per troy ounce, with the real terms price much the same in 2005, more than a century and a half later.

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<sup>2</sup> 'Gold Demand Trends' 2010 Q3 . *World Gold Council*

<sup>3</sup> See C. Lawrence (2003), "Why is gold different from other assets? An empirical investigation", *Report for the World Gold Council*.

<sup>4</sup> See for example R.W. Jastram (2009) *The Golden Constant: The English and American Experience, 1560-2007*, Edward Elgar Ltd and E.J. Levin & Wright, R.E. (2006) "Short-run and long-run determinants of the price of gold", *Report for the World Gold Council*.

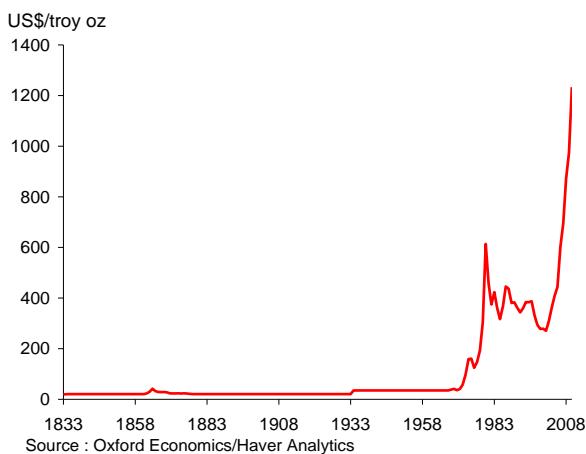
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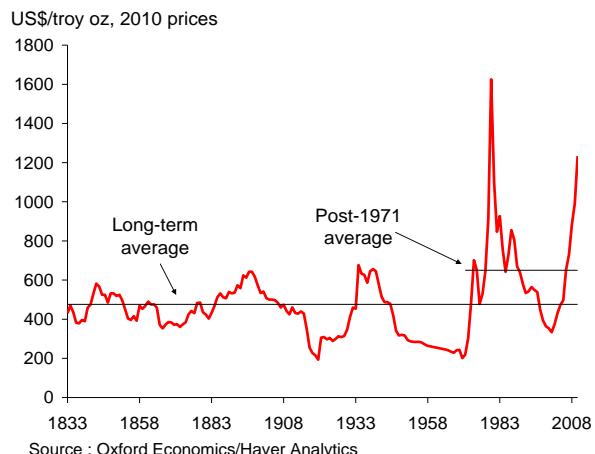
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The tendency for gold to hold its real terms value over long periods has often led to gold being described as an 'inflation hedge'. However, the reality is more complex as the gold price does not simply move in line with the general price level but rather exhibits long periods where it moves without any apparent link to inflation trends. For example, in the early 1980s the real price of gold leapt to over three times its very long-run average, while the 1990s saw a lengthy bear market which saw the gold price fall well below its long-term average.

**Chart 2.1 – Gold price in the long run**



**Chart 2.2 – Real gold price**



The link between gold and inflation is also obscured to some extent by structural changes in the gold market. For much of the 19<sup>th</sup> century the gold standard kept the nominal price of gold fixed for extended periods. After World War II, the Bretton Woods exchange rate system also retained a gold link to the value of the US dollar, which again meant that gold prices were not free to react to the interplay of supply and demand. Only after the abolition of this system did something like a true free market for gold come into being. Notably, the average real price of gold since 1971 is much higher than it was in the preceding 150 years (around US\$650 in 2010 prices versus US\$475) which strongly indicates a major structural change in the market over the last forty years.

Currently, the gold price stands well above its post-1971 real terms average but recent history cautions us against assuming a rapid reversal in the price. The early 1980s experience shows that gold could yet peak significantly higher than current levels. Moreover, gold prices were above their post-1971 real terms average for almost all the 1978-1990 period, while in the current bull market prices have only been clearly above this level since 2007.

It is also possible that while gold's real price eventually falls back this takes place not by a fall in the nominal gold price but by a substantial rise in the general price level, that is that the current price proves an accurate warning of high inflation down the road.

The strong performance of gold during the inflationary 1970s and early 1980s confirms its potential value in periods of rapid price rises. Less clear, however, is how gold might fare in a period of prolonged price deflation. This is because periods of general price deflation are rare. In the last 150 years, the only examples are the Great Depression of the 1930s and the nineteenth century Great Moderation. Moreover, the gold price was fixed for the majority of both periods due to the operation of the Gold Standard.

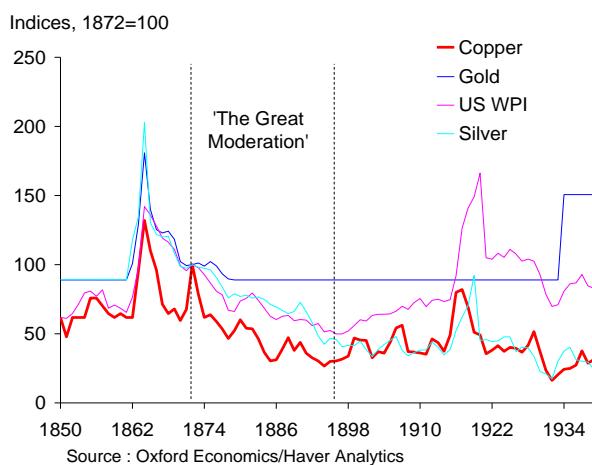
Examination of the behaviour of other commodity prices suggests that had gold been freely floating, its price would probably have declined during both periods. From 1872-1896 the US wholesale price index (WPI) fell by 50%, silver prices fell by 54% and copper by 69%. In 1929-1933 the US WPI fell by 31%, silver by 10% and copper by 60%.

However, this approach fails to take into account that gold is also demanded as a store of value – especially in periods of economic and political turmoil – while other commodities are influenced much more by industrial demand. It is likely that in the early 1930s – a period of severe economic dislocation and high political tensions – gold would have outperformed other commodities had it been freely floating.

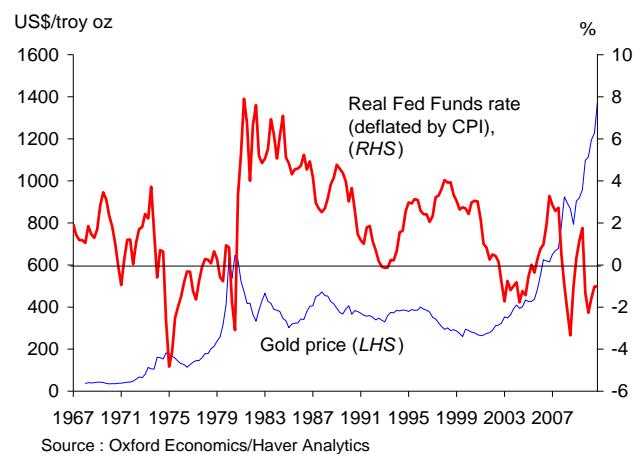
The examination of these two periods of price deflation also shows that 'deflation' periods can be sharply different in character. The nineteenth century Great Moderation was a period of economic expansion where price falls resulted from structural factors such as falling transport costs, which deflated the cost of key staples. By contrast, the Depression saw deflation resulting from the combination of a financial shock and a botched policy response leading to a sharp contraction in the money supply and a massive decline in world output. The behaviour of gold might be expected to vary significantly depending on the causes of deflation.

This highlights the potential importance of the variety of other factors that can have a major impact on the price of gold in the short and medium-run, which we survey below:

**Chart 2.3 – World commodity prices 1850-1939**



**Chart 2.4 – Real interest rates and gold**



## 2.3 Gold and real interest rates

Another factor that can influence gold prices, and to some extent is related to inflation, is the level of real interest rates. As gold lacks a yield of its own, the opportunity cost of holding gold increases with a real interest rate increase and decreases with a fall in real interest rates.

Periods of negative real interest rates ought to be especially positive for gold, and this contention is supported by studying the 1970s when real interest rates were substantially negative for lengthy periods. More recently, short-term rates near zero combined with modest inflation (and inflation expectations) have also implied mildly negative real rates and may have supported the demand for gold.

By contrast, the early 1980s saw substantially positive real rates as a result of a concerted attempt by global central banks to squeeze out inflationary pressures. It is probably no coincidence that in the wake of radical rate hikes by central banks in this period, gold declined from its 1980 peak level with some funds diverted into other assets like cash and government bonds.

## 2.4 Gold and the US dollar

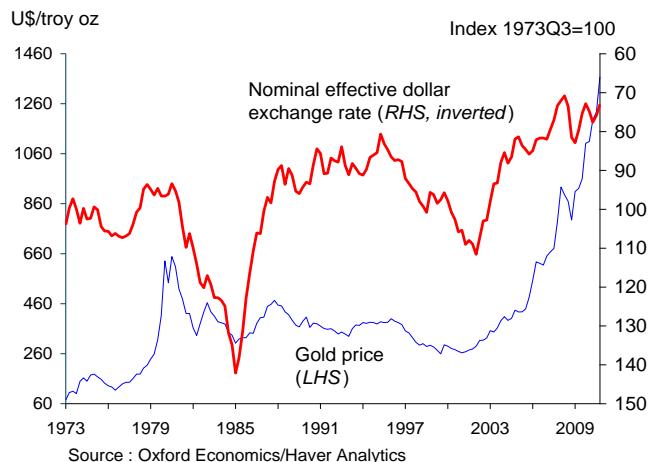
Since the move to floating exchange rates in the early 1970s, the external value of the US dollar has been a significant influence on short-term gold price movements. This relationship has been observed by, among others, Capie et al. (2005)<sup>5</sup> and the International Monetary Fund (IMF). The IMF estimated<sup>6</sup> in 2008 that 40-50% of the moves in the gold price since 2002 were dollar-related, with a 1% change in the effective external value of the dollar leading to a more than 1% change in the gold price.

This relationship exists because:

- A falling dollar increases the purchasing power of non-dollar area countries (and a rising dollar reduces it) driving up prices of commodities including gold (or driving them down in case of a stronger dollar)
- In periods of dollar weakness, investors look for an alternative store of value, driving up gold prices. This includes dollar-based investors concerned about possible inflationary consequences of a weak dollar. In strong dollar periods the dollar itself is often seen as an appropriate store of value.

Recent history confirms the close association of the gold price with the value of the US dollar. The weakness of the dollar in the late 1970s was associated with rising gold prices, as was substantial dollar weakening that began in 2002. By contrast, the strong dollar of the mid-1980s and late 1990s was associated with relatively low gold prices.

**Chart 2.5 – US dollar exchange rate and gold**



## 2.5 Gold and financial stress

A significant and commonly observed influence on the short-term price of gold is the level of financial stress, which has led to gold sometimes being described as 'a crisis hedge'. In periods of financial stress gold demand may rise for a number of reasons:

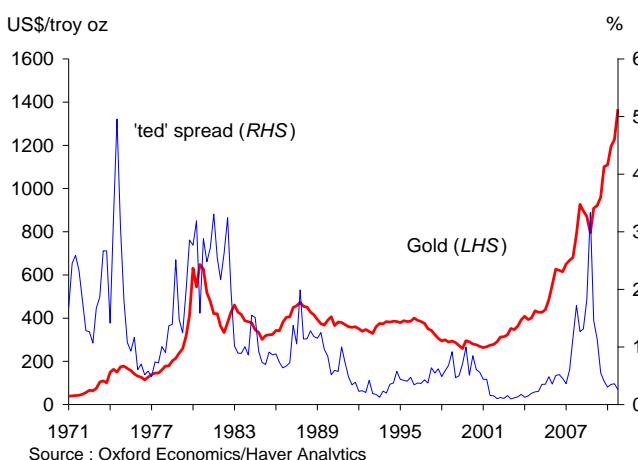
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<sup>5</sup> F. Capie, Mills, T.C. & Wood, G. (2005), "Gold as a hedge against the dollar", *Journal of International Financial Markets, Institutions & Money*, Vol 15, pp. 343-352

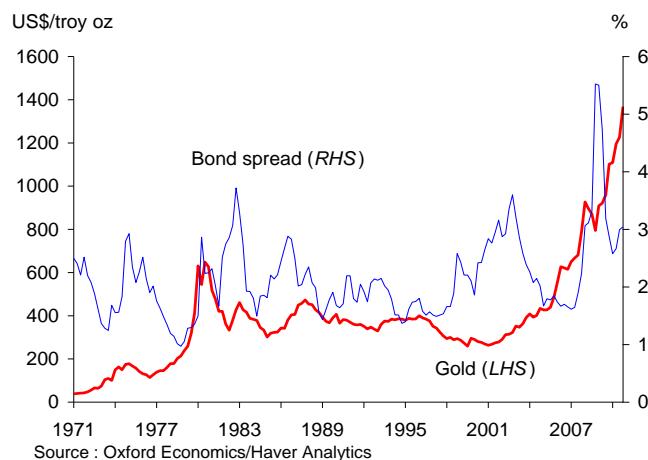
<sup>6</sup> IMF World Economic Outlook April 2008

- Steep declines in the value of other assets such as equities and high volatility of asset prices, leading to demand for a more stable store of value uncorrelated with other assets
- Fears about the security of other assets such as bonds due to the possibility of default, and even fears about cash if the health of the banking system is in question – the fear of systemic collapse
- The need for liquidity in an environment where it may be difficult to realise the value (or the full value) of other assets.

