

The Golden Dilemma

Claude B. Erb

Los Angeles, CA 90272

Campbell R. Harvey

Duke University, Durham, NC 27708

National Bureau of Economic Research, Cambridge, MA 02138

Gold objects have existed for thousands of years but for many investors gold has only recently become a tradable investment opportunity. Gold has been described as an inflation hedge, a “golden constant”, with a long run real return of zero. Yet over 1, 5, 10, 15 and 20 year investment horizons the variation in the nominal and real returns of gold has not been driven by realized inflation. The real price of gold is currently high compared to history. In the past, when the real price of gold was above average, subsequent real gold returns have been below average. Given this situation is it time to explore “this time is different” rationalizations? We show that new mined supply is surprisingly unresponsive to prices. In addition, authoritative estimates suggest that about three quarters of the achievable world supply of gold has already been mined. On the demand side, we focus on the official gold holdings of many countries. If prominent emerging markets increase their gold holdings to average per capita or per GDP holdings of developed countries, the real price of gold may rise even further from today’s elevated levels. As a result investors in gold face a daunting dilemma: 1) embrace a view that “those who cannot remember the past are condemned to repeat it”, there is a “golden constant” and the purchasing power of gold is likely to fall or 2) embrace a view that “this time is different” and the “golden constant” is dead.

First SSRN Version: June 6, 2012. Current Version: May 4, 2013. We appreciate the comments of Arjun Divecha, Steve Hanke, Jens Herdack, Fai Lee, Raymond Kerzérho, Sandy Leeds, Anthony Morris, Tapio Pekkala, seminar participants at the Russell Academic Advisory Board, participants at the CFA seminars in Atlanta and Montreal as well as participants at the Man Summit meetings in Frankfurt, Vienna, Nurnberg and Munich.

Disclosure statement: see http://faculty.fuqua.duke.edu/~charvey/gold_disclosure.htm.

Introduction

The global equity and fixed income markets have a combined market value of about \$90 trillion.¹ Institutional and individual investors own most of the outstanding supply of stocks and bonds. At current prices, the world stock of gold is worth about \$9 trillion. Yet investors own only about 20%, or less than \$2 trillion, of the outstanding supply of gold. A move by institutional and individual investors to “market weight” gold holdings would require them to offer the already existing gold owners a price attractive enough to incent them to part with their gold, probably sending nominal and real prices of gold much higher. Should investors target a gold “market weight”? Could they achieve a gold “market weight” even if they wanted to?

The goal of our paper is to better understand how we should treat gold in asset allocation. We start by examining a number of popular stories that are used to justify some allocation to gold, such as inflation hedging, currency hedging, and disaster protection. We then examine basic supply and demand factors. Remarkably, the new supply of gold that comes to the market each year hasn’t substantially increased over the past decade even though the nominal price of gold has risen fivefold. We also look at the distribution of gold ownership in developed countries and emerging market countries and estimate the impact on gold demand if key emerging market countries follow the same patterns of central bank gold ownership in important developed countries.

Gold has had an amazing recent run. From December 1999 to March 2012 the U.S. dollar price of gold rose more than 15.4% per annum, the U.S. Consumer Price Index increased by 2.5% per annum, while U.S. stock and bond markets registered annual gains of 1.5% and 6.4%, respectively. Indeed, Saad (2012) notes a recent Gallup poll found that about 30% of respondents considered gold to be the best long-term investment, making gold a more popular investment than real estate, stocks, and bonds.

Though some might use historical returns to estimate long-run forward-looking expected returns, it is implausible that the expected long-run real rate of return on gold is about 13% per year (15.4% nominal minus an assumed 2.5% annual inflation). Yet, it is essential to have some sense of gold’s expected return for asset allocation. Current views are sharply divergent. On one side is Buffett (2012) who compares the current value of gold to three famous bubbles: Tulips, dotcom, and the recent housing bust. Buffett writes:

What motivates most gold purchasers is their belief that the ranks of the fearful will grow. During the past decade that belief has proved correct. Beyond that, the rising price has on its own generated additional buying enthusiasm, attracting purchasers who see the rise as validating an investment thesis. As “bandwagon” investors join any party, they create their own truth – for a while.” Berkshire Hathaway 2011 Shareholder Letter, p. 18.

¹ Using the market capitalizations of both the Bloomberg World Exchange Market Capitalization index (WCAUWRLD) and the Barclays Capital Aggregate Bond index.

On the other side is Ray Dalio, who argued in a *Barron's* interview (see Ward 2011) that U.S. Treasury bills are no longer a safe asset and that there will be an ugly contest to depreciate the three main currencies (dollar, Yen and Euro) as countries print money to pay off debt:

Gold is a very underowned asset, even though gold has become much more popular. If you ask any central bank, any sovereign wealth fund, any individual what percentage of their portfolio is in gold in relationship to financial assets, you'll find it to be a very small percentage. It's an imprudently small percentage, particularly at a time when we're losing a currency regime.

It is not surprising that there is so much disagreement about gold's future. This disagreement reflects the fact that at least six somewhat different arguments have been advanced for owning gold:²

- gold provides an inflation hedge
- gold serves as a currency hedge
- gold is an attractive alternative to assets with low real returns
- gold a safe haven in times of stress
- gold should be held because we are returning to a *de facto* world gold standard
- gold is "underowned"

The debate over the prospects for gold resembles in some sense the parable of the six blind men and the elephant (see Saxe 1872). Different perspectives and different models lead to different insights. Depending upon which rationale or combination of rationales one embraces, gold is either very expensive or attractive. The debate over the value of gold is also an example of a Keynesian "beauty contest" which suggests that the price of gold is not determined by what you think gold is worth - what matters is what others think others think gold is worth (see Keynes 1936).³

While the possible value of all the gold ever mined is about \$9 trillion,⁴ only a small amount of gold actually trades in financial markets. We show that the investment demand for gold is characterized by positive price elasticity. This is one way of referring to momentum investing. As a result, even though historical measures of "value" might suggest gold is very expensive, it is possible that the actions of a relatively small number of marginal, momentum, buyers of gold could drive the real and nominal price much higher (especially if the marginal buyers are not focused on "valuation").

² See World Gold Council (2010a).

³ Another example of contrasting views is Howard Marks' (2013) "There is nothing intelligent to be said about gold", <http://business.outlookindia.com/article.aspx?283882>, and Peter Bernstein's (2000) authoritative history of the societal footprint of gold.

⁴ The World Gold Council (2010b) estimated that at year-end 2011 there were about 171,300 metric tons of gold above ground. This is a widely referenced estimate of the cumulative amount of gold that has been mined over time. The fact that this estimate is widely referenced does not mean that it is accurate. Given 32,150 troy ounces per metric ton and a price of \$1,650 per ounces yields a value of about \$9 trillion.

1. Gold as an inflation hedge

Probably one of the most widely held beliefs about gold is that it is an inflation hedge. Jastram (1978) pointed out that historically gold has been a poor hedge of inflation in the short run though it has been a good hedge of inflation in the long run. For Jastram, the short run was the next few years and the long run was perhaps a century. Jastram used the phrase “the golden constant” to communicate his belief that the real price of gold maintained its purchasing power over long periods of time and that gold’s long-run average real return had been zero. Harmston (1998) built on Jastram’s research, finding that in the long run the prices of some goods, such as bread, seem to command a constant price when denominated in ounces of gold.⁵ “Gold as an inflation hedge” means that if, for instance, inflation rises by 10% per year for 100 years then the price of gold should also rise by roughly 10% per year over a century. The “gold as an inflation hedge” argument says that inflation is a fundamental driver of the price of gold.⁶

It is worth asking “for whom might gold be an inflation hedge”? That is, even if gold provides a potential inflation hedging ability, it might not be accessible for investors. For example, in the United States, private ownership of gold was outlawed by President Roosevelt in early 1933 with the signing of Executive Order 6102. Private ownership of gold in the United States was restored when Public Law 93-373 went into effect on December 31, 1974. If different countries have different laws regarding the ownership of gold then investors in different countries face different realities with regard to the legal inflation hedging possibility of gold. Additionally, when an investment is outlawed in a country it is questionable as to whether or not investors in that country are able to observe “market prices” for the outlawed investment. As a result exploring the various arguments for investing in gold requires selecting, and being constrained by, a country perspective and a legal perspective. It is also desirable, and important, that if one invests in a legal inflation hedge that the position remains a legal hedge until at least a fraction of a second after the position is sold.⁷ For the purposes of this paper the United States is a convenient country perspective and the focus is largely on the time period in which it has been legal to own gold in the United States. This does not suggest that the “U.S. perspective” is the only perspective or that investors should only consider legal investments. Rather it is a starting point.

Exhibit 1 illustrates one literal version of the “gold as an inflation hedge” argument. Our initial “legal” sample starts in 1975 because that is when U.S. citizens were once again able to own and trade gold. The “market price” of gold became readily visible with the launch of gold futures trading (for most of the

⁵Harmston (1998) mentions that in 562 B.C., during the reign of the Babylonian king Nebuchadnezzar, an ounce of gold purchased 350 loaves of bread. At the recent price of \$1,600 an ounce, an ounce of gold could buy 350 loaves of bread priced at \$4.57 a loaf.

⁶Greer (1997) argues that there are three asset “super classes”: capital assets, consumable/transformable assets and store of value assets. Gold, as an asset, falls into Greer’s “store of value” super class.

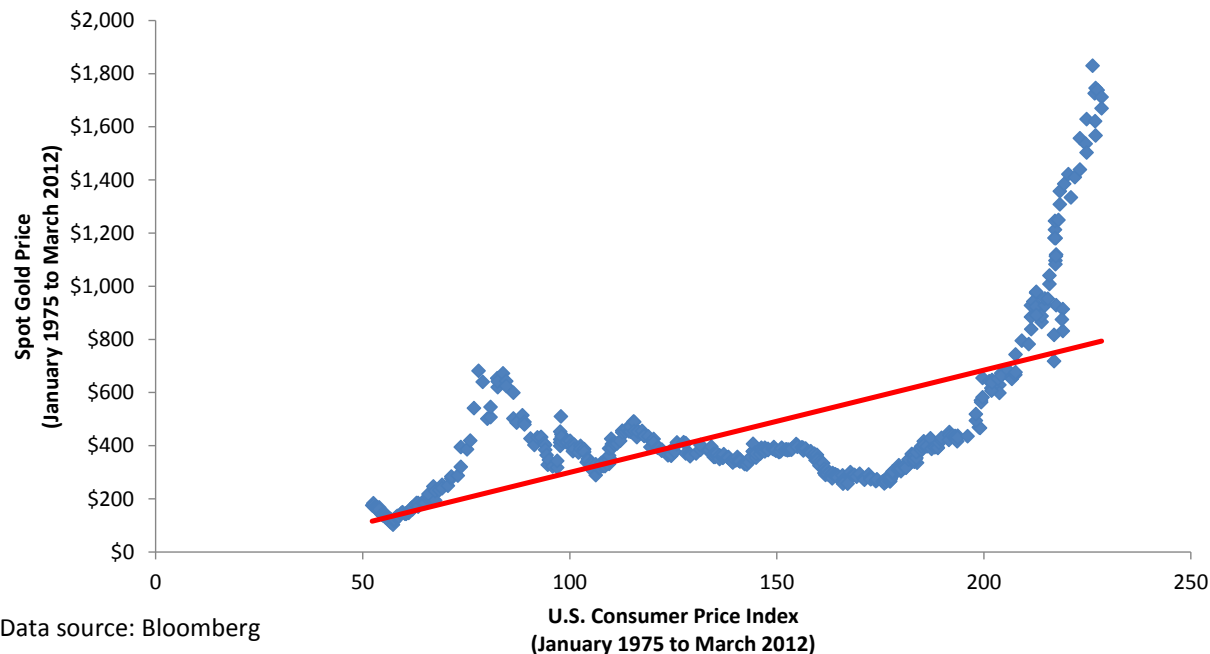
⁷The possibility that the U.S. government will make gold ownership illegal once again, or outright confiscate gold held by individuals, is a popular anxiety inducing gold investing theme. For instance, in August 2011, analyst Marc Faber suggested that U.S. citizens owning physical gold should make sure that their gold was [stored outside of the U.S.](#) (See Cox 2011).

history of the U.S., the price of gold was fixed by the government.⁸) Exhibit 1 shows the month-end value of the nearby gold futures contract versus the monthly reading for the U.S. Consumer Price Index (CPI), over the period January 1975 to March 2012. The red regression line⁹ shows that on average the higher the level of the CPI the higher the price of gold. This line roughly portrays the implied price of gold -- if gold was driven by CPI. However, in Exhibit 1, the price of gold swings widely around the CPI. The inflation derived price of gold and the actual price of gold have rarely been equal. Given the most recent value for the CPI index, this version of the “gold as an inflation hedge” argument suggests that the price of gold should currently be around \$780 an ounce.

⁸ Officer (2006) shows that the official U.S. gold price has been set only a few times: 1792 (\$19.39), 1834 (\$20.67), 1934 (\$35), 1972 (\$38), 1973 (\$42.22). Fama and French (1987) examine the performance of gold futures from February 1975 to July 1984. Our monthly U.S. gold futures data starts with the introduction of legal gold trading in January 1975. Elwell (2011) notes that from 1934 to 1973 (during what he calls a “quasi-gold standard” period) “although there was no private market for gold in the United States, such markets did exist abroad. By the late 1960s, prices in these markets were tending to deviate from official currency prices” (p.13). Bank for International Settlements annual reports (1966-70) refer to “market prices” in London and Zurich. Historical London “market prices” going back to 1968 can be found at the [London Bullion Market Association](http://www.lbma.org.uk/pages/index.cfm?page_id=15&title=market_history). (The first London gold “fixing” occurred in 1919 (http://www.lbma.org.uk/pages/index.cfm?page_id=15&title=market_history). Five gold bullion dealers collectively decided what the price of gold should be on a given day. The London gold fixing was suspended in 1939 and it was reinstituted in 1954). As part of the Bretton Woods system of fixed exchange rates participating governments had an option to settle balance of payments differences with gold reserve transfers. An attempt in the 1960s by the central banks of eight countries to maintain the Bretton Woods fixed exchange rates, by selling gold to “the market” at \$35 an ounce, led to an arrangement called the London Gold Pool. For various reasons the London price of gold rose above \$40 an ounce in 1968 leading to losses for the members of the London Gold Pool and a decision to end the operation of the Pool. Minutes of Federal Reserve conversations (Memorandum of Discussion) in 1967 (page 3, <http://www.federalreserve.gov/monetarypolicy/files/fomcm19671212.pdf>), chronicle the challenges the U.S. experienced trying to support the London Gold Pool. The U.S. ended the convertibility of the U.S. dollar into gold in 1971 and the year-end gold price was about \$43 an ounce in London. In 1973 the U.S. officially ended its adherence to the gold exchange standard. The year-end 1973 price of gold was about \$106 an ounce in London. Barsky and Summers (1988) choose 1973 as the start date for their analysis of Gibson’s paradox noting that “we focus on the period from 1973 to the present, after the gold market was sufficiently free from government pegging operations and from limitations on private trading for there to be a genuine ‘market’ price of gold” (p. 543).

⁹The price of gold was regressed on the contemporaneous value of the U.S. Consumer Price Index. This illustrates the best in-sample fit between the price of gold and an inflation index.

Exhibit 1. Gold as an Inflation Hedge



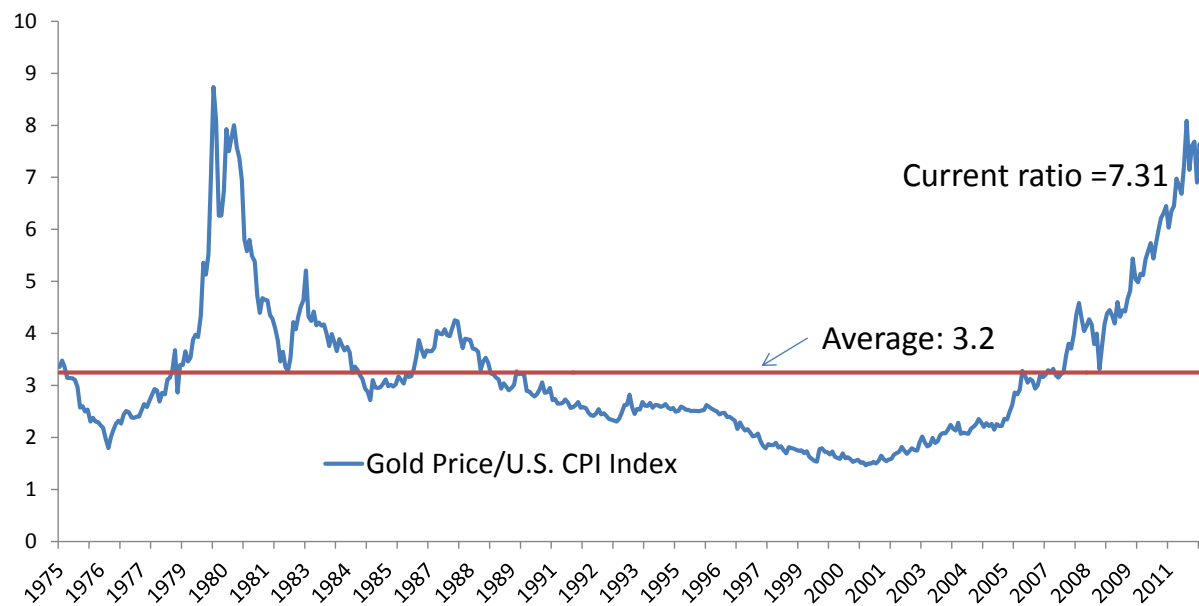
Another way to assess how effective gold has been as an inflation hedge is to examine the historical fluctuations in the real (inflation adjusted) price of gold. If gold were a perfect short-term hedge of inflation, in the sense of Jastram's (1978) metaphor of a long-run zero-real-return "golden constant", then the real price of gold should be a constant and exhibit no real price variability.¹⁰ Alternatively, if the real price of gold fluctuates, perhaps behaving like a valuation measure such as a stock market price-earnings ratio, then gold may be an imperfect hedge of short-term inflation.