**Chart 2.6 – Gold and ‘Ted’ spread**



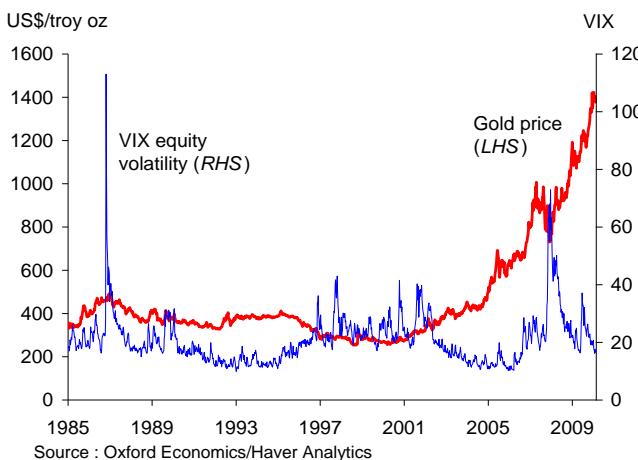
**Chart 2.7- Gold and BBB-AAA spread**



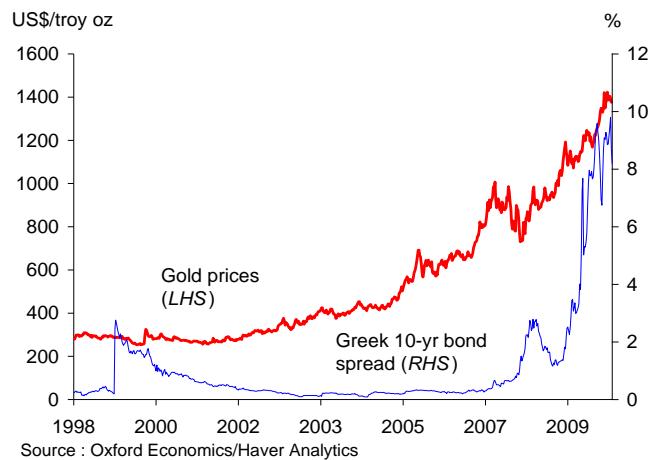
The link between gold prices and these factors can be seen from an examination of gold and financial stress measures in recent decades. A well-known indicator of stress and investor risk aversion is the so-called ‘Ted’ spread, the spread between the 3-month US interbank rate and the 3-month T-Bill rate. This correlates especially well with gold prices in the 1970s when massive spikes in the ‘Ted’ spread were associated with sharp rises in gold. The ‘Ted’ spread also rose sharply in the early 1980s; in 1987 in the wake of the stock market crash and during the global financial crisis of 2007-2009 – both also periods of stronger gold prices.

Another common measure of stress is the spread between yields on low grade corporate bonds and highly-rated bonds (e.g. the BBB-AAA spread). This also correlates quite well with gold prices in the 1970s and in the first part of the recent financial crisis. Notably, however, the correlation in 2002-2003, when the spread widened sharply, is less strong and gold has also remained high even though the BBB-AAA spread has narrowed sharply over the last 18 months.

**Chart 2.8 – Gold and equity volatility**



**Chart 2.9 – Gold and Greek bond spread**



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Gold's correlation with another alternative stress measure, VIX equity volatility, is perhaps looser. Notably, the steep rises in VIX volatility in the late 1990s (connected with the Russian and Brazilian crises) were not associated with sharp rises in gold – indeed gold prices fell during much of this period.

The uncharacteristic behaviour of gold in this period can be seen clearly by examining gold's performance in stressful periods in different decades. In years of elevated stress (when key indicators such as credit spreads, equity volatility and the 'Ted' spread rose sharply) real gold prices rose an average 33% per annum in the 1970s, 18% per annum in 1980s and 16% per annum in the 2000s – all much higher than the average annual growth rate from 1971-2010.

**Table 2.1 – Gold's performance in stress periods**

	Stress periods within the decade				Average
	1970s	1980s	1990s	2000s	
Real gold returns, % annual	32.9	18.1	-10	15.8	6.7

But the 1990s saw real prices fall 10% per annum during 'crisis' years. There appears to be two possible reasons for this. Firstly, that gold went out of fashion as an asset of choice in risky periods, being superseded to some extent by cash and government bonds. A long period of relative macroeconomic stability and low inflation may have reinforced investor perceptions of the safety of cash and government debt, raising their attractiveness relative to gold for risk-averse investors. Significantly, the dollar was generally strong in the 1990s and tended to gain further during stressful periods which might have contributed to the lack of correlation between gold and rising financial stress in these years.

Secondly, other factors may have been at work which pushed down the gold price – a development that may have reinforced the unattractiveness of gold to investors. The most likely factors of this kind were central bank gold sales (see below) and forward hedging by mining firms.

More recently, it is notable that gold has held up well despite a considerable easing of most financial stress measures towards more normal levels. This once again suggests other factors are in play. A possible factor that has not been picked up by the standard stress measures is the eurozone sovereign debt crisis, which has featured government bond spreads in 'peripheral' countries such as Greece, Ireland, Portugal and Spain, widening dramatically on fears of possible sovereign defaults.

State defaults in such advanced countries would be unprecedented in the post-war period and would strike a major blow to the perception of government bonds as a 'safe' asset class. Moreover, they could be accompanied by dramatic events such as the collapse of local financial sectors, countries leaving the eurozone, high inflation and perhaps even the confiscation or freezing of some deposits. Given all this, it is quite possible that the risk of sovereign defaults in the eurozone has contributed to gold's continued strength, and there does seem to be some recent correlation between gold and bond spreads in the peripherals.

## 2.6 Gold and political instability

Another factor that can boost gold prices is political instability. Investor concerns about wars, civil conflicts and international tensions can boost demand for gold for similar reasons to those noted above for periods of financial stress. Gold's potential function as a 'currency of last resort' in case of serious system collapse provides a particular incentive to hold it in case the political situation is especially severe.

To some extent, political concerns will also be picked up by financial stress measures, so separating the two is not entirely straightforward. It is made even more difficult by the absence of clear objective measures of political risk, which makes it hard to test for the impact of political instability. However, the impact of political factors does seem to have been especially important in driving gold at certain times. In particular, gold appears to have been boosted in the late 1970s and early 1980s by incidents such as the Iranian revolution and the Soviet invasion of Afghanistan. Gold prices also rose sharply in the immediate wake of the September 11 2001 attacks in the US.

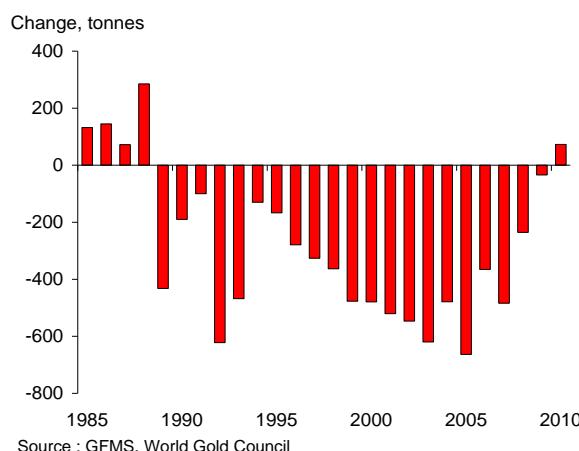
## 2.7 Gold and official sector activity

The behaviour of central banks and other parts of the official sector can have an important impact on gold prices. One reason for this is that central banks are big holders of gold, possessing some 30,500 metric tons in 2010, which is approximately 15% of all above-ground gold stocks. As a result, central bank policies on gold sales and purchases can have significant effects, and these policies have been subject to considerable shifts over the decades.

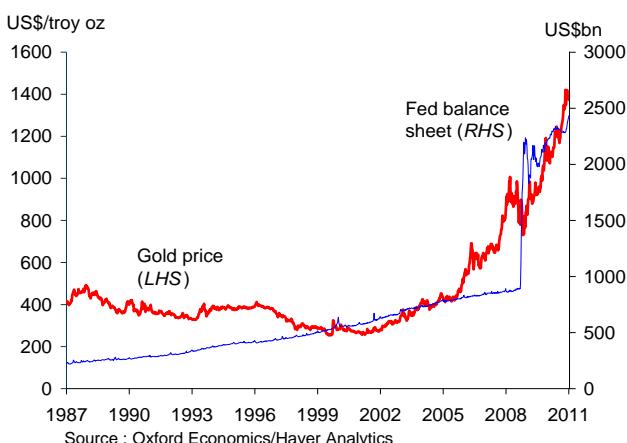
In the 1950s and 1960s, the heyday of the Bretton Woods fixed exchange rate system, central banks were generally significant net buyers of gold which formed a key part of their reserves. After the break-up of Bretton Woods the 1970s and 1980s saw a broadly flat trend in central bank net purchases but this gave way to a period of substantial net sales in the 1990s. During this period, gold fell out of favour among central banks due to a combination of declining price, superior returns on other assets and a generally benign economic and political backdrop.<sup>7</sup>

Official sector sales (including the IMF) from 1989-2009 totalled almost 8,000 tonnes and cut official gold reserves by a fifth while accounting for around 10% of total gold supply. The resultant pushing out of the gold supply curve may have contributed significantly to the bear market in gold that existed for much of this period and the temporary obscuring of gold's normal relation with other economic variables in the 1990s noted above.

**Chart 2.10 – Official sales/purchases of gold**



**Chart 2.11 – Fed balance sheet and gold**



<sup>7</sup> See P.Klapwijk 'The Official Sector: Gold Rehabilitated?', GFMS presentation at London Bullion Market Association Conference September 27 2010

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Things began to change with the first Central Bank Gold Agreement in 1999 which limited future gold sales. By removing the threat to the market of accelerated official sales, these agreements helped boost investor demand for gold, which by the early 2000s was also seen as potentially undervalued (being below its inflation-hedge price). Notably, gold did start to show some positive correlation with financial stress measures again in the early 2000s, for example in the wake of the surge in credit spreads that accompanied the US recession and stock market slump in 2001-2003.

Most recently, central banks have once again become net buyers of gold, buying a net 73 tonnes in 2010 according to GFMS data – the first net purchase since 1988. This would appear to reflect a reassessment of gold's appropriate place in their portfolios in the wake of recent gold price trends, the global financial crisis and perhaps also the future of the dollar as a global reserve currency. It therefore seems likely that official purchases have contributed modestly to gold's recent strong performance.

At the same time as official purchases have boosted gold, other recent central bank activities may have had an even bigger impact. Since 2009 the US Fed, the Bank of England and to a lesser extent the ECB have all expanded their balance sheets significantly through lending to the banking sector and so-called 'quantitative easing'. In the case of the Fed and Bank of England, QE has seen the size of the central bank balance sheet rise by a factor of 2.5-3, an enormous expansion that has taken central bank balance sheets to wartime levels as a share of GDP.

This dramatic policy response to the recession and financial crisis has raised fears in some quarters of rapid future inflation. Although the large balance sheet expansion has yet to feed through into rapid growth in broader money supply measures (considered the key drivers of inflation) there are concerns that this may only reflect the damaged state of the banking system and that broad money measures will soar once banks return to full health. Another concern is that central banks have relatively little experience in running a quantitatively based monetary policy (as opposed to one based on varying the price of money via interest rates) and could make significant policy errors – for example waiting too long to withdraw monetary stimulus as a result of misinterpreting monetary and financial market trends.

As medium-term measures of inflation expectations have risen only modestly since their troughs seen during the global financial crisis, fears of high inflation are apparently not yet widespread. However, the loose monetary policy stance of the US and other major economies has increased the potential tail risk of a high inflation future and this alone may have been enough to spark additional investor demand for gold as 'insurance'. Since 2009, the relationship between gold prices and the size of the US Fed's balance sheets is certainly suggestive in this regard (see chart 2.11).

### 3 Modelling the price of gold

#### 3.1 Estimation of a gold price equation

This section details the results of our efforts to formalise the previous analysis of the determinants of gold prices by estimating an equation to explain both long- and short-run movements in the price of gold.

Despite the importance of gold in central bank reserves and its value to investors as a store of wealth and potential risk-diversifier, there is relatively little academic literature that attempts to estimate price determinants.

The work that has been done (for example, Levine & Wright (2006), Ghosh et. al. (2002) and Capie et. al. (2005)) has highlighted the role of gold as a long run hedge against inflation, short run hedge against exchange rate movements and a risk-diversifier in investment portfolios. In this section we build on these efforts, constructing an equation using a variety of explanatory variables in an attempt to capture more fully the key drivers of the gold price.

Our equation is an error-correction model (ECM) that comprises a long-run element where gold prices move in line with inflation and a short-run element containing the factors noted in section 2 above, which can cause large and persistent swings in the gold price independent of the inflation backdrop. These factors include:

- The current rate of inflation: a rise in the inflation rate may induce movement into 'real' assets like commodities which are seen as inflation hedges
- Inflation volatility: rising inflation volatility increases the uncertainty about future returns on non-inflation proofed assets, and also increases demand for real assets such as gold
- World income: higher income may push up demand for jewellery and industrial uses which can not be fully met by mining output rises in the short run
- The dollar's external value: a US depreciation of the effective dollar exchange rate will tend to push up the US\$ price of gold as described in section 2.4 above
- Real interest rate: higher real interest rates increase the opportunity cost of holding gold and reduce demand, while low or negative real interest rates raise demand for gold
- Gold's Beta<sup>8</sup>: if the return on holding gold is unrelated to the stock market it can act as a diversifier in portfolios. A fall in gold's beta increases the benefit from this and will push the price up
- Financial stress measures: during periods of financial stress investors move out of risky assets into safer holdings. A commonly-used measure of stress is the credit default premium, i.e. the difference in yield between low-rated and highly-rated corporate bonds
- Political risk: in a similar vein to financial stress, increases in political risk are expected to raise the price of gold
- Official sector activity: the recent rapid expansion of the US Fed's balance sheet may have pushed investors towards gold as a hedge against possible policy mistakes leading to high inflation

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<sup>8</sup> Calculated as a moving average of the correlation between movements in the gold price and the Wilshire 5000 index.

## The impact of inflation and deflation on the case for gold

July 2011

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- Central bank gold reserve sales: the sale of gold by central banks in the late 1990s may have artificially depressed the price in this period.

Combining these long and short-run factors we estimated an equation explaining movements in the nominal price of gold over the period 1976-2010.<sup>9</sup> The equation was estimated using quarterly data.

We experimented with a number of specifications incorporating the above factors and some others, but many were found not to add explanatory power and were dropped from the equation. The final equation related gold prices to a series of variables including US CPI inflation, the effective dollar exchange rate, real US interest rates, the default premium (the spread between BBB and AAA-rated corporate bonds) and the US monetary base.<sup>10</sup>

The key features of the equation are as follows:

- The speed of correction of gold prices in response to a shock is comparatively slow. Deviations of the gold price from its long run equilibrium can be significant, long-lasting and take years to fully erode
- In the short run previous momentum in the price of gold (as captured by the two previous quarters' price movements) is a significant factor. If the price of gold rises by 10% in the two previous quarters this will raise the current price by 3.3%, all other things equal
- The effective exchange rate was found to have the strongest contemporaneous statistical relationship with gold, with a rise in the value of the US\$ pushing down the price of gold in US\$. A 10% appreciation of the US\$ reduces the price of gold by 8.4% (this is broadly in line with the elasticity estimated by the IMF noted in section 2.4 above)
- The real interest rate captures the opportunity cost of holding gold relative to other risk free assets which pay a return. As expected, a rise in the real interest rate reduces the price of gold; the equation suggests that a 100 basis point fall in the real interest rate will result in an initial 1.5% rise in the price of gold
- The credit default premium captures the risk environment within the financial system. As a result this term is relatively unimportant in normal times (as the risk premium does not move very much) but in times of crisis it is a significant driver of the price of gold. A 100 basis point rise in the premium will increase the price of gold by 4.4% in the following quarter
- As with the credit default premium, the US monetary base is a relatively unimportant determinant of movements under normal economic conditions but in more recent times it has been a significant driver of the gold price.<sup>11</sup> A 10% point increase in the growth rate of the monetary base results in a 1.4% rise in the price of gold in the current period.

All the above variables had the expected sign and most were significant at the 10% level or better. In addition to these variables we also found it necessary to include dummy variables for the last quarter of 1979 and the first two quarters of 1980 to improve the fit of the equation. These dummies aim to capture the major political disturbances of the period which were not fully picked up by other variables such as the default

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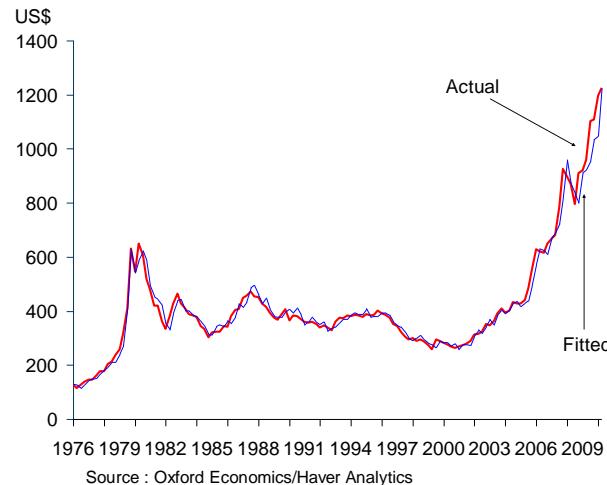
<sup>9</sup> Given the government interference and turbulence in the gold market in the early 1970s, we felt that 1976 was the earliest year possible to begin the regressions.

<sup>10</sup> Full details of the equation can be found in the appendix.

<sup>11</sup> As argued earlier this variable may capture the increased 'tail risk' of high inflation as a result of quantitative easing.

premium.<sup>12</sup> The equation also passed the standard robustness tests, and the estimated price tracked the actual price relatively well over time.

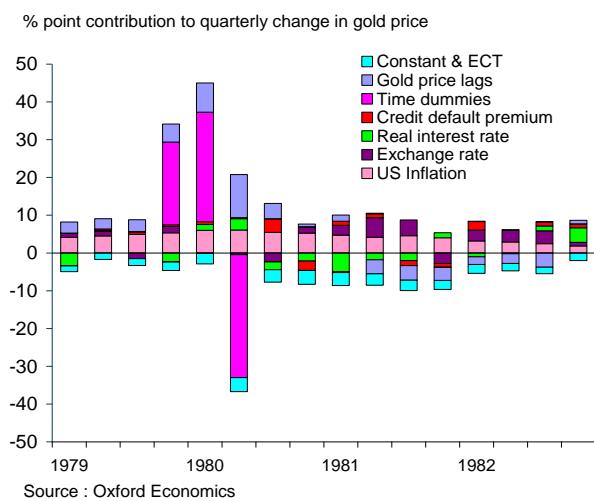
**Chart 3.1: Actual and fitted values from equation**



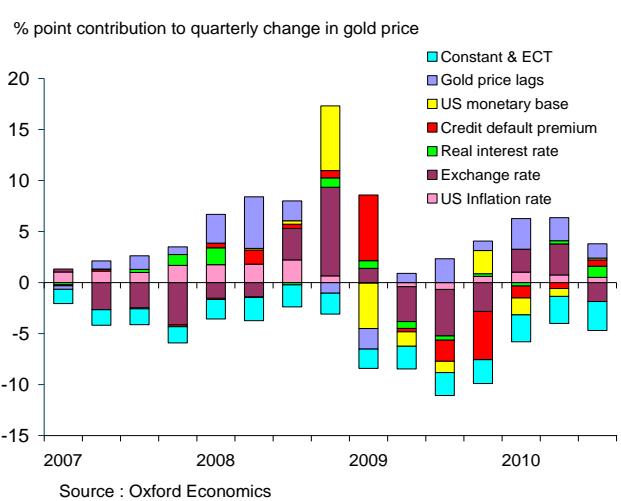
### 3.2 Decomposing two key historical periods

Using our estimated equation it is possible to examine which factors were the main influences on the gold price over time. Decomposing the change in the gold price during the 1979-1982 period, which saw the real gold price spike to an all-time high, shows that the key factors pushing up the price were political risk (as represented by our time dummies), inflation, changes in real interest rates, a weaker US dollar and financial stress. This fits in with the historical analysis we conducted in section 2 above.

**Chart 3.2: Decomposition of gold price 1979-82<sup>13</sup>**



**Chart 3.3: Decomposition 2007-2010**



<sup>12</sup> A similar approach was taken by Levin & Wright (2006) but their use of time dummies was somewhat more extensive; our equation appears to have reduced the necessity for the use of dummies by better capturing underlying economic & financial drivers.

<sup>13</sup> In chart 3.2 and 3.3 the dummy represents dummy variables for the quarters 1979Q4 – 1980Q2, while ECT refers to the error correction term (see appendix for more details).

We can also use the equation to decompose gold price movements in the most recent period (2007-10). Doing this confirms that the recent strong rise in gold prices has been the result of a complex of short-run shock factors:

- The depreciation of effective dollar exchange rate
- The recent financial crisis, which raised financial stress levels
- Most recently the Federal Reserve's quantitative easing policy, which has raised fears over medium term inflation.

Individual factors have had large estimated effects during particular periods. The period of extreme financial stress in late 2008 triggered a rise in the default premium contributing strongly to the rise in gold prices. The 150 basis point rise in the credit default premium in late 2008 can explain 6.4% points of the 13.1% rise in the price of gold in 2009 Q1 alone. Meanwhile, swings in the dollar explained a large share of the gold price rise in 2008 Q4 and 2010 Q1-Q2, and much of the decline in 2009 Q2-Q3.

### 3.3 The drivers of the price of gold going forward

Most research into gold price determinants to date has focused on the US, reflecting its economic and financial weight and the dollar's role as the main reserve currency for the global economy. But looking forward to the next few decades, the relative position of the US is likely to change as the geographical base for economic power shifts toward fast growing emerging economies, especially in Asia.

To account for this shift we attempted to estimate a long run relationship between the price of gold and the global price level (as measured by the IMF) and a demand index for gold constructed using a weighted average of GDP growth rates for the 20 largest consumers of the metal. Unfortunately, data limitations (in particular for the 1970s and 1980s) coupled with the fact this shift has only emerged in the last decade or so resulted in none of the estimates being meaningful.

Although it is not currently possible to quantitatively assess the impact of this shift of economic and financial power on the market for gold, it is arguable that it might alter the structure of the market and generate a new long run equilibrium for the metal's price. Asian markets (such as China and India) are traditionally strong sources of demand for gold, both for jewellery and as a store of wealth, and increasing income and wealth levels have resulted in demand for gold rising rapidly. A potential result of this increasing demand is that the gold price consistently rises faster than the rate of US inflation, generating a positive rate of return on gold holdings. Coupled with this, these countries generally have higher levels of inflation than seen in developed countries, and the need to protect the real value of wealth against this may increase demand further.

As well as rapidly growing demand, the increasing cost of mining may have a significant impact on the market going forward. With the assumption that all easy sources of gold are exhausted, rising production costs are likely to limit supply if prices fall back too far from their current high levels. Given the competitive nature of the market these supply constraints can be expected to feed into the price and may result in the value of gold rising, in real terms, over time.

## 4 Alternative inflation scenarios

### 4.1 Introduction

In this section, we use the estimated equation from section 3 as a basis for examining the possible behaviour of gold in a variety of scenarios featuring different outcomes for global inflation, economic growth and financial conditions. These scenarios were run using the Oxford Global Macroeconomic Model, which contains both foreign trade linkages between countries and a detailed financial sector. By varying the economic and financial assumptions embedded in the model we are able to generate a set of results showing the performance of gold and of competing assets such as equities and bonds.<sup>14</sup>

The different scenarios we investigate are as follows:

- The Oxford Economics baseline scenario featuring a steady economic recovery, moderate inflation and gradual normalisation of financial conditions
- A deflation scenario featuring a massive financial shock leading to renewed recession and falling consumer prices
- A stagflation scenario featuring higher inflation and interest rates but weaker growth than in the baseline
- A high inflation scenario featuring a wage-price spiral and lax monetary policy pushing inflation to double digits and ultimately leading to a sharp monetary tightening and recession.

The full results of these scenarios are presented in the following sections:

**Table 4.1: Summary table of results**

<b>Performance score in different scenarios 2011-2015</b>				
	Baseline	Deflation	Stagflation	Inflation
Gold	1	3	2	5
Equities	5	2	3	4
Bonds	2	4	1	1
Cash	4	5	5	3
House prices	3	1	4	2

Note: Scaling has 5=best performance; 1=worst performance, as shown in the relative performance charts in each scenario

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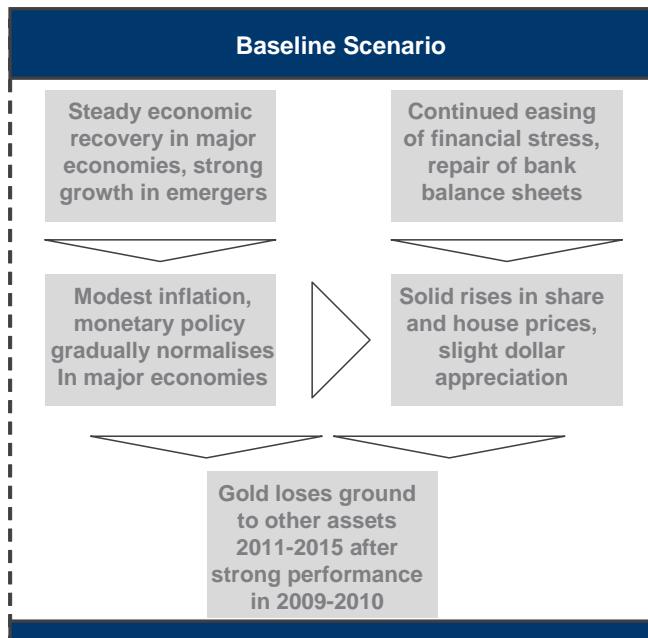
<sup>14</sup> In this study we use the Wilshire 5000 index for US equities and 10-year US treasury bonds for US bonds.