Exhibit 2 shows one way to think about fluctuations in the real price of gold from a U.S. perspective (later we deal with an international perspective; see also Erb and Harvey 2012a). In January 1975, the month-end nominal price of the nearby gold futures contract was \$175 an ounce. The month-end

¹⁰ Bekaert and Wang (2010) illustrate a way to think about an inflation hedge, in the context of a simple linear regression model. They regress the nominal return of an asset on the rate of inflation: $\text{Nominal Return} = \text{"Inflation Alpha"} + \text{"Inflation Beta"} \times \text{Inflation Rate} + \text{error}$. An asset with an Inflation Beta of 1.0 is defined as a "perfect hedge against inflation". An Inflation Beta of 1.0 is another way of thinking about "moving in lockstep with inflation". There are at least three ways to think about the idea of the price of gold and inflation moving in lockstep. One possibility is Jastram's (1978) idea of the "golden constant". One interpretation views gold having an inflation beta of 1.0 and an "inflation alpha" of zero. The "golden constant" is consistent with the idea that the purchasing power, the real price, of gold is constant. Alternatively gold's inflation beta could be 1.0 and its inflation alpha could be positive. This would suggest that in the long run an ounce of gold has a rising real purchasing power and a rising real price. A third possibility is that gold's "inflation alpha" is negative, and the purchasing power, and real price, of gold declines over time. This third case would be problematic. An inflation beta of 1.0 would seem to suggest that gold is an inflation hedge while a negative inflation alpha would suggest that with a long enough time horizon purchasing power would decline to zero. There are, of course, other nuances such as attributing any "inflation alpha" to overlooked risk factors, time horizon issues (monthly, annual, etc.), how to measure inflation and the stability of inflation betas.

January 1975 index value of the U.S. CPI index was 52.1.¹¹ The ratio of the nominal price of gold relative to the CPI index (one way to calculate the “real price of gold”) was 3.36. Since the inception of gold futures trading this real price ratio has averaged about 3.2, reached a low value of 1.46 in March of 2001 and a high value of 8.73 in January 1980. Using this measure, the month-end March 2012 real price of gold was recently 7.3. Since the start of gold futures trading the only other time the real price of gold has been roughly as high as it is today was in 1980. Following the real price high in 1980, the real price of gold, as well as the nominal price of gold, fell significantly.

Exhibit 2. The Real Price of Gold since the Advent of U.S. Futures Trading



Data source: Bloomberg

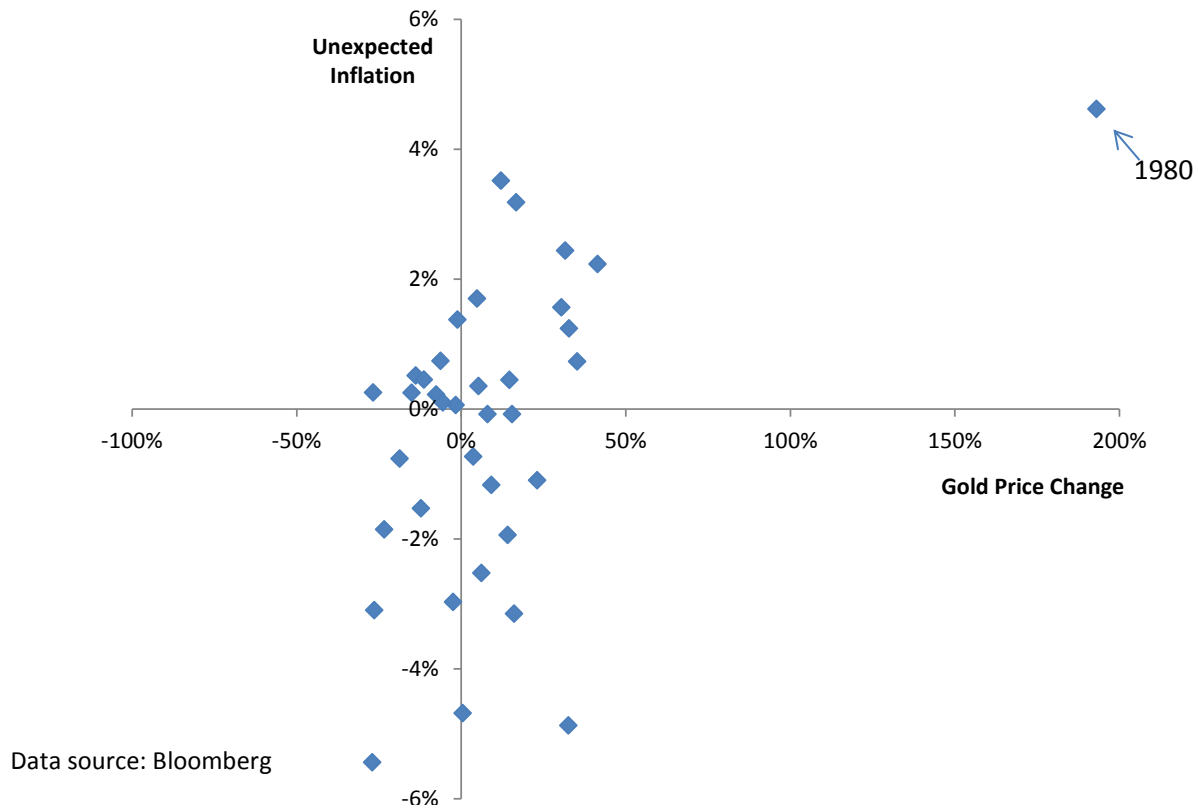
Exhibit 2 illustrates that the real price of gold has been quite volatile. In fact, the volatility of the real price of gold has been basically the same as the volatility of the nominal price of gold and the real price of gold tends to mean revert over a time period of about ten years. The variability of the real price of gold suggests that gold has been a poor short-term inflation hedge.

There are at least two ways to think about inflation: the rate of inflation that investors expect and the rate of inflation that comes as a surprise to investors. An asset that hedges expected and unexpected inflation would probably appeal to a broad number of investors. If an investor possessed perfect foresight then there would be no unexpected inflation. As a result one of the easiest ways to test if an asset is a good hedge of unexpected inflation is to ask if it hedges perfect foresight of future inflation changes. Exhibit 3 details the inability of gold to hedge against unexpected inflation (measured by the

¹¹Note that the base of the CPI is set to 100 in 1982-1984.

actual year-to-year change in the annual inflation rate during the time period 1975 to 2011). There is effectively no correlation here. Any observed positive relationship is driven by a single year, 1980.

Exhibit 3: Gold and Unexpected Inflation, 1975-2011



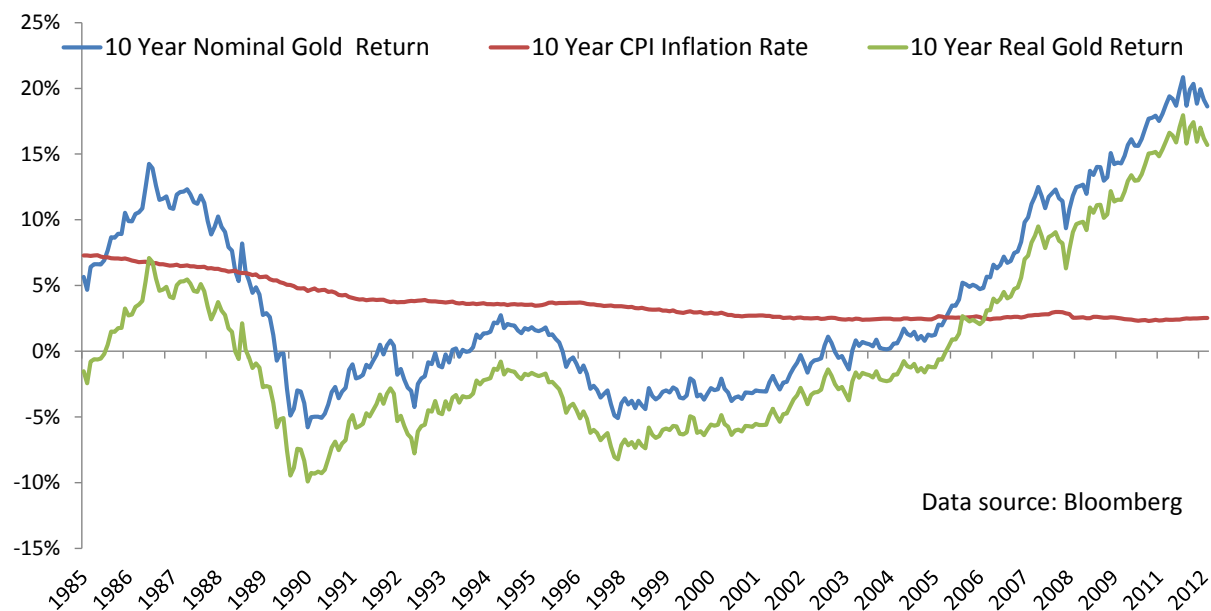
What about the ability of gold to hedge, or keep pace with, longer-term inflation?

Exhibit 4 shows rolling monthly observations of trailing ten-year rates of inflation, as well as both nominal and real gold returns. There has been substantial variation in trailing nominal ten year annualized gold returns: from as low as -6% per annum to as high as +20% per annum. There has also been significant variation in real gold returns. In contrast, over the same time period, the low and high inflation rates were +2.3% per annum and +7.3% per annum – a range of only 5 percentage points.

From Exhibit 4, we can make at least four observations. First, perfect foresight knowledge of the future rate of inflation did not translate into an accurate forecast of future nominal and real gold price returns (inflation did not predict gold returns). Second, knowing future nominal and real gold returns provided no real insight into the course of future inflation (gold returns did not predict inflation). Third, variation in the real price of gold accounts for most of the variation in the nominal price of gold. Finally, observing that the trailing 10-year real gold return was negative from 1988-2005, it is obvious that gold might have failed investor expectations to be an effective long-term inflation hedge.

By definition, the nominal return of gold is the sum of the inflation rate and the real gold price return. Of course, the rate of inflation varies from country to country. In Exhibit 4, the average rate of inflation in the U.S. was about 4% per year, driving a wedge between nominal and real gold returns. What if the average rate of inflation in some other country had been 50% per year, rather than 4% per year? Then, in a “golden constant” sense, the average nominal return of gold would have been higher. However, there is no obvious reason that the real gold return would have changed. In fact, As Erb and Harvey (2012a) illustrate, when the real price of gold is high or low in one country, it is generally high or low in other countries. As a result, the nominal return of gold (within a country) will consist of a local, country specific, inflation effect and what appears to be a global real price effect. Exhibit 4 suggests that the real price of gold can vary a lot. Gold may not be a very effective long-term inflation hedge when the long-term is defined as 10 years.

Exhibit 4. Long-term Inflation Hedging and Gold



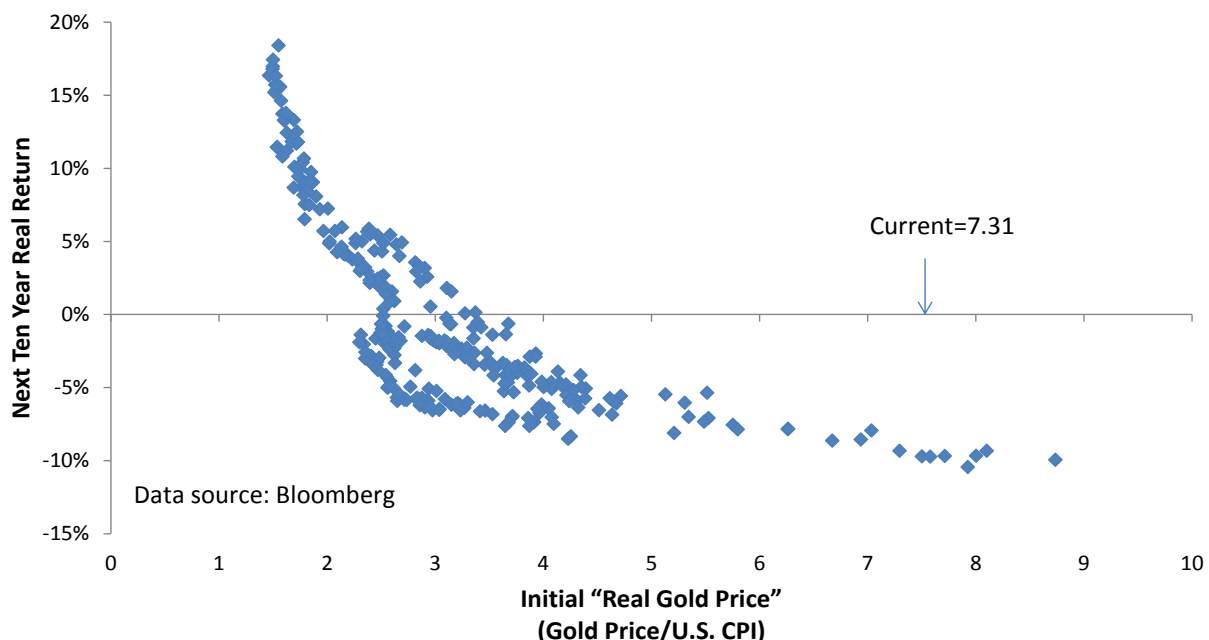
Mean reversion is a “past is prologue” way of looking at the world. The real price of gold is currently high and the real price of gold was high in 1980. In Exhibit 2, the high real price of gold in 1980 was followed by a long period of unattractive gold returns. Exhibit 5 details the historical relationship between the real price of gold and subsequent 10-year real gold price returns since 1975. If the exhibit traced out a “known known” stable relationship then the current high real price of gold would suggest a future 10-year real price return of about -10% per year. But the relationship is not a “known known,” it is a “known unknown”.

Whether the real price of gold forecasts future real gold returns is similar to the debate over the ability of stock market price earnings ratios, valuation ratios, to forecast future stock market real returns. For instance, Campbell and Shiller (2001) and Asness (2012) emphatically argue that valuation matters and that high valuation levels are followed by low real returns. DeLong (2012) diplomatically notes that “only fools say...that movements in market-wide price-earnings ratios are best interpreted as shifts in rational

expectations of future earnings and dividend growth”. However, Ibbotson and Chen (2003) are comfortable with the idea that in an efficient market high price-earnings ratios forecast high future earnings growth rates and Malkiel (2003) views the valuation argument as being inconsistent with market efficiency. Investors observing the behavior of the real price of gold have an opportunity to confirm their pre-existing concepts about how markets operate. The real price of gold may or may not mean revert over time, but the purchasing power of gold is driven by changes in the real price of gold. An investment in gold is a bet on the future evolution of the real price of gold, whether an investor is aware of the bet or not.

Importantly, it is dangerous to draw inference about the future based on what is arguably one historical episode.

Exhibit 5. Mean Reversion of the Real Price of Gold



In 1980 the trailing one year CPI inflation rate was about 13%. Some called bonds “certificates of confiscation” because of a view that the rate of inflation would stay at a stubbornly high level well into the future (see Norris 2010). With the clarity of hindsight, it is possible to see a “Volcker moment” in which the U.S. Federal Reserve turned its back on its dual mandate (maximum employment and price stability) and decided to focus on fighting inflation. The actual return for gold of -5% per year over the period 1980 to 1990 is the one path traveled by history but it is only one of the many paths that were possible to imagine from the vantage point of January 1980.

What might inflation be over the next ten years? By looking at the yields of 10 year nominal Treasury bonds and 10 year inflation linked Treasury bonds it is possible to back out an approximate “market

implied” 10 year inflation forecast.¹² Currently the “breakeven” inflation rate over the next 10 years is about 2% per year. Of course, there is no guarantee that 10 year inflation will actually average 2% per year over the next 10 years. If the real price ratio of gold mean reverts over the coming decade to its historical average of about 3.2, Exhibit 6 shows gold’s possible rate of return will average about -6% per annum.