## 4.2 Baseline scenario

- **Steady economic recovery in major economies supported by strong emerging market growth**
- **Easing of financial stress and repair of banking systems**
- **Modest inflation, gradual normalisation of monetary policy, slight dollar appreciation**
- **Gold underperforms other assets**

This is our central and most likely scenario, in which the global economic recovery proceeds relatively smoothly over the 2011-2015 period. The global recovery is powered mostly by emerging market countries, with emerging Asia expanding 7-8% per annum to 2015, and in the second half of the forecast period by a resurgent US which attains trend growth in 2012 after a weak initial upswing. World growth runs at around 4% per annum, comparable to pre-crisis levels.

Inflation remains relatively moderate in the major economies at 2-2.5% per annum, due to the overhang of spare capacity which is only gradually whittled away by economic growth. This allows the authorities to move gradually in normalising monetary policy – the US Federal Reserve raises rates to 3% by mid-2013 and 4.5% by 2015 but the Funds rate remains below 2007 levels at the end of the forecast period; the dollar strengthens gradually as US growth and interest rates rise.



The key assumptions underlying this scenario include a continued easing of financial stress levels, with interest rate spreads normalising (albeit remaining slightly higher than the compressed pre-crisis levels) and banking sectors cleaning up their balance sheets and returning to health. It is also assumed that policy moves are well calibrated in order to head off inflation pressures and support growth, both in the major and emerging market economies.

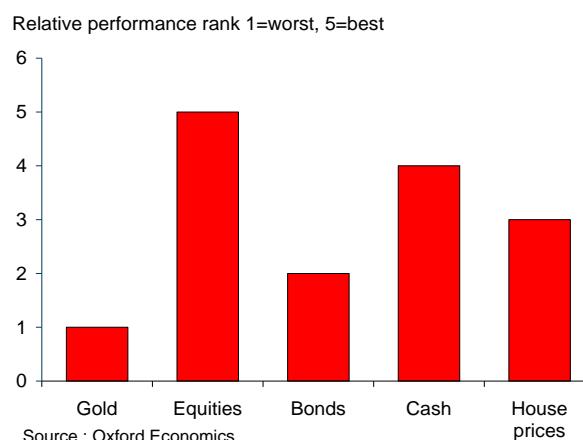
**Table 4.2 – Main economic indicators, baseline scenario**

<b>Baseline</b>						
	2010	2011	2012	2013	2014	2015
<b>GDP % annual</b>						
US	2.9	3.3	3.5	3.6	3.5	3.3
Eurozone	1.7	1.5	1.7	2.0	2.0	2.0
UK	1.6	2.0	2.6	3.0	3.0	2.8
China	10.3	9.8	9.0	8.8	8.7	8.6
Japan	4.2	1.1	2.1	2.0	1.8	1.4
World	3.8	3.5	3.9	4.0	3.9	3.8
<b>CPI % annual</b>						
US	1.6	2.0	1.6	2.9	2.6	2.3
Eurozone	1.5	1.8	1.7	1.8	1.8	1.8
UK	3.3	3.7	1.8	1.8	1.9	2.0
China	3.3	4.7	3.1	3.0	3.0	3.0
Japan	-0.8	0.1	0.5	0.6	0.6	0.6
World	3.4	3.0	2.1	2.2	2.0	2.0

In terms of the outcomes for asset performance, a relatively benign macroeconomic and financial environment sees the impact of a number of the factors that boosted gold prices in 2007-2010 fade, including negative real rates, wide credit spreads and the rapid expansion of the monetary base. The strengthening dollar also exercises a mild downward pull on gold prices.

As a result of these factors, gold underperforms other asset classes in this scenario from 2011-2015, with the best performing assets being equities and then cash. House prices are expected to recover only slowly while bonds perform relatively weakly due to the normalisation of short-term interest rates.

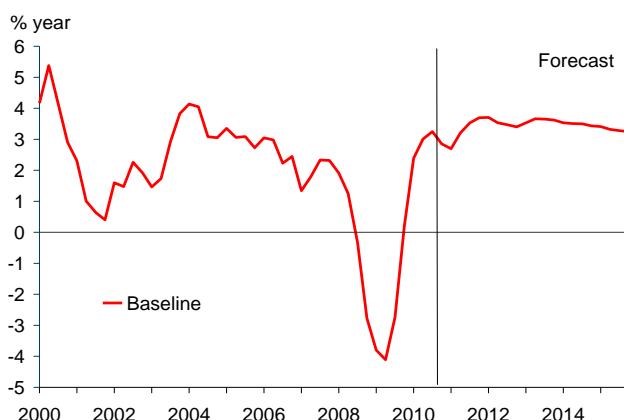
**Chart 4.1 – Relative performance of gold versus other assets, baseline scenario**



Note: All asset prices are for US

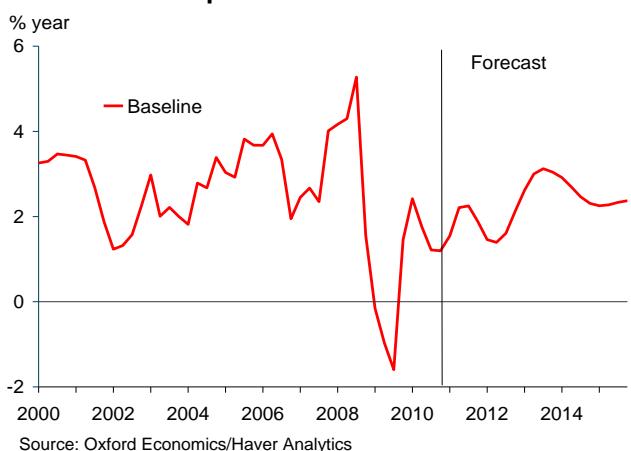
**Background charts – baseline scenario**

**US: GDP**



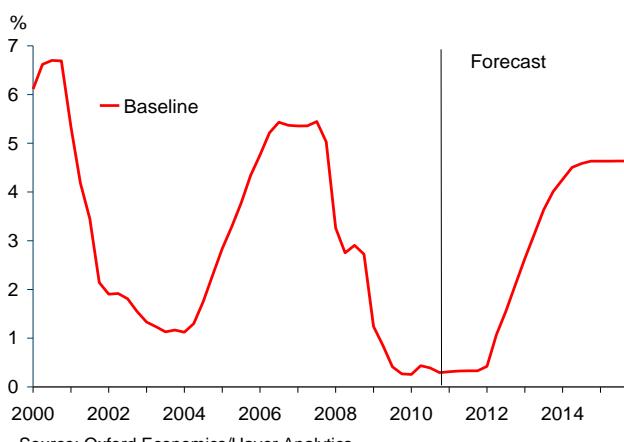
Source: Oxford Economics/Haver Analytics

**US: Consumer price index**



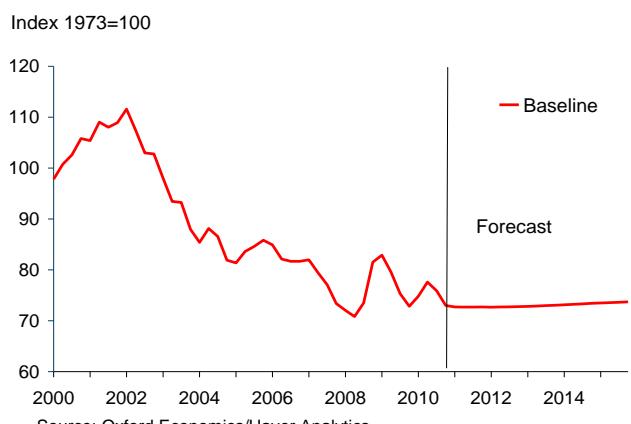
Source: Oxford Economics/Haver Analytics

**US: Short-term interest rate**



Source: Oxford Economics/Haver Analytics

**US: Exchange rate**



Source: Oxford Economics/Haver Analytics

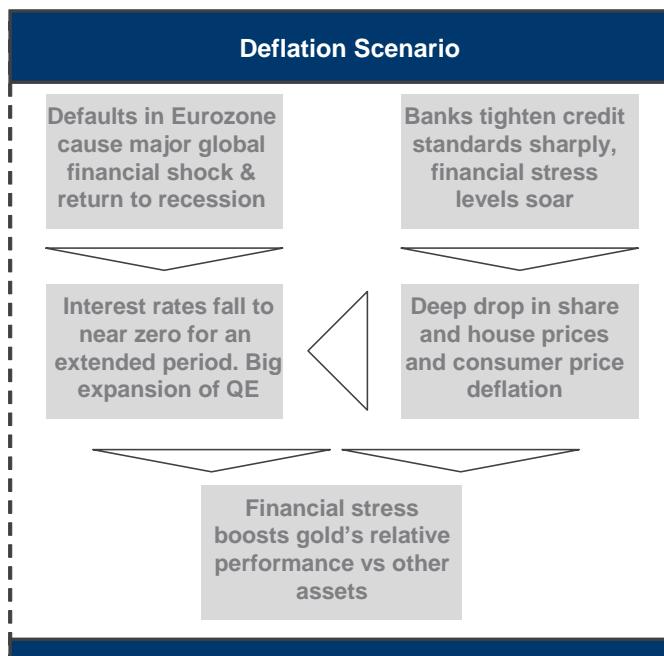
#### 4.3 Deflation

- Major global financial shock caused by eurozone debt defaults, surge in financial stress levels
- Return to recession in major economies, sharp growth slowdown in emerging countries
- Price deflation in many countries, steep asset price falls, interest rates near zero for long period
- Gold performance helped by sharp initial rise in financial stress

This scenario features a major global financial shock that plunges much of the world into a deflationary period. This deflation scenario is best characterised as a generalised version of the syndrome experienced by Japan in the 1990s, being less severe than the global depression of the 1930s and quite different in character from the supply-side deflation of the nineteenth century Great Moderation.

We assume a wave of sovereign defaults in the 'peripheral' eurozone countries, which creates major losses for creditors including banks and steep falls in asset prices. Although centred in the eurozone, interlinkages in the global financial sector and the relatively high weight of the eurozone in the world economy mean the financial disturbance is transmitted worldwide. Global stock prices initially fall by around 20% and there is initial upward pressure on interest rates as counter-party risk pushes up interbank rates and lending spreads soar. Banks also tighten credit criteria sharply. The overall scale of the shock is similar to that seen in the wake of the Lehman Brothers failure in late 2008.

Further negative impacts come from an initial loss of trust in sovereign governments, which pushes up government bond yields, and by emergency fiscal tightening of 1-1.5% of GDP in the major economies aimed at avoiding the risk of being dragged into the defaulting camp. There are also massive outflows of capital from emerging markets as risk aversion soars.



The huge financial shock is transmitted to the real economy through much weaker consumption and investment and results in the major economies slumping back into recession in 2011 and 2012, with growth remaining subdued even in 2015. The major emergers suffer too, with Chinese growth dropping below 6% by

2012 – the lowest rate since 1990. As a result, world growth averages a miserable 1% per annum from 2011-2013 and remains below the 4% rate seen on average in the baseline even in 2015.

Meanwhile, inflation in the major economies turns negative in 2012 and 2013 as a large volume of spare capacity builds up, with the price level only stabilising in 2015 in the US and continuing to fall in the eurozone and Japan even then. China also suffers price falls due to large-scale spare capacity.

In response, policy interest rates are cut to close to zero in the major economies and remain there for most of the forecast period; bond yields also fall sharply – to less than 2% in the 10-year sector in the US. The US engages in major additional QE worth US\$1.5 trillion. This contributes to significant exchange rate swings – initially the euro weakens sharply but expansionary US monetary policy reverses this later in the forecast period and the trade-weighted dollar ends 2015 weaker than in the baseline.

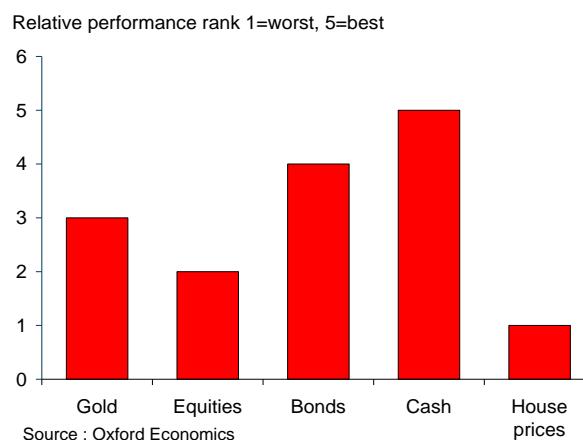
**Table 4.3 – Main economic indicators, Deflation scenario**

<b>Deflation</b>						
	2010	2011	2012	2013	2014	2015
<b>GDP % annual</b>						
US	2.8	0.7	-1.3	-1.0	0.9	2.0
Eurozone	1.7	-1.4	-1.6	-0.9	0.4	2.0
UK	1.6	-0.3	-2.6	-0.9	0.9	2.4
China	10.3	7.1	5.7	6.7	6.7	9.2
Japan	4.1	-1.5	-1.7	-1.2	0.1	1.4
World	3.8	1.3	0.6	1.3	2.4	3.7
<b>CPI % annual</b>						
US	1.6	1.5	-0.6	-1.5	-1.2	0.9
Eurozone	1.5	2.3	0.0	-3.2	-3.3	-1.5
UK	3.3	3.6	0.0	-0.5	-0.5	0.0
China	3.3	3.8	-1.1	-3.3	-2.2	-0.7
Japan	-0.8	-0.9	-2.7	-3.5	-3.1	-0.7
World	3.4	3.0	-0.1	-1.5	-1.7	-0.3

In this scenario the performance of gold receives a major initial boost due to the sharp rise in financial stress. This, plus greater monetary loosening, swamps the effects of a stronger dollar and the shift of real interest rates into positive territory due to deflation and the initial upward pressure on bond yields resulting from a reduction in government creditworthiness. Meanwhile, riskier assets perform poorly, especially property and share prices, while cash and bonds post modest positive returns.

Gold is the number one performing asset until 2013 – despite a deflationary backdrop – and its performance over the whole 2011-2015 period compared to other asset classes is much better than in the baseline scenario. Cash, as might be expected, eventually turns out as the winner in this deflationary story with bonds also performing relatively well.

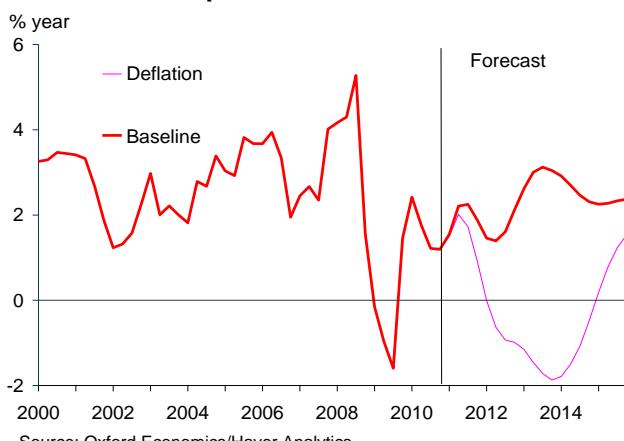
Chart 4.2 – Relative performance of gold versus other assets, deflation scenario



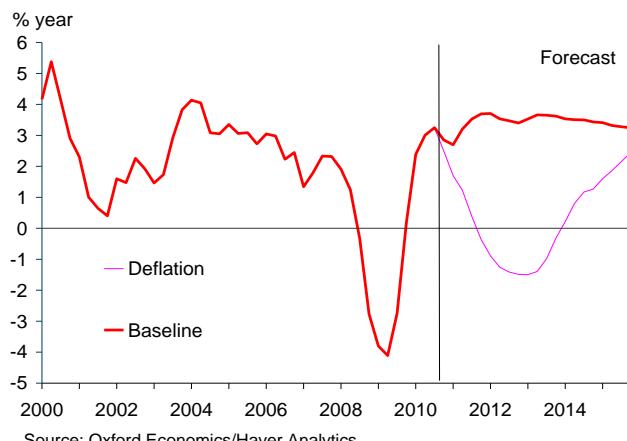
Note: All asset prices are for US

### Background charts – deflation scenario

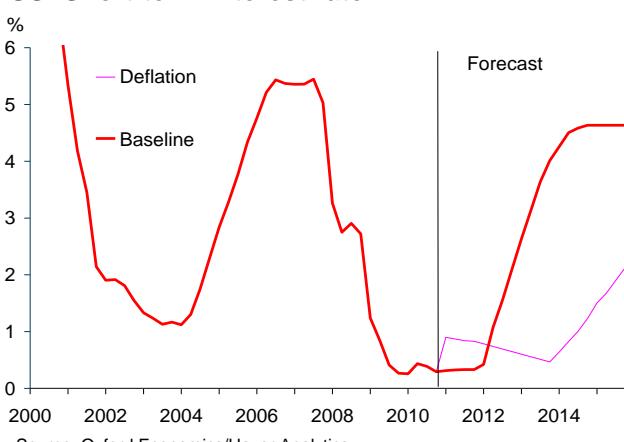
US: Consumer price index



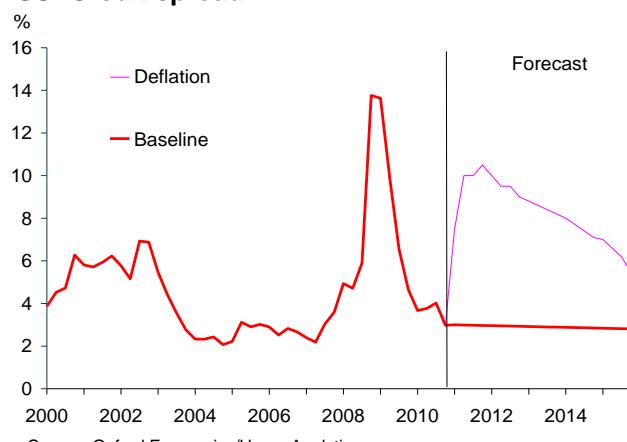
US: GDP



US: Short-term interest rate



US: Credit spread

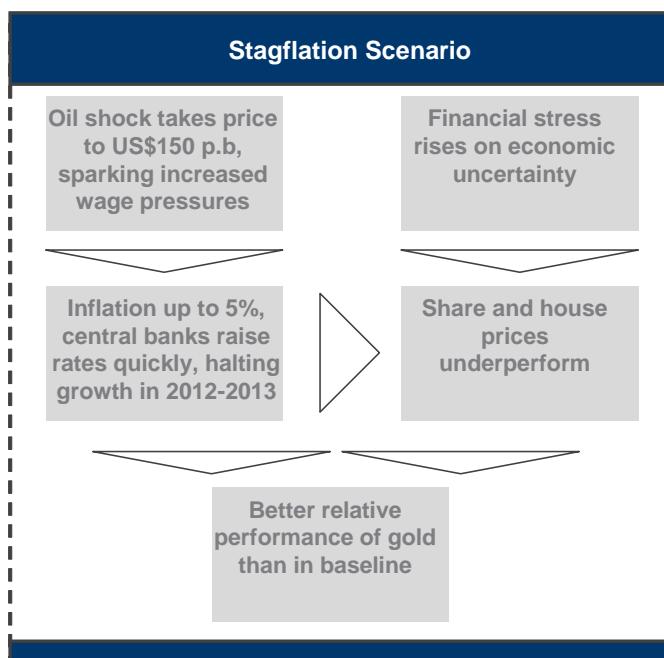


#### 4.4 Stagflation

- Oil price spike to US\$150 per barrel sparks increased wage pressures
- Inflation rises to 5% and sticks there, central banks react with higher interest rates
- Growth grinds to a halt, financial stress rises
- Gold performs better on a relative basis than in the baseline scenario

This scenario examines the consequences of the world moving into a stagflationary phase sparked off by a sharp rise in oil prices to US\$150 per barrel, rescaling the heights seen in 2008. This rapidly feeds into headline inflation and triggers a round of wage inflation as squeezed workers seek to restore their purchasing power, which they are broadly able to do due to loose monetary policy and the recovery in corporate profitability seen in late 2009 and 2010.

Inflation becomes entrenched at around 5% and central banks respond with a sharp tightening of monetary policy designed to break inflationary expectations – US short-term rates rise toward 7% in 2013. But this monetary tightening brings the economic recovery in the major economies to a halt in 2012-2013 with US GDP stagnating and a mild recession in the eurozone. Emerging market growth also slows notably as export demand wanes and capital inflows fall back. As a result, world growth is very sluggish in 2012-2013 averaging below 2% per annum. From 2014, growth picks up again as inflation pressures ease and global central banks are once again able to loosen monetary policy.



The abrupt slowing of the world economy in 2012-2013 leads to a renewed bout of risk aversion on the part of investors and a rise in financial stress as bad loans at banks increase once more, damaging balance sheets and leading to a tightening of credit standards. This helps to boost the performance of gold but higher real interest rates act as a significant drag on its performance.

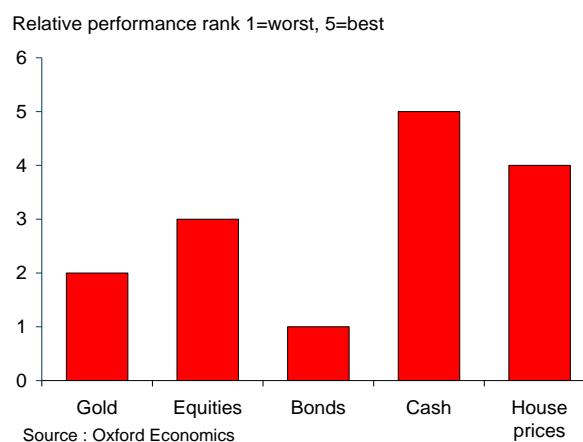
Overall, gold's relative performance from 2011-2015 is better in this scenario than in the baseline, while lagging that in the deflation scenario. The big loser from 2011-2015 is bonds, while cash performs relatively

well due to the adoption by central banks of a policy of high interest rates to combat inflation. This policy also bears down on equity prices which perform notably worse on a relative basis than in the baseline scenario.

**Table 4.4 – Main economic indicators, Stagflation scenario**

<b>Stagflation</b>						
	2010	2011	2012	2013	2014	2015
<b>GDP % annual</b>						
US	2.9	2.2	0.2	0.7	2.1	3.1
Eurozone	1.7	0.0	-0.7	1.0	1.7	2.0
UK	1.6	1.7	0.7	0.2	0.8	3.8
China	10.3	8.6	6.1	6.5	10.5	11.5
Japan	4.2	0.4	-0.4	-1.2	-1.0	-0.1
World	3.8	2.5	1.4	2.2	3.6	4.4
<b>CPI % annual</b>						
US	1.6	3.7	4.4	5.3	4.5	3.4
Eurozone	1.5	3.4	5.1	4.4	4.4	4.9
UK	3.3	6.3	4.9	4.9	5.7	4.2
China	3.3	6.2	6.9	1.9	1.6	2.2
Japan	-0.8	2.1	4.1	3.7	3.4	2.5
World	3.4	5.0	5.5	5.1	4.3	3.6

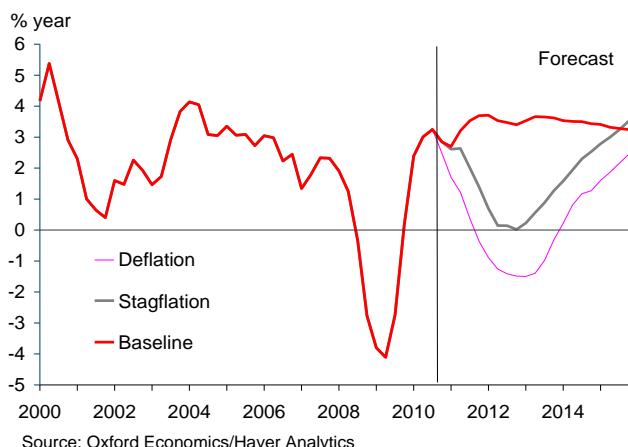
**Chart 4.3 – Relative performance of gold versus other assets, stagflation scenario**