Exhibit 6: Rates of Return on Gold under Different Inflation Scenarios

		Return Given Inflation and Ending Valuation								
		Annual Inflation Rate Over The Next Ten Years								
		0.00%	2.00%	4.00%	5.00%	6.00%	8.00%	10.00%	20.00%	40.00%
Ending Real Price Ratio	12.2	5.32%	7.42%	9.53%	10.58%	11.64%	13.74%	15.85%	26.38%	47.44%
	11.2	4.42%	6.51%	8.60%	9.64%	10.68%	12.77%	14.86%	25.30%	46.19%
	10.2	3.45%	5.52%	7.59%	8.62%	9.65%	11.72%	13.79%	24.14%	44.83%
	9.2	2.39%	4.43%	6.48%	7.51%	8.53%	10.58%	12.62%	22.86%	43.34%
	8.2	1.21%	3.24%	5.26%	6.28%	7.29%	9.31%	11.34%	21.46%	41.70%
	7.2	-0.09%	1.90%	3.90%	4.90%	5.90%	7.90%	9.90%	19.89%	39.87%
	6.2	-1.58%	0.39%	2.36%	3.34%	4.33%	6.30%	8.27%	18.11%	37.79%
	5.2	-3.29%	-1.36%	0.58%	1.54%	2.51%	4.44%	6.38%	16.05%	35.39%
	4.2	-5.34%	-3.44%	-1.55%	-0.60%	0.34%	2.24%	4.13%	13.60%	32.53%
	3.2	-7.88%	-6.03%	-4.19%	-3.27%	-2.35%	-0.51%	1.34%	10.55%	28.97%
	2.2	-11.26%	-9.49%	-7.71%	-6.83%	-5.94%	-4.16%	-2.39%	6.48%	24.23%
	1.2	-16.48%	-14.81%	-13.14%	-12.31%	-11.47%	-9.80%	-8.13%	0.22%	16.92%
	0.2	-30.18%	-28.79%	-27.39%	-26.69%	-25.99%	-24.60%	-23.20%	-16.22%	-2.26%

Assumes an initial gold price of \$1,665 and a March 2012 CPI Index level of 229. The “Return Given Inflation and Ending Valuation” is an exploration of how the possible ten year nominal price return for gold might vary with 1) the current real price of gold (current gold price/current CPI Index), 2) the annualized rate of CPI inflation realized over the next ten years and 3) the ending (ten years in the future) real price of gold (nominal gold price/CPI Index ratio). For instance, if inflation over the next ten years is 2% per year then the ending level of the CPI index will be 279.15 (229×1.02^{10}). If one assumes that the ratio of the price of gold to the CPI index in ten years will be 3.2, then the ten year in the future nominal price of gold will be \$893.28 (279.15×3.2). As a result, the “Return Given Inflation and Ending Valuation” will be -6.03% per year (annualized return = $\exp(\ln(\text{ending price}/\text{initial price})/\text{time horizon}) - 1 = \exp(\ln(\$893.28/\$1,665)/10) - 1$). We highlight in red the current rate of inflation (2.00%) and the current real gold price ratio (3.2).

While Exhibit 2 traces the real price of gold since 1975, received gold lore suggests that gold has been mined since 3600 B.C. (see World Gold Council 2012a). Tversky and Kahneman (1971) warned of the “law of small numbers” which leads to “exaggerated confidence in the validity of conclusions based on

¹² Many investors use Bloomberg terminals. An investor using Bloomberg’s GGR US (U.S. Generic Government Rates) function will see “breakeven rates” calculated as the difference in yields between maturity-matched nominal and real Treasuries (TIPS). For example, Perold (2012) uses expected inflation and breakeven interchangeably. This does not mean that this approach is correct, but it does indicate that many Bloomberg users are exposed to this measure and method of calculation. A more precise calculation might incorporate an estimate of a possible “liquidity premium”. The liquidity premium would increase the breakeven inflation level. See analysis in Christensen and Gillian (2012) and Fleckenstein, Longstaff and Lustig (2012).

small samples” (p. 25). It is possible that the behavior of the price of gold since 1975, a time span of only 36 years, is an example of the “law of small numbers”. A possible, but potentially flawed, way to battle the “law of small numbers” is to obtain more data.

Exhibit 7 shows the estimated growth of the U.S. GDP price deflator since 1792. This increases the historical inflation time span from 36 years to 220 years. Of course, Exhibit 7 does not provide any insight into the cost of things between 3600 B.C. and 1792 A.D. Paul and Lehrman (2007) suggest that “from 1792 to 1971 [the U.S.] had an imperfect money and banking system....but during that time the dollar was always related to gold in one way or another” (p. 2). In a more granular review of historical U.S. currency standards written for members of the U.S. Congress, Elwell (2011, pp. 2-13) labels the bimetallic currency years 1792 to 1834 “basically silver”, the years 1834 to 1862 “basically gold”, the years 1862 to 1879 “fiat paper money”, the years 1879 to 1933 “a true gold standard”, the years 1934 to 1973 a “quasi-gold standard” and the years since 1973 as a pure fiat money regime.

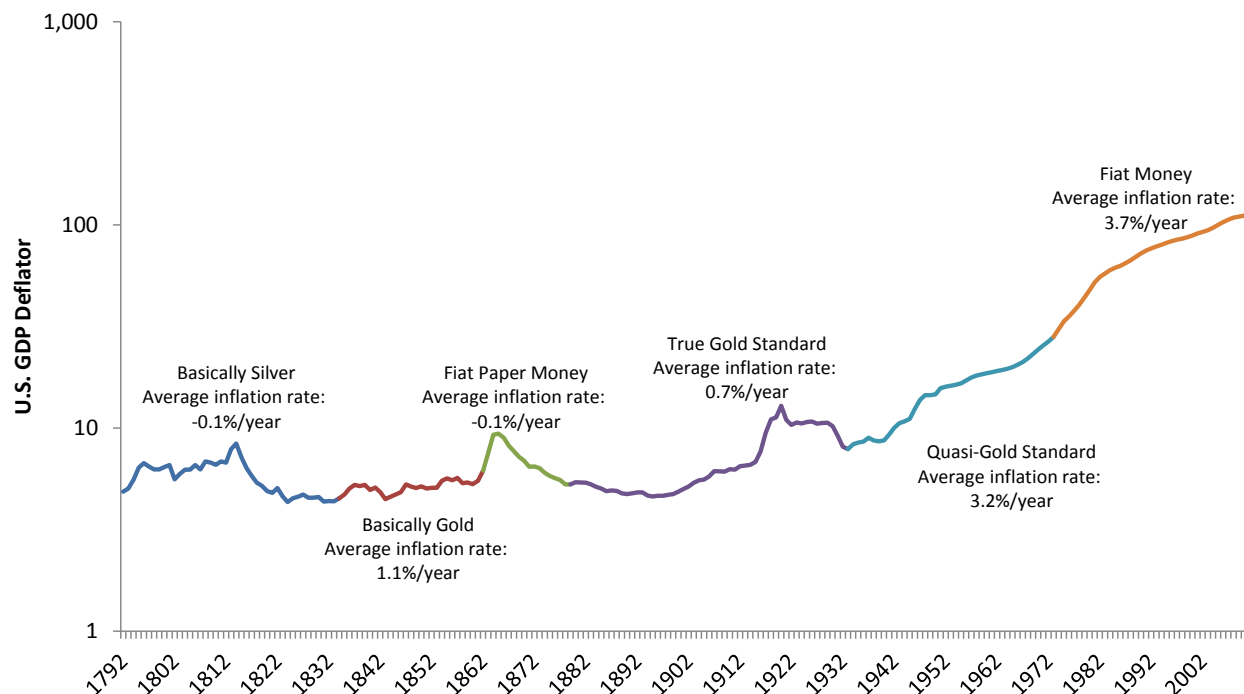
The highest U.S. inflation rate in Exhibit 7 occurred under the current fiat money regime. To some, this is proof of the fragility of a fiat money regime. Von Mises (1953) believed that fiat money systems were inherently prone to inflationary excesses, especially if social policy focused on full employment over price stability.¹³ But the devil is in the details. The fiat money regime of 1862-1879 experienced what seems to be a low rate of inflation and the quasi-gold standard regime of 1934-1973 had a relatively high inflation rate. Bordo and Kydland (1995) point out that a gold standard rule is a contingent commitment to price stability, a commitment that can be temporarily abandoned during times of war or other national emergencies. The U.S. Civil War was financed with the creation of fiat money, greenbacks, and what at the time seemed to be massive borrowing.¹⁴ Even though the wartime financing needs of the Civil War resulted in a high level of inflation in the North during the war, the period from 1865 to 1879 was characterized by deflation. It is possible that over the entire period 1862-1879, given the mores of the time, the U.S. implicitly was following a path of contingent commitment to a gold standard. As a result the fiat money regime of 1862-1879 had a cumulative inflation profile different from the 1973 to present fiat money experience.

The devil is also in the details again for the 1934-1973 “quasi-gold standard” inflation experience. McKinnon (1993) points out that the success of a gold standard is only as good as the willingness of the participants to abide by the “rules of the game”, in which interest rates rise when gold reserves fall and interest rates fall when gold reserves rise. He suggested that the decades prior to 1913 are an example of gold standard countries somewhat playing by the “rules of the game”, and the period from 1934 to 1973 is an example of gold standard countries somewhat abusing the “rules of the game”. An interesting takeaway from Exhibit 7 is the possibility that neither a fiat money system nor a gold system is inherently prone to inflation: what matters is the long-run actions and intentions of market participants.

¹³ von Mises (1953, p. 744) believed that the natural response of “the common man” to a fiat money system was to “flee into real values” by investing in commodities as an inflation hedge.

¹⁴ The first paper notes issued by the United States government that were not backed by coin and were considered legal tender occurred on February 25, 1862. See [*Statutes at Large, 1789-1875*](#), Vol. 12. These notes were known as “greenbacks”. Also see Mitchell (1903).

Exhibit 7. Inflation Rates and U.S. Currency Regimes



Data source: U.S. GDP deflator from Johnson and Williamson (2011). "Currency regime" labels from Elwell (2011).

Exhibit 8 examines the real price of gold in U.S. dollars since 1791. Unlike Exhibit 1, which uses month-end closing prices for gold from a futures exchange, Exhibit 8 uses an annual gold time series that is cobbled together from a number of studies.¹⁵ The price of gold in Exhibit 8 is deflated (divided) by an estimate of the U.S. GDP deflator. There are at least two things to note about this price level indicator. The first is that the GDP deflator is by definition not the same thing as the Consumer Price Index. The cumulative differences between a GDP deflator and a CPI index are typically not large. The second is that GDP was first calculated in 1937, as a result of the pioneering work of economist Simon Kuznets, and backfilled to 1929. The GDP deflator estimates for the years 1791 to 1928 are only "backfilled" estimates.

Exhibit 8 shows that the real price of gold was fairly constant until the 1970s.¹⁶ This stability was the result of the fact that the U.S. operated with a variety of currency regimes "backed" by gold and silver (bimetallism), or just gold, from 1791 until the early 1970s. The exact definition of what "backed" means varied over time (the U.S. dollar was on a full gold standard between 1900 and 1933, a gold exchange standard at other times and gold "backing" was typically suspended during wars or economic emergencies).¹⁷

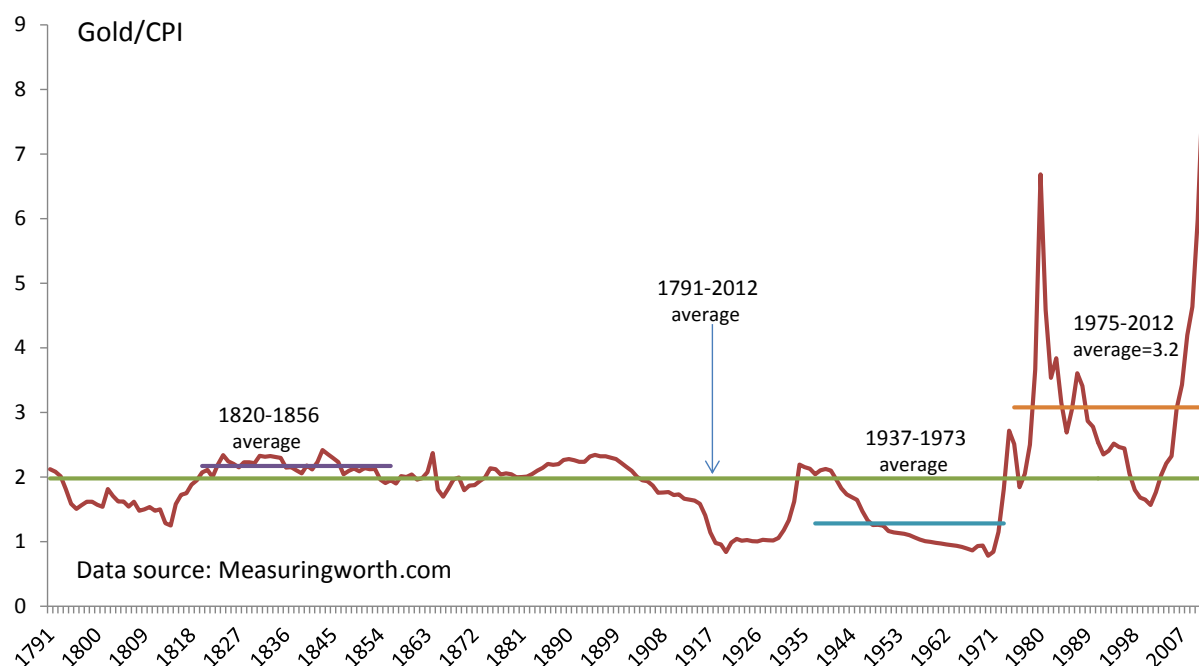
¹⁵ See <http://measuringworth.com/gold/>

¹⁶ Also see the analysis in Barro and Misra (2013).

¹⁷ See Schwartz (1987) for an analysis of the gold standard.

Since the 1970s, the real gold price has fluctuated wildly.¹⁸ The real price of gold is currently very high relative to the 1791-2011 average. Unsurprisingly, as is the case with many economic time series, the overall in-sample average will typically differ from individual sub-period averages. The low average real price of gold occurred during the 36 year time span from 1937 to 1973. The high average real price of gold occurred during the current 36 year time span from 1975 to 2011. The message of Exhibit 8 is that the real price of gold fluctuates and that it seems to have been more volatile recently than during the previous, roughly, 200 years. The absence of a pronounced upward or downward trend in the real price of gold in Exhibits 2 and 8 supports, but does not prove, the idea that gold's real rate of return might be on average close to zero (statistically speaking).

Exhibit 8. The Real Price of Gold over 200 Years



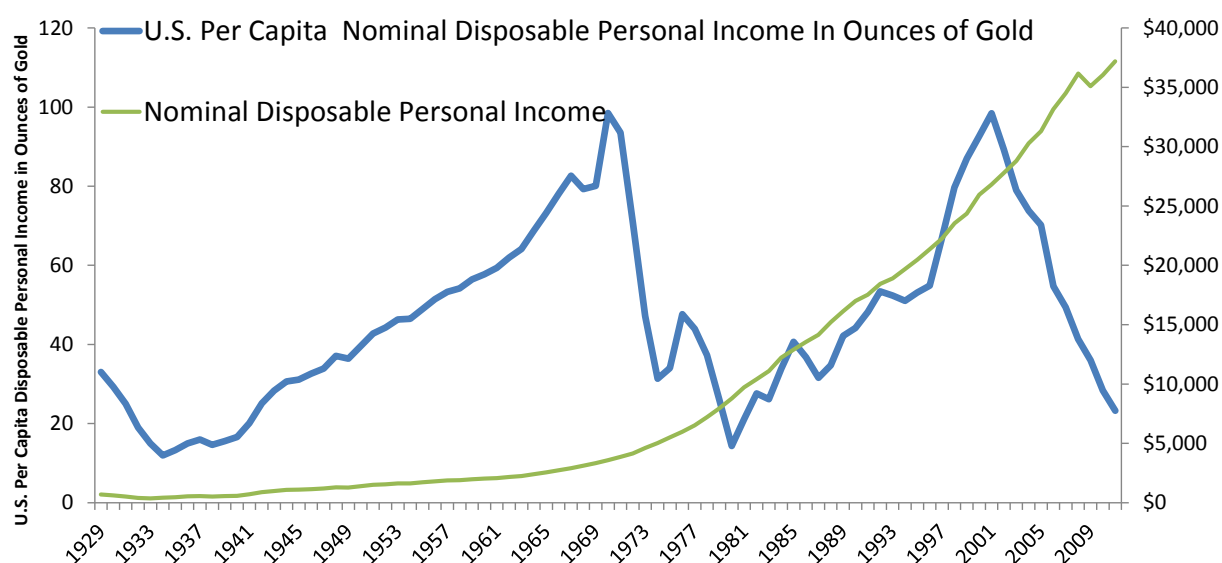
Related to the idea that gold is possibly a long-term inflation hedge is the “constant price in terms of gold” argument, the idea that for some items prices tends to hover around some constant amount of gold. For instance, some claim that over time the cost of a “high quality” man’s suit has cost an ounce of gold (see Arends 2009). This statement is interesting but hard to prove because of issues such as quality differences over time and sumptuary laws, which once regulated the types of clothing different social and economic classes could wear. Since a man’s suit or a loaf of bread is the result of human labor an alternative way to examine the idea that the price of goods in terms of gold remains constant is to look at per capita income measured in ounces of gold. A rising level of purchasing power could be consistent with per capita income “buying” more ounces of gold over time. A stagnant level of purchasing power

¹⁸In 1971 U.S. President Nixon ended the convertibility of U.S. dollars into gold. In effect Nixon brought an end to the 1944 Bretton Woods Accord which allowed 1) the conversion of foreign currencies into U.S. dollars at fixed exchange rates and 2) the convertibility of U.S. dollars into gold.

could be consistent with a Malthusian Trap, in which per capita income “buys” a stable number of ounces of gold.