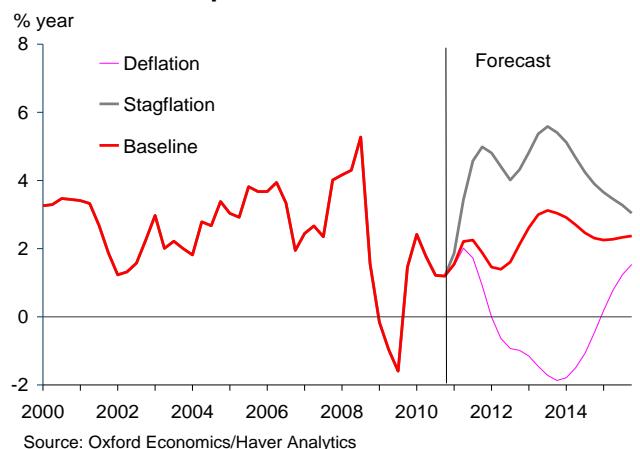
Note: All asset prices are for US

**Background charts – stagflation scenario**

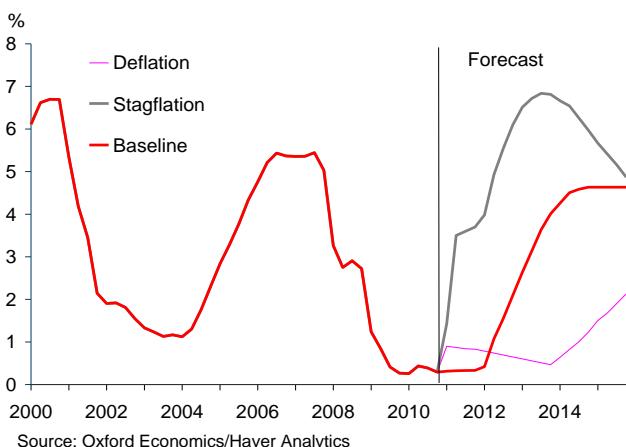
**US: GDP**



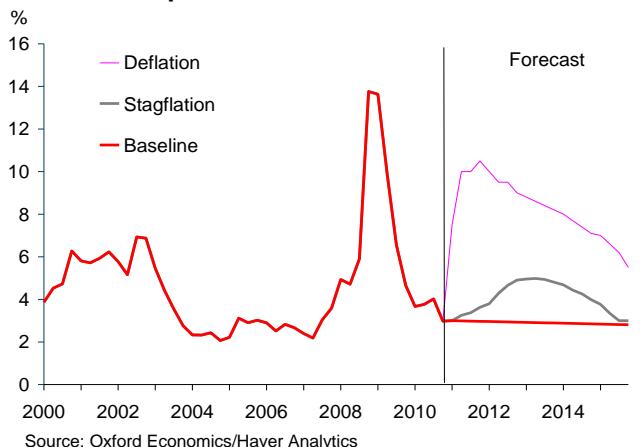
**US: Consumer price index**



**US: Short-term interest rate**



**US: Credit spread**

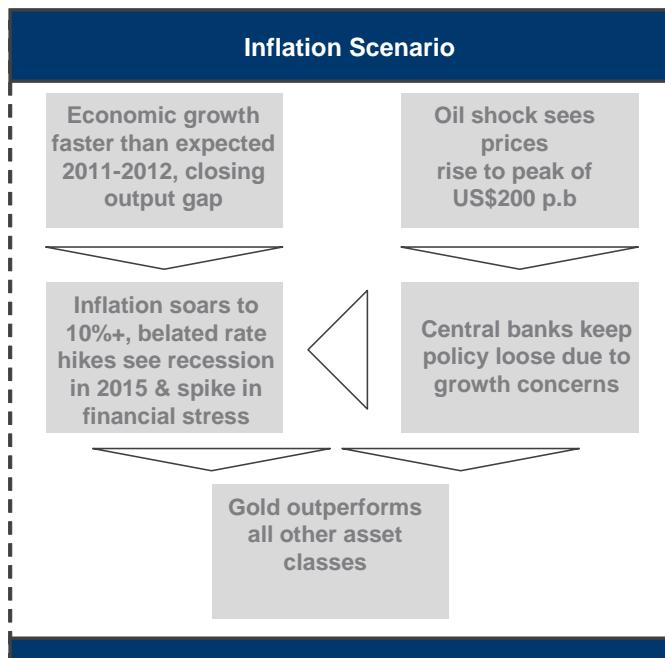


#### 4.5 High inflation

- **Faster than expected initial growth closes output gaps**
- **Oil soars to US\$200 per barrel, creating wage-price spiral as central banks are slow to respond**
- **Double-digit inflation sees belated rate hikes causing recession and a spike in financial stress**
- **Gold outperforms other financial assets in this scenario**

The final variant scenario we explore is one of high inflation based loosely upon the experience of the first half of the 1970s. This features an interaction between strong growth, an oil shock and lax monetary policy, which pushes inflation into double digits toward the end of the forecast period.

Economic growth at the beginning of the scenario is considerably stronger than in the baseline, as previous policy stimulus feeds through more quickly and consumer and business confidence recovers rapidly. This rapidly narrows the margin of spare capacity in the global economy, setting the scene for rising inflation. In addition, we assume that oil prices spike to US\$200 per barrel (the result of both supply and demand factors). This increases headline inflation sharply but central banks are slow to react, concerned that the rise in oil prices could lead to the economic recovery stalling. Against this background a wage-price spiral develops, pushing inflation toward double-digits in the US, UK & eurozone toward the end of the forecast period.



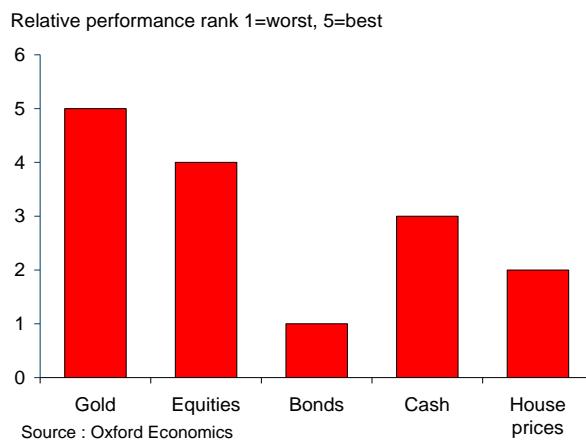
In the face of rampant inflation, the global monetary authorities finally act by introducing a steep interest rate rise but their earlier delay raises the output costs of fighting inflation. The major economies are tipped into recession in 2014-2015 and financial stress levels soar as a result. The dollar also loses substantial ground in this scenario, due to high US inflation, relatively loose US monetary policy, and a faster pace of appreciation by China and other emerging countries, which try to avoid importing US inflation. The trade-weighted dollar is around 15% weaker in 2015 than in the baseline.

Table 4.5 – Main economic indicators, High inflation scenario

High Inflation						
	2010	2011	2012	2013	2014	2015
<b>GDP % annual</b>						
US	2.9	4.6	7.1	4.2	0.8	-0.4
Eurozone	1.7	2.3	3.4	2.5	1.1	0.8
UK	1.6	4.0	6.4	5.6	2.0	-1.0
China	10.3	11.3	11.5	8.7	5.3	5.0
Japan	4.2	2.2	4.5	3.0	0.6	-0.6
World	3.8	4.4	6.0	4.7	2.5	1.3
<b>CPI % annual</b>						
US	1.6	4.1	6.6	9.9	12.1	10.5
Eurozone	1.5	3.1	5.4	8.0	9.2	8.8
UK	3.3	6.5	6.1	9.1	9.8	7.4
China	3.3	6.6	10.3	7.7	6.5	6.7
Japan	-0.8	1.1	3.4	4.1	6.1	6.7
World	3.4	5.1	6.7	7.5	8.4	7.9

This combination of factors is relatively positive for gold. The performance of gold is boosted by high US inflation throughout the forecast period, coupled with a weaker dollar and often-negative real interest rates. As the global economy careers toward recession later in the forecast period, gold also receives a big boost from a steep rise in financial stress – this rise is comparable in scale to that seen during the recent global financial crisis.

Chart 4.4 – Relative performance of gold versus other assets, high inflation scenario

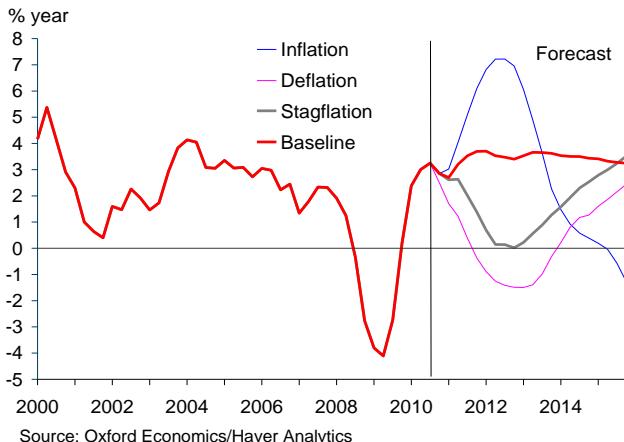


Note: All asset prices are for US

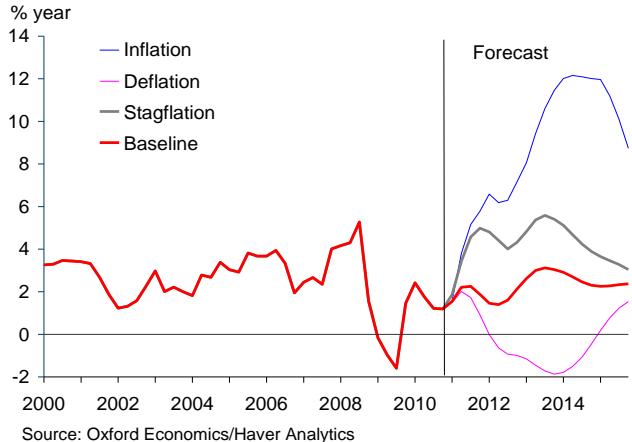
Gold outperforms all other asset classes in 2011-2015. Although house and share prices receive some initial support from the higher inflation environment, their performance stalls at the end of the scenario as recession ensues. Cash performs relatively poorly due to lax monetary policy and bonds perform badly, initially due to high inflation steepening the yield curve and subsequently to the delayed monetary tightening. Equities perform better than all other assets except gold.

Background charts – High inflation scenario

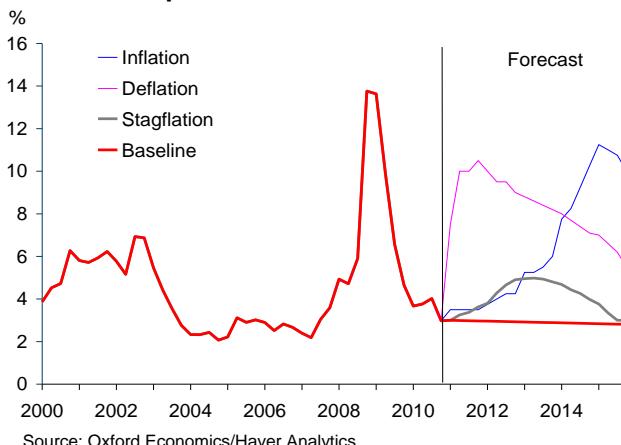
**US: GDP**



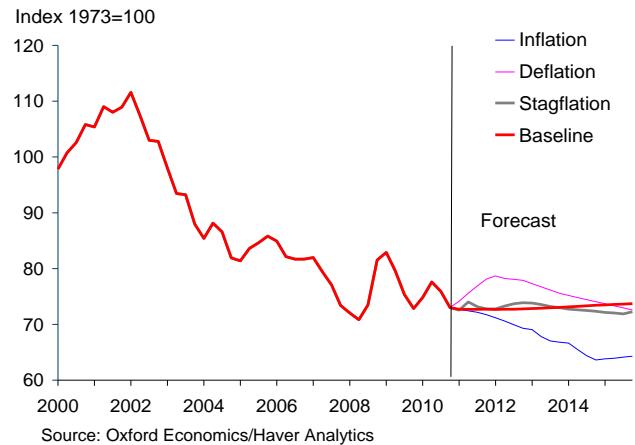
**US: Consumer price index**



**US: Credit spread**



**US: Exchange rate, alternate scenarios**



## 5 Gold in an efficient investment portfolio

- Lack of correlation with other assets gives gold a useful role in stabilising the value of a portfolio
- Simple optimisation framework suggests gold's optimum share of a long-term portfolio is around 5% for UK investor in baseline economic case
- Gold's optimal share rises in a more inflationary case and equally rises for low risk investors in a lower growth and lower inflation scenario

### 5.1 Introduction

Section 4 examined the performance of gold over a relatively short time frame, in response to major divergences from our baseline economic scenario. This analysis confirmed gold's value as a hedge against macroeconomic and financial shocks such as a rapid rise in inflation and sharp increases in financial market stress. In this section, we seek to examine gold's properties as an asset over a longer time period and in the context of an efficient investment portfolio containing a set of other financial assets. As in section 4, we do this both for a base case and for some variant scenarios. The variant scenarios, as in section 4, are designed to capture the effects of divergent inflation outcomes. Both a more inflationary long-term scenario and a long-term scenario featuring lower inflation and lower growth are examined.

The role of gold in an efficient investment portfolio is examined using optimisation techniques and based on the outlook of a sterling-based investor choosing between gold, cash, gilts, equities and property (other commodities and assets such as foreign equities, index-linked bonds and 'alternative' assets are not included in this analysis).

Investment strategy has to take account of factors other than the expected return on alternative assets. The optimal mix of assets in a multi-asset portfolio depends on the aim of the investor, the nature and duration of their liabilities, and the degree of risk the investor is prepared to take. Modern Portfolio Theory suggests that by looking at the asset mix we can propose combinations of assets (cash, gilts, property, equities and gold in this case) that might be 'efficient' in the sense of having the least volatility, for a given return, or the maximum return for a given exposure to volatility (Markowitz, 1952, 1959).

Using estimated returns (real returns are used here), defining volatility as the (standard) deviation of the expected returns and assuming that future real volatility will not be dissimilar to that experienced in the past, we can estimate the risk-return trade-off between alternative assets. We can be more forward looking with returns, depending on the economic outlook, and we can vary these assumptions (and those for volatility) depending on the economic scenario selected. These assumptions can critically change the outcomes for a portfolio mix which depends on the cross-correlation between asset classes and risk. However, the emphasis is not on the precise outcomes in terms of portfolio mix (that is a matter for further study and a substantial project all of its own) but rather the focus is on the impact of different economic environments on allocation strategy.

Using the expected returns, volatilities and cross correlations of the different assets, we can construct an efficient frontier, representing portfolios for which the expected return is maximised for a given level of risk. Asset allocations will vary with the level of acceptable risk. Lower risk<sup>15</sup> portfolios place more emphasis on

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<sup>15</sup> In the analysis that follows we define the riskiness of portfolios based on the standard deviation of returns

reducing the riskiness of the overall portfolio and are attracted towards assets whose returns are less volatile. In particular, they will move towards assets whose returns are negatively correlated with other assets as investors are attracted by the benefits of diversification. Higher risk portfolios place more emphasis on boosting returns and are more attracted by high absolute returns than the benefits of diversification.

This study goes a step further than specifying a base case by looking at the implications of different economic scenarios on both expected returns and future volatility. This means that different GDP growth/inflation combinations change the shape of the efficient frontier, and varying scenarios can show significant differences in the optimal asset allocations for a given level of acceptable risk.

## 5.2 Optimisation results

We now turn to the optimisation results. These use UK data on real returns and volatility for different assets going back to 1971 (this allowed us to make use of lengthy available data series on real returns for different asset classes in the UK). Returns on assets in the variant scenarios come from using coefficients derived from historical correlations between asset returns and inflation and GDP growth. The assets covered are cash, UK equities, UK gilts, UK commercial property and gold.

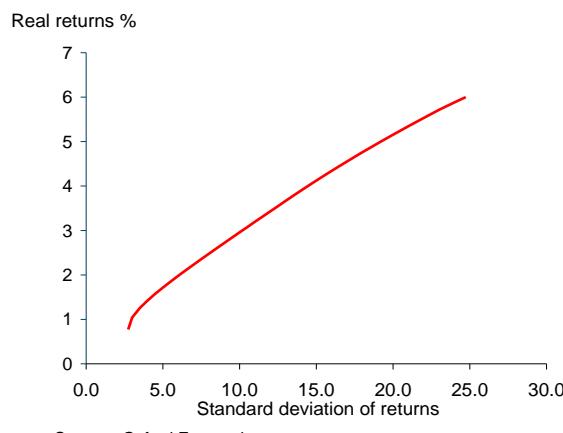
We considered a base case where long run (CPI) inflation runs at 2% per annum and real GDP growth at 2.25% per annum. Based on the assumed average future real asset returns and volatilities specified in table 5.1 below, our optimisation process creates the efficient frontier shown in chart 5.1, where real returns are traded off against the investor's risk tolerance as represented by the standard deviation of the real returns.

Essentially, the frontier shows either the minimum level of risk an investor needs to accept in targeting a given return or the maximum level of return that can be expected for a given level of risk tolerance.

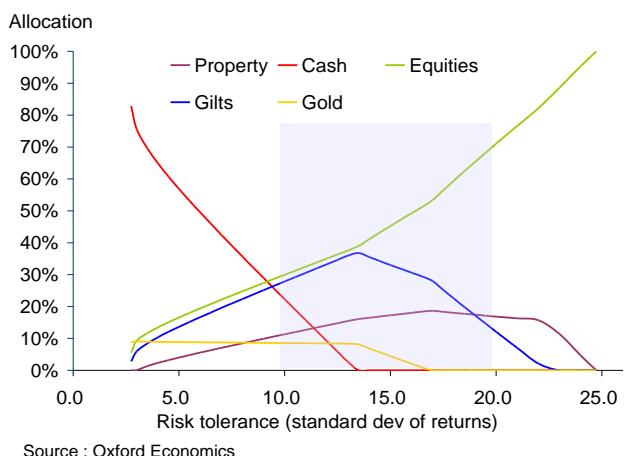
The optimal allocation of an investor's funds to different asset classes will vary as risk tolerance changes. Investors with higher risk tolerance will tend to allocate more funds to riskier assets like equities, while low risk investors allocate more to 'safe' assets such as cash and bonds. In our view, most mainstream investors would tend to cluster around an area where the standard deviation of real returns is from 10-20, i.e. broadly the centre of the risk tolerance spectrum.

In our base case the average optimum portfolio share for equities across this 'mainstream' risk tolerance range is around 45%; for bonds around 30%, for property around 15% and for cash around 5%. These shares vary somewhat from one end of the risk tolerance range to another, e.g. cash is rapidly discarded for other higher yielding assets as risk tolerance rises.

**Chart 5.1 – Efficient frontier in base case**



**Chart 5.2 – Allocations in base case**



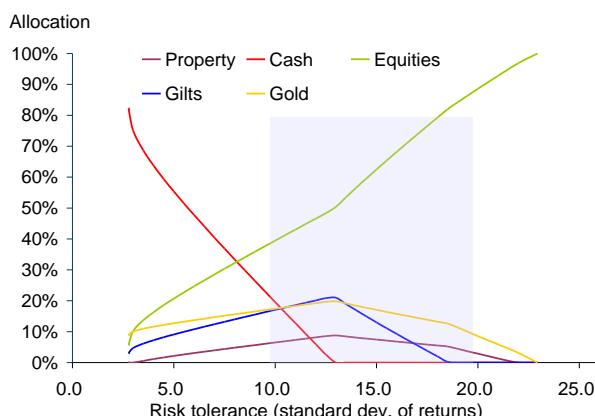
Note: shaded area represents the estimated area occupied by most mainstream investors

For gold, the average optimum allocation is around 5%. Gold benefits in this analysis from the fact that it has a zero or negative correlation with other assets so its inclusion in the portfolio reduces the overall volatility (see table 5.4). In addition, the fact that this analysis is carried out in real terms is positive for gold. As gold is correlated with inflation it shows relatively lower volatility than other assets, which do not move in time with inflation, compared to an analysis undertaken in nominal terms.

Gold's estimated optimum allocation is relatively high compared to what might be found in a typical mainstream investment portfolio, especially as we conservatively assume a slightly negative real annual return for gold (-0.2% per annum). This partly reflects the limitations of our modelling framework, which does not include all possible assets. The space occupied by gold in our framework might in reality also be occupied to some extent by index-linked bonds, for example, which also show a low correlation with mainstream assets<sup>16</sup> as well as offering protection against inflation. Index-linked bonds currently account for around 12% of pension fund assets.<sup>17</sup>

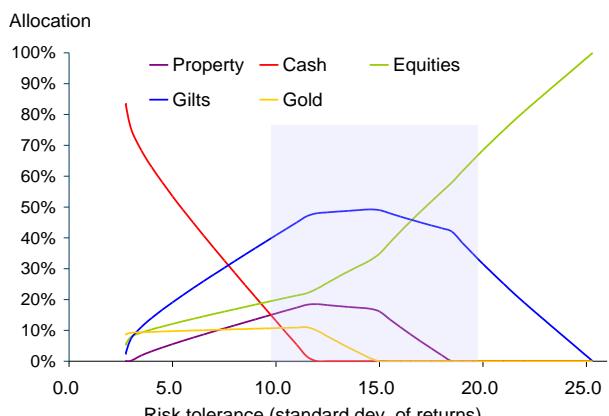
Other 'alternative' assets such as hedge funds, private equity, other commodities and foreign stocks might also partly occupy this space, especially to the extent that they also offer portfolio diversification benefits. However, it is notable that a recent asset allocation survey of institutional investors found the share allocated to 'alternative' assets (excluding property) to be around 20% and within this the share for commodities and other 'real' assets accounted for 5% of total portfolios.<sup>18</sup>

**Chart 5.3 – Allocations in higher inflation case**



Source : Oxford Economics

**Chart 5.4 – Allocations in lower inflation and lower growth case**



Source : Oxford Economics

Note: shaded areas represent the estimated area occupied by most mainstream investors

Varying our long-term assumptions on macroeconomic outcomes and real asset returns produces significantly different optimum allocations for different assets. In a more inflationary scenario where long-term annual inflation runs at 3% and growth is slightly weaker at 2% per annum (a scenario that might be seen as an extension of the inflation scenario specified in section 4. above) the average optimal allocation

<sup>16</sup> See for example E. Dimson & P. Marsh 'UK Financial market Returns 1955-2000' Journal of Business Vol.74 2001, S. Kothari & J. Shanken 'Asset Allocation with Conventional and Indexed Bonds', Paper for Barclays Capital 2002

<sup>17</sup> See NAPF annual asset allocation survey 2010

<sup>18</sup> JP Morgan Asset Management Alternative Asset Survey September 2010

over our 'mainstream' volatility range drops notably for property and gilts, especially for investors toward the higher end of the risk tolerance range.<sup>19</sup> Meanwhile, average allocations for equities rise significantly, as does gold's average optimum allocation (see table 5.1).

In a lower inflation and lower growth scenario, where CPI inflation and real GDP growth run at around 1.75% per annum, the average optimal allocations over the 'mainstream' risk tolerance range for equities falls back, as does the property allocation, while that for gilts rises somewhat. For gold, the average optimal allocation over the 'mainstream' risk tolerance range is little changed from the base scenario but this disguises some variation across this risk tolerance range. For investors at the lower risk end of this range the optimal allocation rises, while closer to the centre of the range the optimal allocation falls as investors substitute toward gilts, effectively using them - rather than gold - along this part of the risk- return trade-off (see table 5.2). It is only at low risk that the strong diversification properties of gold come into play.

**Table 5.1 – Changes in investor optimum weightings in different scenarios**

<b>Effect on optimal asset allocations, mainstream investor range</b>					
<b>Scenario</b>	<b>Cash</b>	<b>Equities</b>	<b>Gilts</b>	<b>Property</b>	<b>Gold</b>
Base case allocations, %	5	45	30	15	5
Higher inflation scenario	unch.	++	--	-	++
Lower inflation & lower growth scenario	unch.	--	++	-	unch.

Note: Average investor range covers standard deviations of returns from 10-20, average allocations across this range used

**Table 5.2 – Changes in gold optimum weightings in different scenarios**

<b>Effect on optimal gold allocations</b>			
<b>Scenario</b>	<b>Lower risk</b>	<b>Average</b>	<b>Higher risk</b>
Base case allocations, %	9	5	0
Higher inflation scenario	++	++	++
Lower inflation & lower growth scenario	+	-	unch.

Note: Lower risk investor here defined as with standard deviation of returns at 10, average at 15, higher risk at 20.

These results are quite sensitive to the precise assumptions used, in part due to the long time frame used (20-30 years), which magnifies the impact of small changes on scenarios. As such, they should be seen as largely illustrative, rather than prescriptive in terms of the optimal allocations estimated. These allocations are efficient in the sense that they maximise returns for a given range of risks or minimise risk for a given set of returns, but the analysis is limited by the relatively small number of assets considered.

In addition, real world investors would also need to consider issues such as the liquidity of different asset classes, possible supply constraints or limits (regulatory and market) on purchasing an asset, and their particular objectives (for example, some institutional investors with inflation-linked liabilities might have a

<sup>19</sup> This illustrates a key point which is that property is not, contrary to popular belief, an inflation hedge. Property is only weakly correlated with inflation, so that for every 1% rise in inflation real returns fall 0.44%. Hence in inflationary scenarios optimum property allocations tend to fall unless growth is also rapid – GDP growth is the key driver for property.

particular bias towards inflation-proofing their portfolios, while some investors might also be unwilling to allocate too large a portion of their portfolios toward non-core assets).

Of particular interest, however, is the way that the allocations shift as we vary the underlying economic assumptions and assumptions about real returns. Relatively small variations can lead to quite large shifts in the optimum allocations, illustrating that major economic shocks or significant reassessments by investors of the properties of different assets could lead to a big move in the actual content of the portfolios of mainstream investors. In particular, any upward shift in investors' views about long-term inflation rates ought to prompt a rise in the allocations given to gold.

**Table 5.3 – Assumptions for base case**

<b>Base case</b>		
<b>2% inflation, 2.25% GDP growth</b>	<b>Real Return</b>	<b>Volatility</b>
Cash	0.5	3.5
Equities	5.0	24.7
Gilts	2.0	12.1
Gold	-0.2	20.4
Property	3.0	20.7

**Table 5.4 – Assumptions for higher inflation case**

<b>Higher inflation case</b>		
<b>3% inflation, 2% GDP growth</b>	<b>Real Return</b>	<b>Volatility</b>
Cash	0.0	3.6
Equities	5.3	22.9
Gilts	2.0	13.5
Gold	-0.1	21.0
Property	2.6	18.7

**Table 5.5 – Assumptions for lower inflation and lower growth case**

<b>Lower inflation &amp; lower growth case</b>		
<b>1.75% inflation, 1.75% GDP growth</b>	<b>Real Return</b>	<b>Volatility</b>
Cash	0.6	3.5
Equities	5.0	25.3
Gilts	3.2	14.9
Gold	-0.1	20.8
Property	2.6	18.7

Note: Real returns and volatilities in the variant scenarios are based on adjusting the base case figures using historic correlation coefficients (estimated over 1971-2010) with GDP growth and inflation.