Exhibit 9 shows time series for nominal U.S. per capita disposable income and U.S. per capita disposable income measured in ounces of gold. Since 1929 per capita income has grown about 5% per year, the price of gold has grown about 5.5% per year and per capita income measured in ounces of gold has fallen by about 0.5% per year.¹⁹ Looking at nominal per capita income it is possible to see a picture of positive and reasonably stable income gains over time. Looking at per capita income measured in ounces of gold reveals a volatile landscape of slowly declining purchasing power. Since 1929 per capita income has on average been worth 46 ounces of gold. Currently per capita income can buy about 20 ounces of gold. Exhibit 9 suggests that in terms of ounces of gold per capita income has been stagnant since 1929. Viewing per capita income in ounces of gold, this observation is consistent with the assertion that the “gold price” of certain “items” is, on average, constant over time. It is perhaps gold’s way of saying that the more things change (nominal income) the more things stay the same (real income).

Exhibit 9. U.S. Per Capita Disposable Income in Ounces of Gold



Data source: U.S. Bureau of Economic Analysis and Bloomberg

Why might income measured in ounces of gold have been stagnant? First, the lack of income growth could be viewed as being consistent with the vision of English political economist Thomas Robert Malthus that the trade-off between technology and population growth would lead to stagnant incomes (see Hansen and Prescott 2002). A Malthusian explanation carries a lot of deadweight intellectual baggage since Malthus is often criticized for successfully describing life in the European Dark and Middle

¹⁹1929 is the earliest date for which the U.S. Bureau of Economic Analysis (www.bea.gov) reports macroeconomic data such as Gross Domestic Product (GDP) and its constituents (personal disposable income and personal disposable income per capita).

Ages and missing the transformative significance of the Industrial Revolution. So maybe Malthus was right about stagnant incomes but wrong as to why incomes would be stagnant.

Second, it is possible to view Exhibit 9 as a reminder that some people might suffer from money illusion. The American economist Irving Fisher (1928) referred to money illusion as “the failure to perceive that the dollar, or any other unit of money, expands or shrinks in value” (p. 4). Money illusion is a behavioral weakness borne of the desire to prosper. Consider the following example. Imagine that you are presented with one of two ways to receive your pay. In the first case, you can take a pay cut of 10 percent in a world with 0% inflation and in the second case you can take a pay raise of 10% in a world with 20% inflation. In both instances the inflation adjusted level of income declines 10%, but in the second case a decline in real income is paired with an increase in nominal income. Money illusion suggests that on average people prefer to focus on nominal gains in income rather than observe the path of their real incomes. Money illusion does not explain why gold denominated incomes have been stagnant though it does provide a reason some might prefer to look at nominal rather than gold denominated incomes. Additionally it might be that the purchasing power of wages has been more robust than depicted in Exhibit 9 when measured in terms of an evolving basket of goods and services that reflects changes over time in tastes, preferences and technology.

Third, it is possible to interpret the lack of growth in disposable income, measured in ounces of gold, as indirect evidence that gold is overvalued today. In Exhibit 9, 2011 disposable personal income equaled about 19.7 ounces of gold. This implies an income (in ounces of gold) annual growth rate of -0.6% since 1929. Alternatively, suppose the price of gold was the same today as in 1999. In this scenario, personal per capita income would command 132.3 ounces of gold. This implies an annual growth rate of 1.7% since 1929.

While Exhibit 9 presents a picture suggesting little advancement in U.S. per capita pay when measured in ounces of gold over the last ninety years, Exhibit 10 extends this framework to one of the few reasonably close wage comparisons that can be made across a long period of time: military pay. The Romans were skilled at building roads and aqueducts as well as recording how much it cost to staff a Roman legion. Legionaries were the lowest ranking soldiers in a Roman legion, similar to a private in the U.S. Army. A centurion commanded a century of 80 legionaries and had a rank somewhat similar to a captain in the U.S. Army.

In the era of Emperor Augustus (reigned from 27 B.C. to 14 A.D.), a Roman legionary was paid about 2.31 ounces of gold a year (225 denarii) and a centurion was paid about 38.58 ounces of gold a year (3,750 denarii).²⁰ Converted to U.S. dollars, the pay of a Roman legionary was about 20% that of a

²⁰ Goldsworthy (2003) notes that from the time of the Emperor Augustus the number of Roman legions fluctuated “a little above or below 30 for the next 300 years”. A legion typically consisted of 4,800 legionaries (which can alternatively be viewed as consisting of 10 cohorts of 480 legionaries or 60 centuries of 80 legionaries). Under Augustus, a legion was usually commanded by a legate, who in turn was assisted by a Camp Prefect (a former senior centurion) and up to six tribunes. There seems to be little evidence as to the pay of these officers. There is a consensus, though, as to the pay of legionaries and centurions. The consensus could, of course, be wrong. It is common to assert that a legionary typically was paid 225 denarii a year and that a centurion was paid 3,750 denarii a year. MacMullen (1974) refers to three pay levels for centurions: 3,750 denarii a year for 50 “regular

modern day private in the U.S. Army and the pay of a centurion was about 30% greater than the pay of a captain in the U.S. Army.

Exhibit 10. Military Pay in Ounces of Gold

	U.S Army Private	Roman Legionary	Growth Rate	U.S Army Captain	Roman Centurion	Growth Rate
Salary	\$17,611	\$3,704	0.08%	\$44,543	\$61,730	-0.02%
Price of Gold	\$1,600	\$1,600		\$1,600	\$1,600	
Ounces of Gold	11.01	2.31	0.08%	27.84	38.58	-0.02%

Data source: U.S. Army and MacMullen (1974)

Similar to the U.S. aggregate experience since 1791, there is little or no income growth in military pay over 2,000 years. Interestingly, this conclusion is not that sensitive to the final price of gold.

There are two insights here. First, some incomes denominated in gold might be a very long-term hedge – in that the real purchasing power of some wage rates are roughly preserved. Second, it helps us to begin to understand what the expected return on gold is not. Even though 2,000 years is only a fraction of the time that gold has been mined, it provides a lot of annual compounding periods. A claim that gold could have “equity-like” returns in the future needs to be reconciled with the past. Starting 2000 years ago in the year 12 A.D. one dollar compounding at just 1% a year, turns into \$439 million over 2,000 years. If the rate of return is increased to 1.62%, the ending value is \$100 trillion – more than the today’s combined capitalization of world stock and bond markets.

In “normal” times, gold does not seem to be a good hedge of realized or unexpected short-run inflation. Gold may very well be a long-run inflation hedge. However, the long-run may be longer than an investor’s investment time horizon or life span. In the short-run the real price of gold has been the

centurions”, 7,500 denarii a year for 9 “primi ordinis” centurions and 15,000 denarii a year for one “primus pilus” centurion. Speidel (1992) refers to legionary pay of 225 denarii a year but mentions 3,375 denarii (13,500 sesterii) a year as the pay of a “centurio legionis”, what MacMullen referred to as an ordinary centurion. There seem to be more references (for example, see [Wacher \(2002\)](#), [Stoke-on-Trent \(2013\)](#) and [Adkins \(1998\)](#)) to “basic” centurion pay of 3,750 denarii a year than to centurion pay of 3,375 denarii a year. For this reason Exhibit 10 uses Centurion pay of 3,750 denarii a year. Another assumption used in Exhibit 10 is that an aureus contains roughly 8 grams of gold (a Roman pound was about 329 grams and an aureus was 1/40th of a pound). In addition the purity is 99% gold – effectively 24ct. See https://www.britishmuseum.org/explore/highlights/highlight_objects/cm/g/gold_aureus_of_octavian.aspx.

dominant driver of the price of gold and the returns from gold. We will return to the inflation argument when we explore the “safe haven” argument where we explore hyperinflation.

2. Gold as a currency hedge

There are at least two ways to interpret the “gold as a currency hedge” argument. The first interpretation suggests that “gold is a foreign exchange currency hedge”. In this case, the expected return of gold should offset the expected decline in the value of one’s own currency. If, for instance, the U.S. dollar declines 10% against the Japanese yen then the “gold as a currency hedge” argument would suggest that the price of gold should rise by 10%. The net result of this hedge should be a return of zero (gold return + currency return = 0).

This perspective has the following problem. If the price of gold in a country is driven by its own inflation rate and if the exchange rate between two countries is driven by the difference in their inflation rates, then gold will only reliably be a hedge of the foreign exchange rate if one of the two countries always has an inflation rate equal to zero.²¹

A second way to interpret the “gold as a currency hedge” argument sees “gold as a hedge of my own currency, spent in my own country, when the local government is printing money with abandon”. This is also sometimes referred to as “currency debasement”. If this debasement is a result of inflation, then this interpretation is just another version of the “gold as an inflation hedge” argument.

Exhibit 11 highlights the historical gold betas of seven currencies (the Australian dollar, the Canadian dollar, the Bloomberg estimated Deutsche mark, the Japanese yen, the New Zealand dollar, the Swiss franc and the British pound). These gold betas are the result of regressing the monthly changes in the exchange rate (foreign units per dollar) on the monthly change in the price of gold. There are three things to notice. First, all of the coefficients are negative, which is the correct sign for a U.S. dollar investor who presumes that gold is a currency hedge. For example, if the U.S. dollar price of gold increased by 10%, the yen/dollar beta says that the yen appreciated on average about 1.4% (or alternatively that the dollar on average depreciated about 1.4%).²² Second, the average coefficient is small, about -0.15 across the seven currency pairs. The average beta coefficient is significantly different from zero but also significantly different from -1.0. Technically these small average gold betas are driven by low gold-currency return correlations and by the fact that the currency return standard deviations are about one-half the size of the gold return standard deviation. Third, if gold was a good currency

²¹ Given this framework, say the inflation rate in country A is I_A and the inflation rate in country B is I_B . Then, if by assumption inflation differences drive currency moves, the assumed change in the currency exchange rate will be $I_A - I_B$ and the nominal gold price appreciation in country A will be I_A . If I_A is greater than I_B then this means that more of currency A is needed to buy one unit of currency B. This means that the change in the exchange rate will equal the change in the price of gold when: $I_A = I_A - I_B$. This will occur when I_B equals zero.

²² From a U.S. perspective, the Japanese yen is quoted in terms of the number of yen in a U.S. dollar. If the yen-dollar exchange rate starts at 100 and falls to 98.6 then the yen has appreciated by 1.4% and the dollar has depreciated by 1.4% (absent any important Siegel’s paradox effect. Black’s (1995) discussion of “universal currency hedging” reviews Siegel’s paradox).

hedge the statistical fingerprint of this belief should be supported by high regression R^2 s. However, for this universe of currencies, there seems to be little connection between currency returns and gold returns. Additionally, from a broad perspective the “gold up-currency down” idea sometimes misfires. From 1975 to the present the U.S. dollar price of gold rose and the U.S. dollar depreciated against the Japanese yen. However, the Japanese yen price of gold rose and the Japanese yen appreciated against the U.S. dollar.

Exhibit 11. Gold as a Currency Hedge, 1975-2012

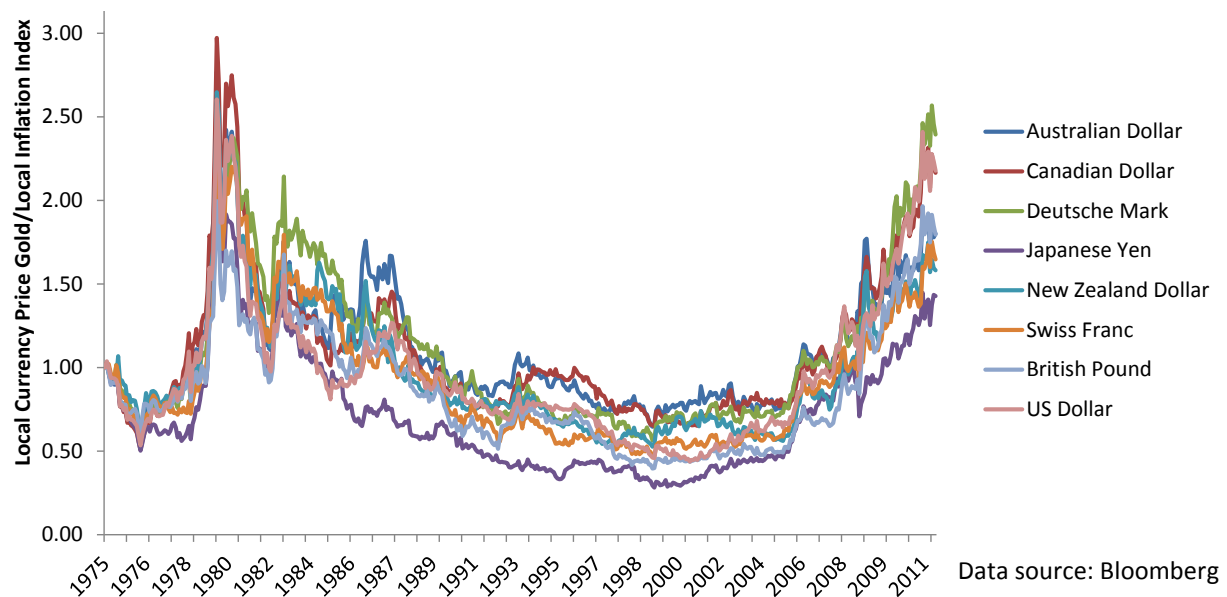
	Gold	AUD	CAD	DEM	JPY	NZD	CHF	GBP
Gold beta	1.00	-0.16	-0.09	-0.21	-0.14	-0.17	-0.24	-0.15
t-stat		-5.95	-5.62	-8.47	-5.46	-5.63	-8.85	-6.12
Correlation with gold	1.00	-0.27	-0.26	-0.37	-0.25	-0.26	-0.39	-0.28
Standard deviation	19.8%	11.7%	6.6%	11.3%	11.3%	12.7%	12.3%	10.4%
R^2	100.0%	7.4%	6.6%	13.9%	6.3%	6.7%	15.0%	7.8%
Indexed USD value (USD/Foreign 1975=1.0)	\$9.51	\$1.29	\$1.00	\$0.63	\$0.28	\$1.62	\$0.36	\$1.49

Data source: Bloomberg

Exhibit 12 shows how the local currency real price of gold has fluctuated in a number of countries: Australia, Canada, Germany, Japan, New Zealand, Switzerland, the U.K. and the U.S. In each case the local currency price of gold is divided by a local inflation index (using inflation index data from the International Monetary Fund) and the resulting ratio is normalized to an initial value of 1.0. The message of Exhibit 12 is that since 1975 the real price of gold in these eight countries seems to have moved largely in tandem.²³ Erb and Harvey (2012a) look at a broader universe of 23 developed and emerging countries and find that the real price of gold rises and fall at the same time. The real price of gold reached a high level in 1980 amongst all eight countries. The real price of gold fell to a low level in each of the eight countries in the 1990s, and more recently the real price of gold has risen to very high levels in all eight countries. The historical evidence of a seemingly common local currency movement in the real price of gold does not lend itself to a convenient “gold as a currency hedge” explanation. In fact, the change in the real price of gold seems to be largely independent of the change in currency values. Furthermore, since the real price of gold seems to move in unison across currency perspectives, it is unlikely that currency movements help in explaining why the real price of gold fluctuates.

²³ Pukthuanthong and Roll (2011) find that on average a higher gold price was correlated with not just a weaker U.S. dollar but a weaker U.S. dollar, euro, yen and pound.

Exhibit 12. The Real Local Price of Gold, 1975-2012



Is gold a currency hedge? It appears the answer is no. Do currency returns help explain movements in the real price of gold? No.