**Table 5.6 – Historic correlations between asset classes**

Correlations between variables					
	Cash	Equities	Gilts	Property	Gold
Cash	<b>1.0</b>	-0.2	0.1	0.0	-0.3
Equities	-0.2	<b>1.0</b>	0.5	0.4	-0.3
Gilts	0.1	0.5	<b>1.0</b>	0.2	-0.4
Property	0.0	0.4	0.2	<b>1.0</b>	0.0
Gold	-0.3	-0.3	-0.4	0.0	<b>1.0</b>

## 6 Conclusion

The strong price increase seen for gold in recent years has been the result of a complex of short-term factors including a weak dollar, low real interest rates, high levels of financial stress and central bank quantitative easing policies, which may have raised the 'tail risk' of high inflation.

These factors have led to a strong rise in gold prices and it might be expected that gold prices will tend to fall back in the years ahead. However, historical analysis suggests gold could peak at levels even higher than the current ones, and both past experience and our estimated equation for the gold price also suggest that any ultimate adjustment from peak levels may not be rapid. Our equation implies that it can take years for a disturbance which pushes the gold price away from its long run equilibrium to be fully reversed – and then only if all other factors remain constant.

Given the uncertainties facing the global economy, there must be a question mark against whether all other factors can be expected to remain constant. In particular, the eurozone sovereign debt crisis has the potential to generate major financial stresses should it end in sovereign defaults – possibly on a scale comparable to that seen in the global financial crisis of 2008-2009. Major sovereign defaults could also prompt a serious reassessment by investors of the nature of government bonds as a 'safe' asset.

Another significant risk is that inflation accelerates considerably as a result of the dramatic expansion of central bank balance sheets since 2009. While inflation pressures appear to be contained at present, this may not remain the case as the global banking system heals itself and the massive liquidity injections of recent years start to leak into faster broad money and asset price growth. The possibility that central banks miscalculate when and by how much to withdraw their previous stimulus must be a very real one, given their limited experience in implementing monetary policies of this kind.

Inflation risks could be further heightened by spreading political turmoil in the Middle East and its impact on global oil markets, and by possible overheating in some rapidly growing emerging markets including China. A final long-range factor that could boost gold is the path of the US dollar. Our analysis shows that dollar moves can have a substantial short-term impact on gold prices so that a weakening of the trade-weighted dollar connected with loose monetary policy, a faster revaluation of Asian currencies or perhaps a loss of international investor confidence connected with the problematic US fiscal situation, could all keep gold prices high.

Our scenario analysis using the Oxford Global Model shows that gold may perform especially strongly in more extreme economic scenarios featuring high inflation, a weak dollar and elevated levels of financial stress. But gold also performs well in our deflation scenario, where very high levels of financial stress triggered by sovereign defaults in the EU causes a flight to safe assets. As such, gold's potential role as 'risk insurance' in a balanced investment portfolio is clear. Moreover, our optimisation analysis suggests gold's lack of correlation with other assets means that it has a role to play in reducing the volatility of investment portfolios even in more benign scenarios when its long-run real return is negative; gold's optimal portfolio allocation in our baseline scenario is 4-9%, depending on risk appetite.

These considerations may partly explain why gold's use as an investment vehicle appears to be rising, with investment-driven demand up to around 40% of the total in 2010 from less than 15% in 2002. With central banks becoming net buyers of gold in 2010 for the first time since the late 1980s, there seems to be evidence of a reappraisal of gold's value by various classes of investors.

## 7 Appendix – equation details

In line with the general macroeconometric literature, we have adopted an error correction format to model the price of gold.<sup>20</sup> This format separates the determinants of the price into two components: a long run relationship and drivers of short run fluctuations.

For the long-run part of the equation we followed the academic literature and assumed that the gold price has an elasticity of one with respect to inflation in the long run, so that gold and the price level move together one-for-one over the very long term.<sup>21</sup>

But whilst this assumption is currently standard, it implies that gold has a zero real rate of return over the long run. The experience of the past 30 years or so, where the real rate of return to gold has been positive for long periods of time, suggests that there may be other factors pushing up the price faster than the rate of inflation. This observation suggests that there may be other factors which determine the long run rate of return, such as the cost of mining gold, the global rate of inflation and the level of demand (proxied by the growth in world GDP and world GDP weighted by each country's demand for gold).

Despite the positive rates of return observed over the last 35 years, our econometric investigation suggests that over the long term the price of gold is driven by the rate of inflation. As such, we have adopted the long run model that is consistent with academic literature, and assumed that the gold price and general price level move together in a one-for-one relationship:

$$\gamma(\ln PG_{t-1} - \ln CPI_{t-1})$$

Where  $\gamma$  is the error correction term, i.e. the amount by which gold moves toward its long-run equilibrium value, PG is the price of gold and CPI is the US price level (as defined by the consumer price index).

The coefficient  $\gamma$  takes a value between 0 and -1; if we start from equilibrium and the price of gold rises faster than the general price level today, the error correction term will result in gold prices falling tomorrow (other things equal) to move back towards equilibrium and vice versa if gold prices rise more slowly than the price level today the error correction term will push gold prices upwards in the following period. The absolute size of the coefficient determines the speed of adjustment, with a higher value signalling quicker adjustment.

Having established the long run relationship driving the price of gold over the very long term, the short-run part of the equation seeks to capture the factors responsible for the significant deviation between movements in the gold price and the price level observed historically. As is standard in the error correction format, these variables were included as differences rather than absolute levels, so that in the long run (when the price is in equilibrium) their value is zero.

The movements of the gold price over the short run, in particular the tendency for the price to rise rapidly in times of crisis but more slowly in more stable periods, suggest that some of the variables outlined above (in particular the financial stress measures, the exchange rate and monetary policy) may have a non-linear impact on the price. To test for this, these variables were included with linear terms, squared terms and interaction terms, which were positive in times of financial stress.

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<sup>20</sup> To fit an error correction format, the price of gold and any variables in the long run part of the equation must be non-stationary. This assumption was tested and found to be statistically true for all relevant variables.

<sup>21</sup> This relationship has been noted empirically and formally tested in E.J. Levin & Wright, R.E. (2006) "Short-run and long-run determinants of the price of gold", *Report for World Gold Council*.

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After experimenting with various combinations of different variables and non-linear terms, a final equation was derived which removed all variables that proved insignificant. The final form of the equation is:

$$\% \text{ Ch. PG}_t = \alpha + \beta_1(\% \text{ Ch. PG}_{t-1}) + \beta_2(\% \text{ Ch. PG}_{t-2}) + \beta_3(\text{US Inflation}) + \beta_4(\% \text{ Ch. Ex Rate}_t) + \beta_5(\text{Ch. Real Rate}_t) + \beta_6(\text{Ch. Default Premium}_{t-1}) + \beta_7(\text{Ch in growth rate of US monetary base}_t) + \gamma \text{ECM}_{t-1} + \text{Time Dummies}$$

Where **PG** is the price of gold (US\$/troy ounce):

**$\alpha$**  is the constant term;

**$\beta_1$ ...  $\beta_7$**  are coefficients capturing the impact on the price of gold of a 1% change in the variable;

**$\gamma$**  represents the speed of adjustment to the long run equilibrium;

**US Inflation** is the annual rate of CPI inflation in the US;

**Ex Rate** is the US nominal effective exchange rate;

**Real Rate** is the estimated real interest rate (calculated as the five year bond yield minus 5-year ahead inflation expectations reported by the University of Michigan Consumer survey, i.e. an ex ante measure of inflation expectations);

**Default Premium** is the yield spread between BBB-rated corporate bonds and AAA-rated bonds;

**US Monetary Base** is the seasonally adjusted US monetary base, (US\$ millions).

All the variables had the correct sign and most were significant at the 10% level or better. In addition to these variables, we also found it necessary to include dummy variables for the last quarter of 1979 and the first two quarters of 1980 to improve the fit of the equation. These dummies aim to capture the major political disturbances of the period which were not fully picked up by other variables such as the default premium.<sup>22</sup>

Having done this, the estimated equation passes the standard tests for normality of errors, serial correlation and heteroskedasticity, and has an R-Squared of 0.54, which is a relatively high value for a differences equation. The estimated price of gold is close to the actual price of gold in almost all periods and the broad movements are well tracked over time.

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<sup>22</sup> A similar approach was taken by Levin & Wright (2006) but their use of time dummies was somewhat more extensive; our equation appears to have reduced the necessity for the use of dummies by better capturing underlying economic and financial drivers.

Table 7.1: Gold price equation

An estimated equation for gold				
Sample (adjusted): 1976Q2 2010Q3				
Included observations: 138				
<b>Dependent variable: Change Ln(Gold price)</b>				
	Coefficient	Std error	t-statistic	p-value
EC term/Speed of adjustment	-0.024	0.016	-1.506	0.135
<b>Long run coefficients</b>				
Constant	0.542	0.016	0.804	0.423
Ln(US price level)	1.000	-	-	-
<b>Short run coefficients</b>				
$\Delta$ Ln(Gold price (-1))	0.172	0.076	2.276	0.025
$\Delta$ Ln(Gold price (-2))	0.156	0.069	2.266	0.025
US inflation	0.004	0.002	1.875	0.063
$\Delta$ (US broad exchange Rate)	-0.837	0.169	-4.957	0.000
$\Delta$ (US real interest rate)	-0.015	0.008	-1.942	0.054
$\Delta$ (credit default premium(-1))	0.044	0.021	2.078	0.040
$\Delta$ (growth rate of Fed balance sheet)	0.140	0.117	1.204	0.231
Time Dummies				
R-squared	0.541	Mean dependent var	0.016	
Adjusted R-squared	0.500	S.D. dependent var	0.079	
S.E. of regression	0.056	Akaike ubfi criteria	-2.842	
Sum squared resid	0.396	Schwartz criteria	-2.587	
Log likelihood	208.073	Hannan-Quinn criteria	-2.738	
Durbin-Watson statistic	1.884			
Gold price	Price of gold, US\$/troy ounce			
US price Level	Level of US consumer price index			
US inflation	Annual percentage change in US CPI			
US broad exchange rate	US nominal broad exchange rate			
US real interest rate	US medium term real interest rate			
Credit default premium	Interest rate spread between AAA and BBB bonds			
Fed balance sheet	Level of Federal Reserve balance sheet			

The presence of two lags of the gold price in the estimated equation may suggest that other short run variables do not have much explanatory power. To test this we re-estimated the final equation but removed the gold price lag terms. Although the fit worsened (the R-Squared value fell from 0.54 to 0.5) it remained

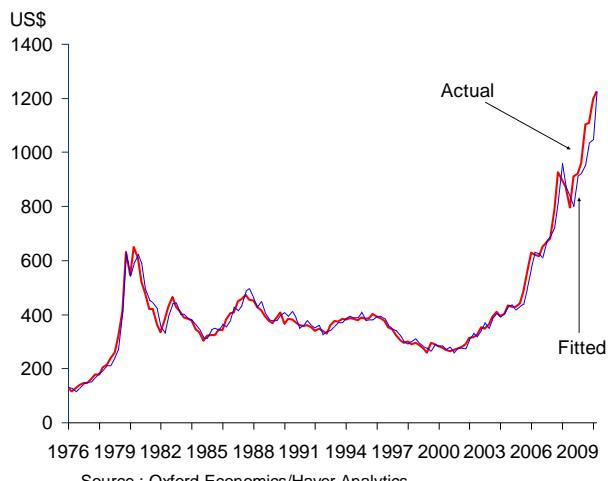
## The impact of inflation and deflation on the case for gold

July 2011

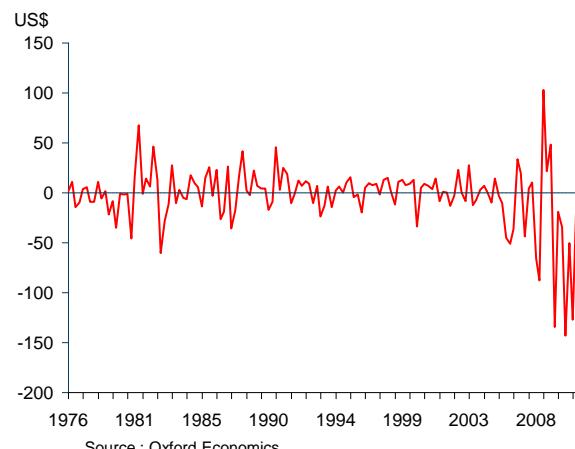
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good.<sup>23</sup> All key changes in momentum remain identified, as do the upward trends in recent years. This suggests that gold is not strongly affected by its previous values, and other short run determinants such as the exchange rate and real interest rate are more important determinants of short run shifts in the price.

**Chart 7.1: Actual and fitted values from equation**



**Chart 7.2 – Equation residuals**



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<sup>23</sup> As well as the worsened R-Squared the equation without the lagged values fails the heteroskedasticity and serial correlation diagnostic tests, both of which indicate that the equation is mis-specified. These test results highlight the importance of the lags, even though their coefficients are relatively small.

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