3. Gold as an alternative to assets with low real returns

The “gold as an alternative to other assets with low real returns” is a competing assets argument. The most frequent manifestation of this story is “the price of gold rose because nominal, or real, interest rates fell” argument.²⁴ DeLong (2011), Elfenbein (2012), Barsky and Summers (1988) and Krugman (2011) look to Keynes’ (1930) Gibson’s Paradox for a link between the price of gold and interest rates.

Exhibit 13 illustrates the historical relationship between the real price of gold in U.S. dollars (using the observations from Exhibit 2) and the real yield of a generic 10-year Treasury Inflation Protected Security (TIPS). Month-end observations from the inception of TIPS trading in 1997 to the present are used. Superficially, the message of Exhibit 13 seems to be fairly obvious. When real interest rates are high, as

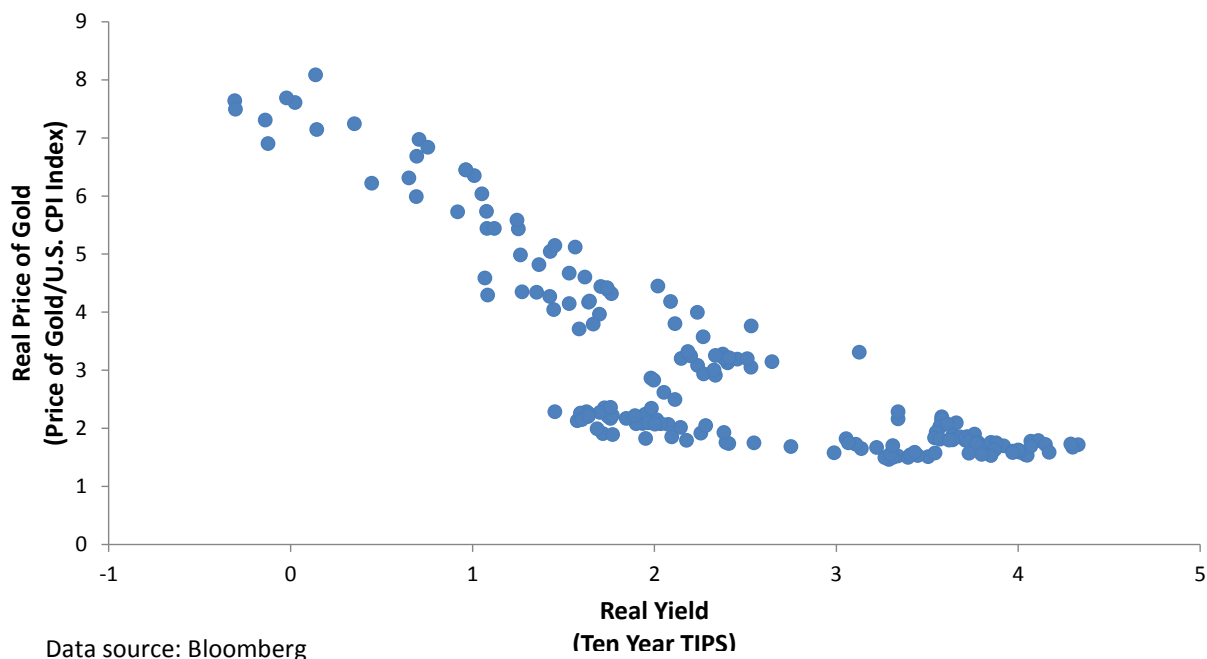
²⁴ See for example, <http://www.commodityonline.com/news/Real-interest-rates-are-the-prime-driver-of-gold-price-24907-3-1.html>, <http://www.crossingwallstreet.com/archives/2010/10/a-model-to-explain-the-price-of-gold.html>, <http://www.crossingwallstreet.com/archives/2011/09/gold-and-gibsons-paradox.html>.

they were during the late 1990s introduction of TIPS in the U.S., the real price of gold was low. Now that the real yield on a 10-year TIPS is low (close to zero) the real gold price is high. The correlation between ten year TIPS real yields and the real price of gold is -0.82. Is it possible to disagree with the view that low real yields caused the real price of gold to be high? Yes.

Exhibit 13 illustrates what seems to be a compelling pattern. An obvious question is how robust the correlation between real yields and the real price of gold might be to alternative perspectives. Does the finding hold up if a longer time period is examined? When looking at a longer data sample from the U.K., the correlation between real yields and the real price of gold falls to -0.31.²⁵ A “glass half full” interpretation of this means that real yields explained 9% of the variation in the U.K. real price of gold and a “glass half empty” interpretation means that real yields explained very little of the variation in the U.K. real price of gold.

Returning to the U.S. experience over the past 15 years, the historical correlation between real yields and a time trend is about -0.90 and the correlation between the real price of gold and a time trend was about 0.87. The highly positive correlation between the real price of gold and a time trend suggests that the real price of gold increases with the passage of time, without limit. A challenge with the time trend story is that, even though it “fits” the data better than the real yield story, the possibility of an infinite real price of gold is hard to grasp. Rather than focusing on fragile correlations perhaps a closer look at the real yield-real price of gold story might help.

Exhibit 13. The Real Price of Gold and the Real Interest Rate, 1997-2012



²⁵ Exhibit 13 covers 15 years, the years since the inception of trading in inflation protected fixed income in the U.S. Using U.K. data (where inflation linked bonds started trading in the early 1980s), the correlation between the real yield of the Barclays U.K. Government Inflation-Linked bond index and the U.K. real price of gold is -0.31

There are a number of stories suggesting a connection between the real price of gold and the level of interest rates: the central bank gold leasing story, the low opportunity cost story and the Gibson paradox story. Each of the stories has an air of plausibility.

Historically, some central banks “leased” part of their gold reserves.²⁶ Working with “bullion banks”, gold leasing allowed central banks to turn part of their gold holdings into interest earning assets. To some, such as the Gold Anti-Trust Action Committee,²⁷ the pursuit of gold leasing looked like central banks were actively trying to suppress the price of gold by effectively selling gold. It is certainly possible that as interest rates fall gold leasing becomes less attractive for a central bank. The gold leasing story basically comes down to saying that as interest rates fall, less gold is “sold” (leased). Central banks, though, have little reason to publicly disclose their gold leasing activities. In fact, International Monetary Fund (1999) accounting rules (1999) state that a central bank gold lease does not result in a “statistical” change of ownership and that a gold lease is similar to a repurchase agreement (repo). So in the absence of hard data on the amount of gold leasing, assessing the marginal impact of central bank gold leasing on the real price of gold is like searching for a black cat in a dark room and not knowing which room to look in.

DeLong (2011) expresses the “opportunity cost” view by pointing out that “gold...is...expensive to hold in your portfolio when real interest rates are high, and cheap to hold it in your portfolio when real interest rates are low”. This is somewhat different from the gold leasing story. This story suggests that an investor should be more inclined to buy gold as the level of interest rates fall. But why? If the real price of gold is constant then it is easy to map out the interest rate determined cost of owning gold. If the real price of gold fluctuates then the exercise becomes more challenging. Exhibit 13 illustrates a correlation between the real price of gold and real interest rates. Yet Exhibit 5 shows a historical propensity for low real gold returns to follow high real gold prices. Asness (2003) argued that the popularity of the “Fed model” illustrated how a compelling story empowered investors to set stock market price earnings ratios using nominal, rather than real, interest rates. To Asness, these investors suffered from money illusion. It is entirely possible that the “opportunity cost” view is to investing in gold what the “Fed model” is to investing in stocks: an entertaining and compelling story that seems to be out of synch with future real returns.

Yet another “Fed model”-type story is Gibson’s paradox. Gibson’s paradox is an observation that during the gold standard years 1821-1913 in the United Kingdom, nominal interest rates were positively correlated with the aggregate price level (rather than the inflation rate). Barsky and Summers (1988) interpret this to mean that under a gold standard “the price level is the reciprocal of the real price of gold” (p. 529). Keynes (1930) referred to Gibson’s paradox as “one of the most completely established facts in the whole field of quantitative economics” (p. 198). There are at least two challenges with applying Gibson’s paradox to the current world of fiat money. First, Gibson’s paradox is an explanation

²⁶ The history of gold leasing is explained in Szabo (2007).

²⁷ The Gold Anti-Trust Action Committee ([GATA](#)) points out that it was “organized in 1998 to expose, oppose and litigate against collusion to control the price and supply of gold and related instruments”.

of how the real price of gold fluctuates under a gold standard when the nominal price of gold is a constant. It is not a model of the behavior of the real price of gold under a fiat money regime. Second, Barsky and Summers find no evidence of Gibson's paradox under a fiat money regime.

For investors who want to believe that interest rates drive the real price of gold, the good news is that they can cherry-pick the story that most appeals to their sensibilities. However investors are still left with the unappetizing fact that a time trend seems to explain the real price of gold more than these stories.

It is important to avoid the "correlation implies causation" trap. The negative TIPS real yield-gold real price correlation of -0.82 is a measure of the linear correlation of real yields with real gold prices. While it is possible to argue that historical data suggest that low real yields "cause" high real gold prices (Gibson's paradox), it is equally possible to argue that causality runs in the other direction and that high real gold prices actually "cause" low real yields. Alternatively, it is possible that both low real yields and high real gold prices are driven by some other influence, such as a possibly immeasurable fear of hyperinflation.²⁸

Does the competing assets argument "explain" the nominal price of gold? No. Does the competing assets argument "explain" the real price of gold? No.

4. The "gold as a safe haven/tail risk insurance" argument

The safe haven/tail protect argument has already appeared three times. First, it is possible that gold does not hedge day-to-day inflation surprises but provides some protection in a hyperinflationary environment. Second, gold may not provide very effective hedging for currencies in usual circumstances but might provide some protection in situations of significant debasement – such as one associated with hyperinflations. Third, the negative correlation between real gold prices and real interest rates may be driven by the fear of a large negative macro event – such as hyperinflation.

4.1 *The Safe Haven*

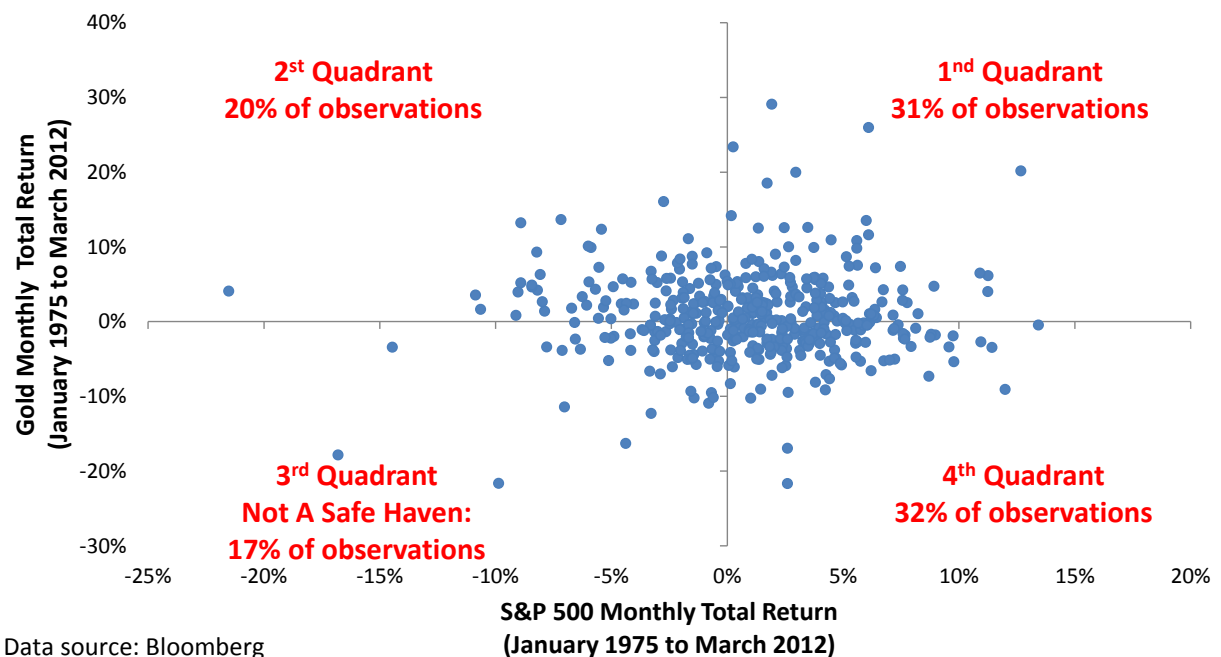
There is no formal definition of what makes an asset a safe haven asset. However, it should hopefully be possible to list at least two characteristics that a safe haven asset might have. One characteristic might be that a safe haven asset should have a stable value during "times of stress". Of course, there is no simple definition of "a time of stress". Baur and Lucey (2010) offered the suggestion that gold is a safe haven from losses in financial markets. Specifically they proposed that gold does well during periods of negative stock market returns. Another characteristic might be that a safe haven asset is something that can be accessed during times of stress. These two conditions provide ways to think about the "gold as a safe haven" argument: that if gold is a safe haven then its value should be stable when other asset markets falter and that gold's stable value should be dependably accessible during times of stress. A

²⁸ It is possible that the correlation between real gold returns and ten year real yields was a data-mined, after-the-fact, spurious correlation, such as Leinweber's (2007) finding that butter production in Bangladesh historically "explained" 75% of the variation in the S&P 500.

final thought suggests that a safe haven should be liquid; something that investors believe can be bought or sold anytime without impacting the price of the safe haven asset.

First, let's examine the safe haven with respect to financial stress. Exhibit 14 shows the joint distribution of U.S. stock and gold returns. How does gold hold up in Quadrant 3 (negative equity returns matched with negative gold returns)? The simple safe haven test states that there should be very few observations in Quadrant 3. In fact, 17% of the monthly stock and gold return observations fall in Quadrant 3. This suggests that gold may not be a reliable safe haven asset during periods of financial market stress. Exhibit 14 illustrates that nominal gold returns have historically had a low correlation with nominal U.S. equity market returns. Interestingly, depending upon how one defines a "safe haven", a good portfolio diversifier may not be a "safe haven" asset.

Exhibit 14. Gold and the S&P 500, 1975-2012



A possible second condition for a safe haven is that during times of stress it should be possible to access the safe haven asset. Consider the famous Hoxne Hoard which is currently on display at the British Museum. The Hoxne Hoard is an example of what can happen when trying to make a safe haven investment. The Hoxne Hoard is the largest collection of Roman gold and silver coins discovered in England. Evidence suggests that the hoard was buried sometime after 400 A.D. by a wealthy family seeking a safe haven for some of its wealth.²⁹ The 5th century A.D. was a time of great social stress and political turmoil in England as the Western Roman Empire unraveled.³⁰ The fact that the hoard was discovered in 1992 means that the family failed to reclaim its safe haven wealth. Indeed, the Hoxne Hoard is an example of an "unsafe haven".

²⁹ There is no record of the fate of the owner of the Hoxne Hoard.

³⁰ See William of Malmesbury (1847, p.6).

Jeffrey Gundlach astutely pointed out that the weight of gold limits its portability, both during normal times and during times of stress. Thinking in terms of the ratio of market value to weight (somewhat like a “flight capital” Sharpe ratio), he observed that many precious gems are a more efficient store of flight capital than gold (see Or and Phillips 2011).³¹ Gold is viewed by many as being durable and largely imperishable, characteristics which make gold its own safe haven against the ravages of the world. It is not necessarily a safe haven for the owner of gold. As Marc Faber³² once put it, “When Timur sacked Aleppo and Damascus in 1400, it didn't help to have your savings in gold. You lost your life and your gold” (see Ash 2009).

4.2 Tail Risk and Hyperinflation

Does gold provide some protection from tail risk?³³ Montier (2011) notes that there is no clear cut definition of tail risk: it is important to define what specific risk one is concerned about and to take a stab at defining what tail risk means in the context of that risk. Given Montier’s observation, it is possible to define inflation risk as the risk of unexpected inflation and inflation tail risk as the risk of hyperinflation.

For some proponents of gold investment, the hyperinflation of the Weimar Republic stands as an electrifying example of the risks of a fiat currency regime. The hyperinflation of the Weimar Republic during the years 1922 and 1923 is an example of a possible endgame for a country that spends much more than it earns. The German mark-U.S. (gold) dollar exchange rate rose from 430 in 1922 to about 433,000,000,000 by 1924. If such a hyperinflation unfolded in the U.S. today, if gold moved exactly in line with the inflation rate and if the real price of gold was unchanged, then the price of gold would exceed \$1.68 trillion an ounce.

So, does the price of gold provide hyperinflationary tail risk protection? Is gold a hyperinflationary talisman? Not surprisingly, the answer to a large degree depends on how the question is asked and the specific scenario that unfolds. It is perhaps instructive to think about how an absolutely clairvoyant investor might assess the ability of gold to provide a hyperinflation hedge. It is also useful to be aware of the historical frequency and magnitude of hyperinflationary episodes.

Imagine a Brazilian investor in 1980 who possessed perfect foresight of how Brazilian inflation would unfold between 1980 and 2000. Exhibit 15 shows that from 1980 to 2000 Brazil had an average annual inflation rate of about 250%, the currency was renamed and devalued numerous times, and the nominal price of gold rose substantially in Brazilian currency terms. Yet, using the IMF’s measure of Brazilian inflation, the real price of gold fell by about 70% between 1980 and 2000. This means, broadly and illustratively speaking, that by the year 2000, an ounce of gold had 30% of its 1980 inflation adjusted

³¹ At the current price of \$1,600 per ounce, \$5 million dollars weighs 215 pounds.

³² Polleschi (2012) tells of a recent instance in which an Italian businessman and his daughter were caught trying to smuggle 50 kilograms (110 pounds) of gold into Switzerland in what was supposed to be a hidden compartment in his car. This highlights that it is important to have an effective way to get one’s gold across “the border”. Some may be successful in getting their gold across “the border” by asking others to help transport a cache of gold.

³³ See World Gold Council (2010).

purchasing power. This is similar to the real price decline of gold faced by a U.S. investor during the same time period.

So, if purchasing power declined 70%, was gold a successful Brazilian hyperinflation hedge? It depends on one's perspective. Compared to an expectation that gold would move one-for-one with the Brazilian price level then gold was not a successful hyperinflation hedge between 1980 and 2000. However, investors keeping cash-in-a-mattress or investing in a portfolio of Brazilian nominal bonds probably lost most of their real value from 1980 to 2000. Compared to a close to 100% decline in real value for cash and nominal bonds the 70% decline in the real value of gold was a great alternative. A key takeaway from Exhibit 15 is that even though countries, such as the U.S. or Brazil, may experience very different inflation experiences their real gold return experiences will probably be similar and there is no reason to expect that the real gold return will be positive when a specific country experiences hyperinflation.

Exhibit 15. Real Gold Price Risk and Brazilian Hyperinflation

	1980	2000	2000/1980 Ratio	Annualized Growth Rate
Cruzeiro/USD	65.50	5,362,500,000,000.00	81,870,229,007.63	251.28%
Gold (USD)	589.75	272.25	0.46	-3.79%
Gold (Cruzeiro)	38,628.63	1,459,940,625,000,000.00	37,794,268,499.07	237.96%
Inflation Index (IMF)	86.50	11,092,888,909,767.90	128,238,525,233.73	259.25%
Real Price Ratio	446.56	131.61	0.29	-5.93%

Note: Data begins in 1980. In 1980, the currency of Brazil was the Cruzeiro. In 1986, 1 Cruzado replaced 1,000 Cruzeiros. In 1989, 1 Novo Cruzado replaced 1,000 Cruzados. In 1990, the Cruzeiro replaced the Novo Cruzado. In 1983, 1 Cruzeiro Real replaced 1,000 Cruzeiros. In 1994, 1 Real replaced 2,750 Cruzeiro Reals. The real price of gold is calculated as the local currency price of gold divided by the IMF inflation index for Brazil. See World Bank (1994) Brazil: An Assessment of the Private Sector".

Exhibit 16 provides a list of 56 major and minor country hyperinflationary experiences catalogued by Hanke and Krus (2012). Earlier research by Bernholz (2006) and McGuire (2010) mentions about 30 cases of hyperinflation. Hanke and Krus identify multiple bouts of hyperinflation in a country where Bernholz and McGuire primarily focus on broader start and endpoints. Hanke and Krus, Bernholz and McGuire follow the lead of Cagan (1956) in defining hyperinflation as a situation in which a country experiences a monthly inflation rate greater than 50% (an annualized rate of about 13,000%). Within each country's hyperinflation experience, Hanke and Krus identify the highest monthly inflation rate, the equivalent daily inflation rate during the month of the highest inflation rate and the required time for prices to double at the rate of the highest monthly inflation rate. Hungary experienced a highest daily inflation rate of 207% and Zimbabwean daily inflation soared as high as 98%. Excluding the French mandats and assignats issued during the French Revolution in the 1790s, all of the reported instances of hyperinflation have occurred since 1900 – during the era of fiat currency regimes. A key question for

investors is: is it possible to estimate the probability of hyperinflation under a fiat currency regime? There is obviously no easy way to answer this question but looking at history can be somewhat illuminating. It is also worth reemphasizing that even if one has a firm grasp on the probability of hyperinflation in a country that says nothing about whether or not the real price of gold will maintain its purchasing power during the hyperinflationary experience.

Exhibit 16. Hyperinflation Risk

Country	Start Year	End Year	Highest Daily Inflation	Country	Start Year	End Year	Highest Daily Inflation	Country	Start Year	End Year	Highest Daily Inflation
Angola	1994	1997	2.1%	Danzig	1922	1923	11.4%	Philippines	1944	1944	1.6%
Argentina	1989	1990	3.7%	Estonia	1992	1992	2.1%	Poland	1923	1924	4.5%
Armenia	1992	1992	1.9%	France	1795	1796	4.8%	Poland	1989	1990	1.9%
Armenia	1993	1994	5.8%	Georgia	1992	1992	3.7%	Russia	1992	1992	4.2%
Austria	1921	1922	2.8%	Georgia	1993	1994	3.9%	Soviet Union	1922	1924	3.9%
Azerbaijan	1992	1994	2.6%	Germany	1922	1923	20.9%	Srpska	1992	1994	64.3%
Belarus	1992	1992	3.2%	Germany	1920	1920	1.5%	Taiwan	1945	1945	5.5%
Belarus	1994	1994	1.4%	Greece	1941	1945	17.9%	Taiwan	1947	1947	1.4%
Bolivia	1984	1985	3.5%	Hungary	1923	1924	2.3%	Taiwan	1948	1949	2.5%
Bosnia	1992	1993	4.9%	Hungary	1945	1946	207.0%	Tajikistan	1992	1993	3.7%
Brazil	1989	1990	2.0%	Kazakhstan	1992	1992	3.0%	Tajikistan	1995	1995	1.7%
Bulgaria	1991	1991	2.7%	Kazakhstan	1993	1993	1.5%	Turkmenistan	1992	1993	5.7%
Bulgaria	1997	1997	4.2%	Kyrgyzstan	1992	1992	3.2%	Turkmenistan	1995	1996	1.6%
Chile	1973	1973	2.1%	Latvia	1992	1992	1.7%	Ukraine	1992	1994	4.6%
China	1943	1945	4.8%	Lithuania	1992	1992	1.5%	Uzbekistan	1992	1992	2.6%
China	1947	1949	14.1%	Moldova	1992	1993	4.2%	Yugoslavia	1989	1989	1.6%
Congo (Zaire)	1991	1992	2.6%	Nicaragua	1986	1991	4.4%	Yugoslavia	1992	1994	64.6%
Congo (Zaire)	1993	1994	4.3%	Peru	1988	1988	2.6%	Zimbabwe	2007	2008	98.0%
Congo (Zaire)	1998	1998	2.0%	Peru	1990	1990	5.5%				

Note: Data from Hanke and Krus (2012), Bernholz (2006) and McGuire (2010). These sources use a definition from Cagan (1956) that says hyperinflation exists when a country's monthly inflation rate exceeds 50%.

What broad observations arise from Exhibit 16? First, most of the countries listed could be described as minor, not major, countries. This does not mean that hyperinflation is more likely in a minor country than a major country since there are many more minor countries than there are major countries. It is hard to embrace the idea that a country could never experience a hyperinflationary episode, but accepting the possibility of a non-zero probability of hyperinflation is not the same thing as estimating a specific probability of hyperinflation. Second, many of the hyperinflationary situations seem to occur after stressful times in a country such as losing a war (Germany and Austria following World War I) or a significant change in the way that a society is governed. Third, many investors are concerned about high inflation -- and hyperinflation (at least 13,000% annualized inflation) is simply an extreme version of high inflation. According to Exhibit 16 Brazil had two hyperinflationary years, 1989 and 1990, yet during the two decades from 1980 to 2000, Brazil experienced many years of high inflation. And finally, even if the real purchasing power of gold rose in each of the historical instances of hyperinflation, it would be hard to figure out why that fortunate circumstance would hold in the future.

5. The “de facto gold standard/gold is money” argument

The Chief Executive Officer of Barrick, the world’s largest gold miner, once announced that gold is the “default global currency” (see Regent 2011. p. 4). In an overly literal sense, in a world in which no country has been on the gold standard since the Swiss ended convertibility in 2000, gold is not an “official” default currency (see Roth 1999). One characteristic of an official currency is that it is possible to pay taxes and purchase goods and services with the official currency. For most people, it is probably difficult, for instance, to pay income taxes with bars of gold or to get a soft drink from a vending machine with a quarter grain of gold.³⁴

While it is possible to debate whether or not the world is on a “de facto gold standard” it seems likely that this insight is basically another version of the “gold as an inflation hedge” argument. If the “de facto gold standard” argument is just another version of the “gold as an inflation hedge” argument, and if the “gold as an inflation hedge” argument provided no explanation for the high real price of gold, then it is reasonable that the “de facto gold standard” argument does little to explain variation in the real price of gold.

Why is no country on the gold standard? Some of the supposed possible benefits of a gold standard are: “life without inflation, an end to the business cycle, rational economic calculation in accounting and international trade, an encouragement to savings, and a dethroning of the government-connected financial elite” (see Rockwell, 2002). Others such as DeLong (1996) highlight a belief that a gold standard would result in loss of “normal” monetary policy options (such as the possible Phillips curve trade-off between inflation and employment and impart a recessionary and deflationary bias to countries with balance of payments deficits). This line of thought relates to the work of Eichengreen and Temin (2010) who note that during the Great Depression those countries that abandoned the gold standard earliest suffered the least economic harm. One view of the “de facto gold standard” argument is that the gold standard is the worst form of currency except for all those other forms that have been tried from time to time.³⁵

If a gold standard exists then gold is money, but the “gold is money” argument does not require the existence of a gold standard. The “gold is money” argument is essentially another way of stating the “constant price when measured in gold” argument. For instance, investors Brodsky and Quaintance (2009) and hedge fund manager Dalio (2012) have argued that “gold is money” without arguing that the world is on a de facto gold standard.³⁶ For Brodsky and Quaintance (2011), the “shadow price of gold”,

³⁴ Gold ATMs are available in a number of cities such as Boca Raton, FL. Some dispense gold coins and others dispense small gold bars.

³⁵ To paraphrase a comment Winston Churchill made in the House of Commons in 1947: “Democracy is the worst form of government, except for all those other forms that have been tried from time to time.”

³⁶ Dalio (2011) refers to the workings of financial markets and economies as an “economic machine”. By viewing the world as a machine Dalio seeks to find “timeless principles” that are independent of personal experience. Dalio’s view (2012) that “... almost all important events never happen in your life before...” can be viewed as an attempt to deal with the possible limits of induction from personal experience

the price they believe gold should trade for, is equal to the amount of the U.S. monetary base divided by the official gold holdings of the U.S. Given a monetary base of \$2.7 trillion and official U.S. gold holdings of 8,300 metric tons this yields a “shadow gold price” of about \$10,000 an ounce. Similarly, Dalio thinks that “the price of gold approximates the total amount of money in circulation divided by the size of the gold stock.” (see Cassidy 2011).³⁷

The “shadow price of gold” or “gold is money” argument is an intriguing concept. The “gold is money” argument is influenced by Milton Friedman’s (1963) assertion that “inflation is always and everywhere a monetary phenomenon” (p. 39). As a result the “gold is money” argument is essentially a restatement of the “gold as an inflation hedge” argument, and it should not be expected to more successfully explain the variation in the real price of gold. However, the “gold is money” or “shadow price of gold” argument yields a fairly specific prediction: a view of where the price of gold should be if the world actually accepted this specific view. From a U.S. standpoint, all that is needed to know where the price of gold is headed is a sense of the size of official U.S. gold holdings and the size of the U.S. “money supply”.

Exhibit 17 shows a time series of official U.S. gold holdings since 1870.³⁸ Official gold holdings peaked at about 20,000 metric tons following implementation of U.S. President Roosevelt’s Executive Order 6102, which outlawed the private ownership of gold in the U.S.³⁹ Official gold holdings entered a period of decline during the Eisenhower administration that continued until 1971, when U.S. President Nixon officially took the U.S. off the gold standard.⁴⁰ Since that time, the official gold holdings of the U.S. have been slightly greater than 8,000 metric tons.

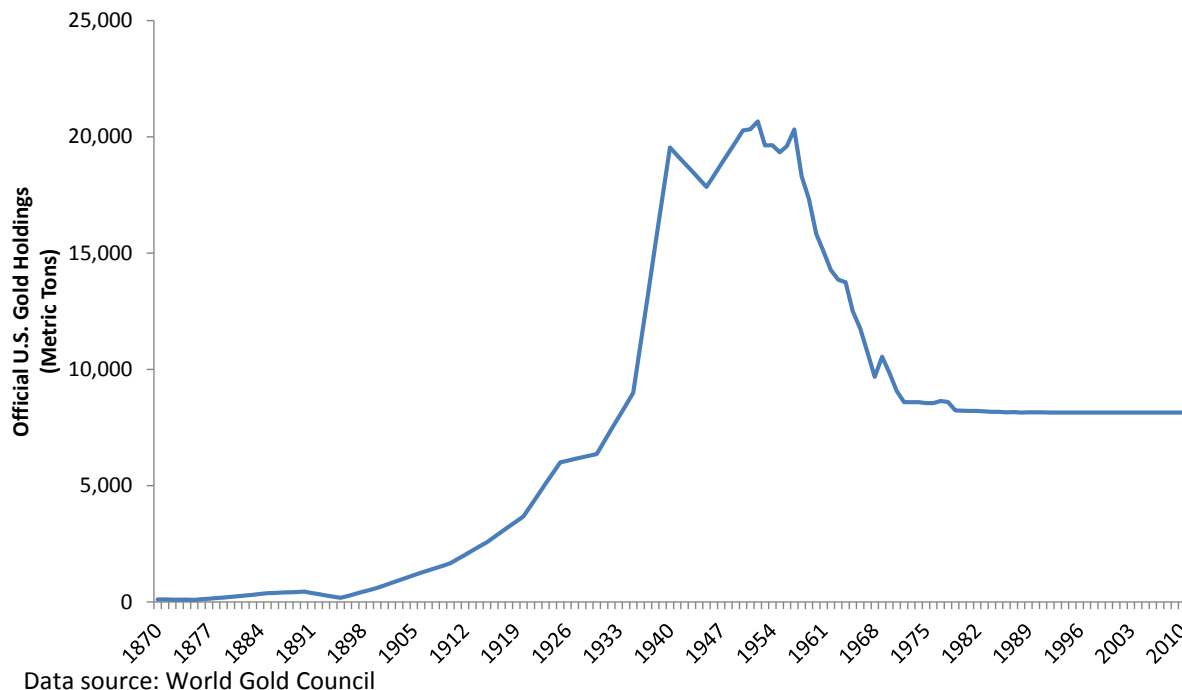
³⁷ It is possible to argue that ideally one should look at the total gold and money supplies of all countries over all time periods.

³⁸ Data from Green (1999).

³⁹ Signed April 5, 1933. The order was posted with the preamble “All persons are required to deliver ON OR BEFORE MAY 1, 1933 all GOLD COIN, GOLD BULLION, AND GOLD CERTIFICATES now owned by them to a Federal Reserve Bank, branch or agency, or to any member bank of the Federal Reserve System.” The notice (signed by the Secretary of Treasury) also detailed the criminal penalties for violating the order “\$10,000 fine or 10 years imprisonment, or both”. The Secretary of the Treasury, William H. Woodin, was a coin collector, and inserted an exception in Section 2 of the Order to exempt “gold coins having a recognized special value to collectors of rare and usual coins”. Note that the \$10,000 fine was very punitive. Using the ratio of 2011 and 1933 per capita nominal GDPs, the fine is equivalent to \$1.1 million in today’s terms.

⁴⁰ In the speech of August 15, 1971, President Nixon declared: “I have directed Secretary Connally to suspend temporarily the convertibility of the dollar into gold or other reserve assets, except in amounts and conditions determined to be in the interest of monetary stability and in the best interests of the United States.” See Nixon (1971). Note this was not an Executive Order. Executive Order 11615 signed on August 15, 1971 dealt with wage and price controls. Proclamation 4074 on August 15, 1971 dealt with tariffs. Ironically, Proclamation 4071 on August 2, 1971 established “National Clown Week”.

Exhibit 17. Official U.S. Gold Holdings (Metric Tons)



The “shadow price of gold” is simply the “money supply” divided by the official gold holdings of the U.S. There is, of course, some ambiguity as to which definition of the money supply to use. The Federal Reserve currently publishes three versions of the “money supply”: the monetary base, M1 and M2. Furthermore, the Federal Reserve once published an M3 money supply number, but M3 was discontinued in 2006. Using the monetary base as the money supply value with which to calculate the “shadow price of gold” yields a current gold price target of about \$10,000 an ounce. Using M1 as the money supply value with which to calculate the “shadow price of gold” yields a current gold price target of about \$8,000 an ounce. Using M2 as the money supply value with which to calculate the “shadow price of gold” yields a current gold price target of about \$37,000 an ounce.

These “shadow prices of gold” may seem alarming since each of the “shadow prices” is much higher than the current price of gold. Additionally, part of the “shadow price of gold” argument is that the higher the “shadow price of gold” is relative to the market price of gold the greater the latent inflationary pressures faced by the U.S.

There are a few obvious challenges with this line of reasoning. First, in the U.S. there has been an abundance of research that finds little evidence of a link between money supply growth rates and inflation rates.⁴¹ Second, why just focus on the U.S.? The U.S. official holdings are only about 5% of the world gold supply. In summary, the shadow price of gold is an engaging concept but because it relies upon a vague model (the theory of exchange) and poorly defined monetary aggregates; it does not help us understand the underlying dynamics of the gold price.

⁴¹ Anderson et al. (2003) noted “it is commonplace today for monetary policy analysis, both in theory and practice, to be conducted without reference to the monetary base or other monetary aggregates” (p. 39).

6. The “gold is underowned” argument

Of the six arguments to own gold, the “gold is underowned” argument offers probably the best way to understand why the real price of gold might vary. In order to explore the nuances of the “gold is underowned” argument, it is important to address a number of subsidiary issues: how much gold exists, who owns the gold, and have demand trends changed over time. Of course the “gold is underowned” argument is somewhat ambiguous since all of the gold in the world is currently owned by someone (see Madura 2011). In its simplest version, the “gold is underowned” argument asserts that not enough people own gold, that maybe everyone should own some gold and the move towards universal gold ownership should cause the nominal and real prices of gold to skyrocket.

6.1 The stock of gold

How much gold is there? Gold exists both above and below the ground. Above ground gold is gold that has already been mined. Below ground gold is gold ore that has yet to be mined. No one knows exactly how much above ground gold exists. The World Gold Council (2012b) estimates that 171,300 metric tons of gold have been mined since the beginning of civilization. The World Gold Council estimate provides a convenient anchor for measuring the number of tons of gold but given the Herculean task of enumerating gold holdings “since the beginning of civilization” the actual, unknown, number could be much lower or higher. Buffett (2011) points out that 171,300 metric tons of gold would create a cube measuring 67 feet on each side. The U.S. Geological Survey (USGS, 2011) suggests that there might be 51,000 metric tons of “below ground” gold reserves that could be mined in the future. If the USGS estimate is correct then over 76% of the world’s actual and potential gold has already been mined. This balance of already-mined-gold relative to yet-to-be-mined-gold once prompted the CEO of Barrick Gold to speculate about the possibility of entering a period of “peak gold”.⁴² The estimate of below ground gold reserves is more uncertain than the estimate of above ground already mined gold. The USGS reserve estimate is a best efforts estimate of how much gold might be mined in the future given existing technology.⁴³

Of course, future technological change might usher in opportunities to mine more than the 51,000 metric tons of gold reserves. For instance, there is considerable interest in near Earth asteroids given an important study by Brennan and McDonough (2009) that argues that much of the Earth’s precious metals are a result of asteroid collisions. The near-Earth asteroid 433 Eros might contain up to 125,000 metric tons of gold (see Whitehorse 1999). The website asterank.com catalogues 580,000 asteroids in our solar system and provides estimates of both the mineral value and the estimated profit from harvesting. There are currently 15 near-Earth asteroids with expected profit greater than \$1 trillion according to the

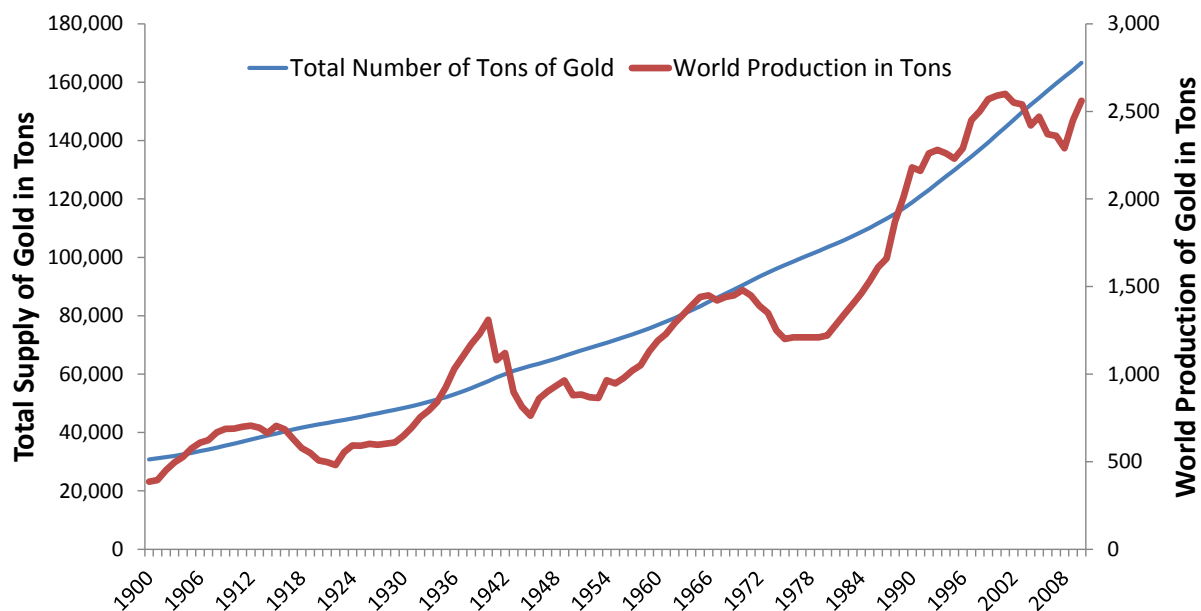
⁴² See Evans-Pritchard (2009). The fact that a CEO of the world’s largest gold mining company once referred to “peak gold” does nothing to demonstrate the existence of “peak gold”. It is simply an observation that a CEO used a colorful metaphor to illustrate his personal view that the supply of gold was likely to be constrained in the future.

⁴³ Gold mining company Barrick reported 2011 cash gold mining costs of \$460/ounce and expects 2012 cash gold mining costs in the range of \$520-560/ounce (<http://www.barrick.com/company/profile/default.aspx>).

website.⁴⁴ Closer to home, perhaps someday in the future someone will figure out how to implement Nobel prize winner Fritz Haber's plan to electrochemically recover some of the estimated 8 million tons of gold in the world's oceans (see Miller 2012).

The USGS keeps track of estimated annual global gold mine production. Exhibit 18 presents the USGS gold mine production time series, which starts with the year 1900. Annual global mine production has averaged about 2,500 tons per year for the last few years. In 1900, about 30,000 metric tons of gold had already been mined. This means that over 80% of the current above ground supply of gold has been mined since 1900 and that the above ground stock of gold has increased by about 1.5% per annum. If global production of gold continues at a rate of 2,500 metric tons a year, and if the USGS is correct in its estimate that there are only 51,000 metric tons of exploitable gold reserves, then gold production will be exhausted in about 20 years.

Exhibit 18: Annual Gold Mine Production and the Total Supply of Gold



Data source: U.S.G.S.

There are basically three uses for the above ground supply of gold: jewelry, investment and technology. The investment category encompasses the holdings of central banks, individuals and other institutions. Jewelry claims about 50% of the outstanding above ground stock of gold, central banks and private investment each claim about 18% of the above ground stock of gold and fabrication accounts for about 12%.

⁴⁴ Two companies have been formed to mine asteroids: Planetary Resources (supported by Larry Page, Eric Schmidt and James Cameron) (<http://planetaryresources.com>) and Deep Space Industries (<http://deepspaceindustries.com>).

6.2 Demand and supply

The World Gold Council tracks annual demand for gold from the jewelry, investment (central bank and private investment) and technology (fabrication) sectors. Exhibit 19 provides a sense of how the demand for gold from these sectors has varied since 2001. As the price of gold per ounce rose from \$279 in 2001 to \$1,567 in 2011, the annual demand from the jewelry sector declined from 3,009 metric tons in 2001 to 1,963 metric tons in 2011, annual demand from the investment sector rose from 357 metric tons to 1,641 metric tons and annual demand from the technology sector barely changed going from 363 metric tons to 464 metric tons. On average gold mine production was about 2,500 metric tons per year. The difference between production and demand was made up from scrap, sourced primarily from the jewelry and technology sectors.

Exhibit 19. Demand and Supply of Gold

<u>Year</u>	<u>Demand (Metric Tons)</u>			<u>Production</u>	<u>Implied Scrap</u>	<u>U.S. Dollar</u>
	<u>Jewelry</u>	<u>Investment</u>	<u>Technology</u>	<u>(Metric Tons)</u>	<u>(Metric Tons)</u>	<u>Gold Price</u>
2001	3,009	357	363	2,600	1,129	\$279
2002	2,662	343	358	2,550	813	\$348
2003	2,484	340	382	2,540	666	\$416
2004	2,616	485	414	2,420	1,095	\$438
2005	2,718	601	433	2,470	1,282	\$519
2006	2,298	676	462	2,370	1,066	\$638
2007	2,417	688	465	2,360	1,210	\$838
2008	2,192	1,181	439	2,290	1,522	\$884
2009	1,760	1,360	373	2,450	1,043	\$1,096
2010	2,060	1,333	420	2,560	1,253	\$1,421
2011	1,963	1,641	464	2,821	1,247	\$1,567
Price elasticity	-0.24	0.98	0.10	0.01	0.20	Data source: World Gold Council

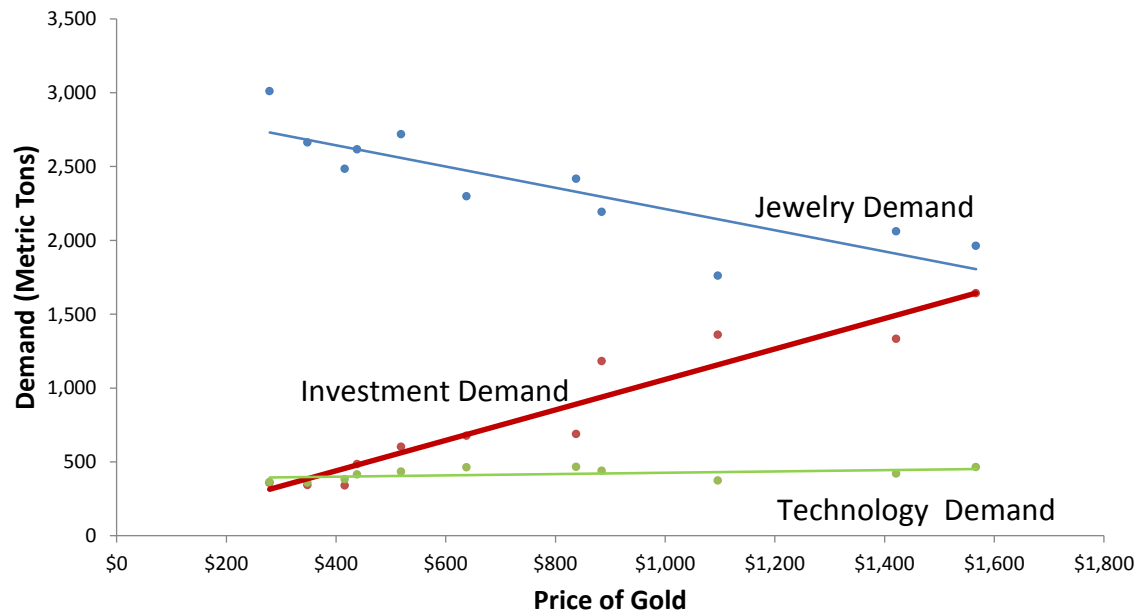
Exhibit 19 also provides a rough approximation of the price elasticity of demand for gold. This measures the percentage change in demand for gold in response to a 1% change in the price of gold. The estimate of jewelry's price elasticity of demand is only -0.24. This means that a 10% increase in the price of gold is associated with less than a 2.4% decrease in demand for gold. However, this is likely overstated because we do not control for wealth increases and population changes.⁴⁵ The price elasticity of investment demand is *positive* and has a value of 0.98. This means that a 10% increase in the price of gold was met with about a 9.8% increase in the investment demand for gold. The price elasticity of technology demand was close to zero. Interestingly, both the production as well as the supply of scrap gold also is insensitive to the price of gold.

Exhibit 20 plots investment demand, jewelry demand and technology demand relative to the U.S. dollar price of gold over the time period 2001 to 2011. The investment demand for gold seems to rise with the

⁴⁵ Our elasticity estimates are based on a regression of the log of a variable, such as the log of the investment demand for gold, on the log of the gold price. Batchelor and Gulley (1995) estimate the price elasticity of demand for gold jewelry to be between -1.0 and -0.5.

price of gold. This upward sloping investment demand is striking. While it is possible that the upward sloping investment demand for gold is an example of a Giffen good or a Veblen good, there are two other explanations that might be more plausible: the impact of momentum-based investors and “too much” demand, totally divorced from a momentum motive, chasing “too little” supply.

Exhibit 20. Demand Price Elasticity



Data source: World Gold Council

Asness, Moskowitz and Pedersen (2012) have written extensively about the momentum effect, the possibility of an attractive financial pay-off from buying an asset that has performed well in the past. Research by Asness and others over the last 20 years has created an environment that is increasingly accepting of momentum-based strategies. There are at least two ways to think about the rationale for momentum investing: some view it as a pay-off from the slow transmission of meaningful fundamental information in a somewhat efficient market and others view momentum as a proxy for expected returns in an efficient market. While there is no precise estimate of how much capital has been allocated to momentum-based strategies but it is fair to believe that there is more capital allocated to momentum based strategies today than in the past.

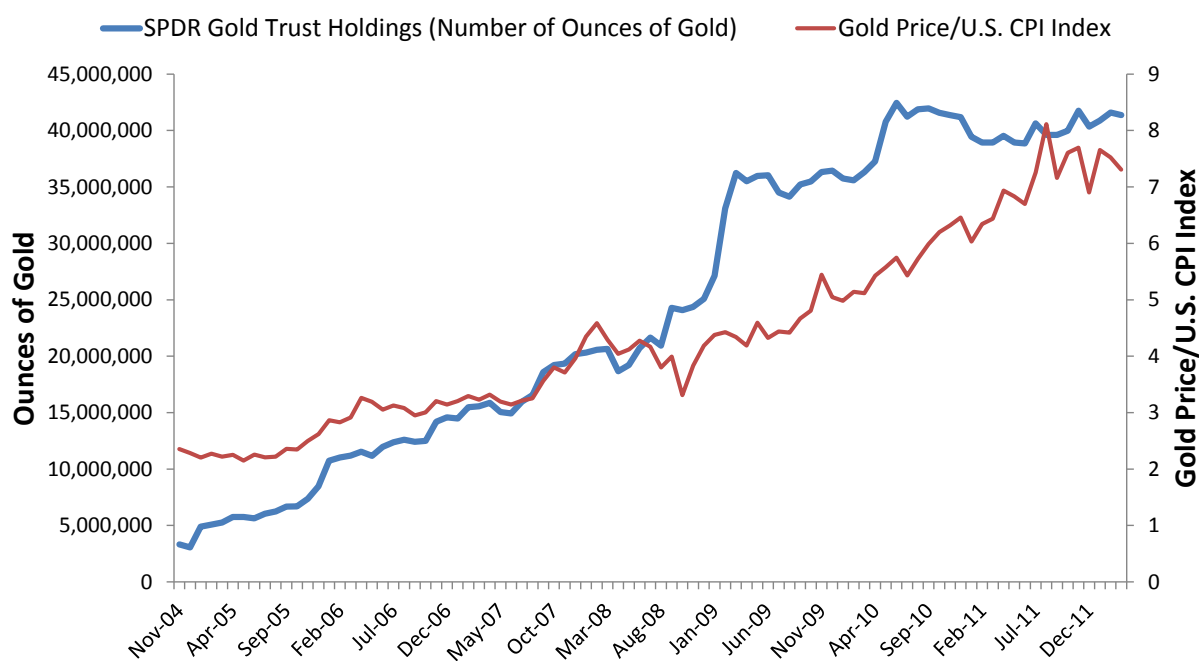
A momentum investor faces an upward sloping demand curve: the higher the past return of an asset the higher momentum investor's demand for the asset. There is another type of momentum investor, one who attempts to replicate the pay-off from a call option. As Perold and Sharpe (1995) show, an investor pursuing a call option replication strategy will buy more of an asset as its price rises and sell the asset as its price falls.

It is worth noting that while momentum may work for a talented portfolio manager, it is questionable that momentum can work for most people. The U.S. residential housing “bubble” can be thought of as a momentum-based strategy in which many people participated. For a while, there was an upward sloping demand curve for residential housing -- the higher the average price of housing the higher the demand

for housing, but ultimately things changed. The “internet stock bubble” at the turn of the century is another possible example of a momentum based market characterized by an upward sloping demand curve for “internet stocks”. A key point is that while an upward sloping demand curve is inconsistent with certain textbook microeconomic principles, it is consistent with the presence of momentum investors.

Exhibit 21 displays the trajectory of the real price of gold and the physical gold holdings of the world’s largest gold exchange traded fund, the SPDR Gold Trust. The SPDR Gold Trust, ticker symbol GLD, was launched in 2004. Since then its holdings of physical gold (stored in vaults in London) have grown from nothing to over 1,000 metric tons. GLD currently holds a little less than 1% of the world’s known supply of above ground gold. GLD’s purchases of gold represent about 15% of the total investment demand for gold since 2004. As we will soon see, this ETF has more gold than the official holdings of China. Exhibit 21 illustrates a rising amount of gold investment as the price of gold rises, which is consistent with an upward sloping demand curve for gold. While momentum investing is consistent with an upward sloping demand curve from traditional financial investors, in which a rising price leads to rising demand, it is also possible that there has been too much “central bank momentum” gold demand, relative to supply, and that excess demand has driven the real price of gold to historical high levels.

Exhibit 21. The Real Price of Gold and SPDR Gold Trust Gold Holdings



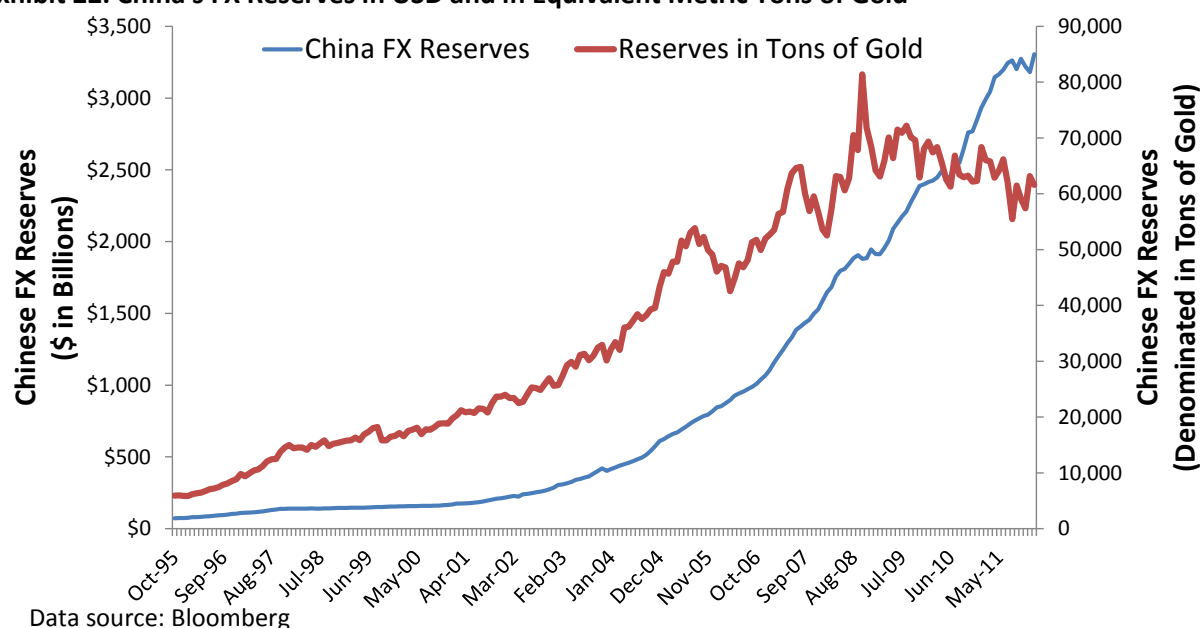
Data source: Bloomberg

6.3 BRICs and gold

One possible source of “too much demand” for gold might be the efforts of the Chinese government to reduce the size of its U.S. dollar foreign exchange reserves. Exhibit 22 shows the reported size of Chinese foreign exchange reserves since 1995 and the hypothetical metric ton reserve equivalent. For instance in 1995, if 100% of China’s foreign exchange reserves had been invested in gold China would have owned about 6,000 tons of gold (assuming no price impact). Using the same sort of hypothetical framework, China’s current foreign currency reserves would “buy” about 66,000 tons of gold at current prices. This would represent about one-third of the total above ground stock of gold.⁴⁶ Of course in this hypothetical and simplified example of China pursuing an “all in” gold allocation, the gold purchases needed to effect this foreign exchange reserve reallocation would likely drive the price of gold higher. For a fixed amount of foreign exchange reserves, the higher the price of gold the fewer tons of gold that must be purchased.

There is another important nuance. Given that the above ground stock of gold has recently increased about 1-2% per annum, a move to acquire up to one-third of all the gold in the world would mean that the current owners of gold would have to be offered a price for their gold that makes them happy to part with their gold. Erb and Harvey (2012b) and Zhang (2012) point out that massive gold accumulation by the Chinese will do much to increase the wealth of existing, largely non-Chinese, owners of gold. In this sense, if there is a wealth effect, Chinese gold purchases could marginally stimulate global GDP outside China. It is entirely possible that the current owners of gold know nothing about the value of gold and only the Chinese know the true value of gold. In that case the current owners of gold will one day regret parting with the gold they sell to the Chinese. Or it could be that Chinese accumulation of gold could ultimately resemble the attempts of the Hunt Brothers to corner the silver market in 1980.

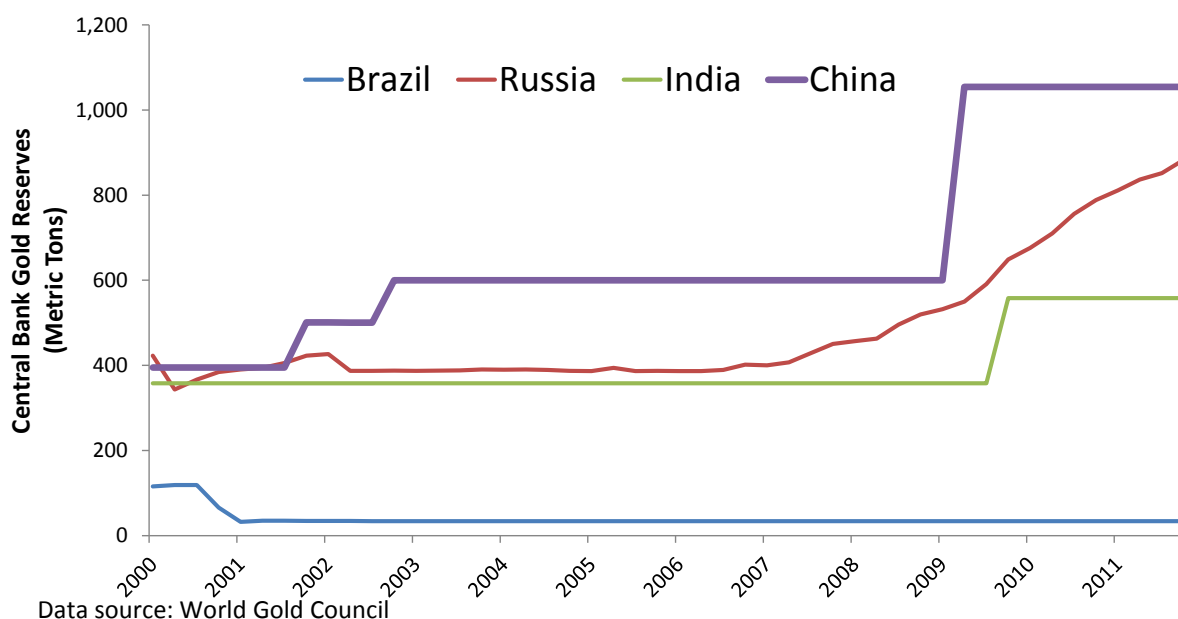
Exhibit 22. China's FX Reserves in USD and in Equivalent Metric Tons of Gold



⁴⁶ The ratio of gold reserves to total foreign exchange reserves is only 1.7% in China. This compares to 76.1% in the U.S. and 73.2% in Germany. See World Gold Council (2012c).

Have the Chinese been buying gold? Exhibit 23 shows World Gold Council estimates of the central bank gold holdings for Brazil, Russia, India and China, the BRIC countries. China's estimated central bank gold holdings are currently over 1,000 metric tons. There is no reason to believe that Chinese central bank gold holdings are more accurately reported than any other Chinese government statistic. Even though China's gold holdings have risen sharply over the last few years, as just noted, China holds less gold than the SPDR ETF. China's gold holdings may still be rising.⁴⁷

Exhibit 23. BRIC Central Bank Gold Holdings

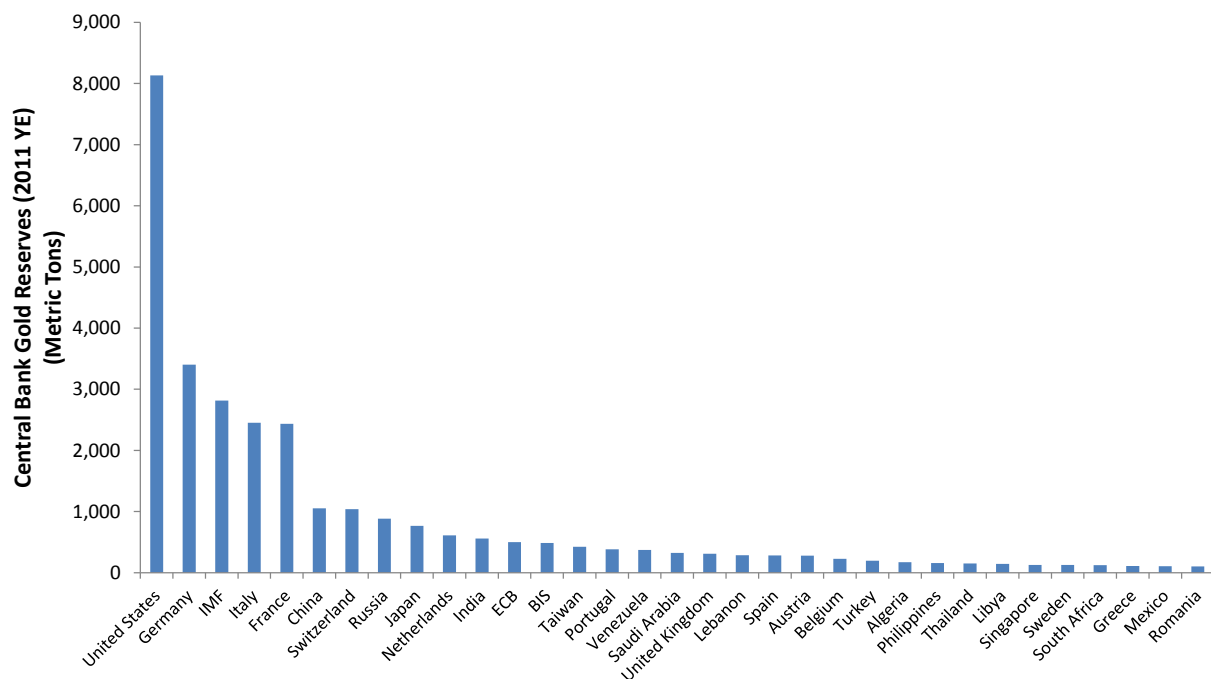


6.4 Central banks

Exhibit 24 provides a snapshot of estimated central bank gold holdings of 33 official entities holding more than 100 tons of gold. Overall, the central banks of the world hold a little over 30,000 metric tons of gold, somewhat less than 20% of the estimated above ground gold stock. The U.S., viewed by some as a profligate debtor country, has about 8,000 tons of gold, and Switzerland, viewed by some as a model of financial probity, has a little over 1,000 tons of gold.

⁴⁷ China is perceived to be the world's largest producer of gold with possible annual gold mine output of about 350 tons in 2011. The Chinese government could conceivably increase its gold holdings by purchasing all of China's gold output. Is it in China's interest to purchase gold in secret? Perhaps. It is also possible to ask what, if anything, China might gain by disclosing the size of its gold holdings. It is hard to believe that reported Chinese government gold holdings or Chinese gold output are reported any more reliably than other official Chinese statistics.

Exhibit 24. Central Bank Gold Reserves



Data source: World Gold Council

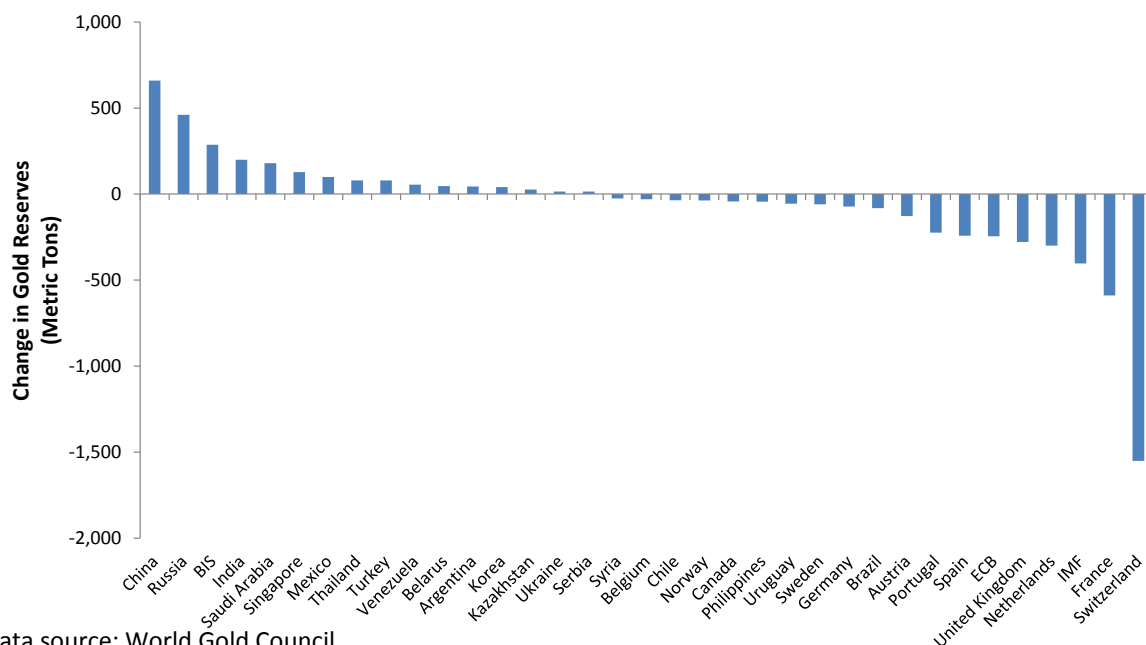
Exhibit 25 profiles the entities that have either purchased or disposed of the largest gold holdings since 2000. China, Russia and Saudi Arabia have been enthusiastic purchasers of gold and the Netherlands, France and Switzerland lightened up on their gold holdings. For many years the central banks of the Western countries viewed gold as a “barbarous relic” that cluttered up their balance sheets.⁴⁸ Some Western central banks sought to lighten up on their gold holdings but the lack of liquidity in the gold market forced them into a series of Central Bank Gold Agreements (CBGA). The essence of the CBGAs was that the central banks that wished to sell gold collectively agreed that they would not sell more than some set amount of gold in any one year. Depending upon the terms of the specific CBGA, the typical amount of sales was limited to 400 or 500 metric tons per year. The motive for limiting the number of tons of gold sold in any one year was a belief that the gold market could not absorb more gold sales without the price of gold falling significantly.

Just as OPEC attempts to keep oil prices as high as possible by matching supply to demand, the CBGAs were an attempt to prevent the price of gold from collapsing by matching supply to demand. Western country CBGA gold sales have declined substantially over the last few years as the central banks of the Western countries have reassessed the wisdom of selling their gold holdings in an environment characterized by rapidly rising gold prices. The CBGAs existed because large holders of gold realized that fairly small gold sales (400 tons annually) could upset the price of gold in what supposedly is a large market (171,300 tons). The CBGAs focused on limiting the negative price impact of “excess supply”. At

⁴⁸The “barbarous relic” phrase was made popular by Keynes. To be precise, Keynes was referring to the gold standard not gold itself: “In truth, the gold standard is already a barbarous relic”, see Keynes (1924, p. 172).

the margin, for the last few years the gold market has been impacted by central bank “excess demand” and it is possible that this “excess demand” could persist well into the future.

Exhibit 25. Change in Central Bank Gold Reserves 2011 to 2000



6.4 What if emerging markets emerge?

The U.S. is the world’s largest debtor country and it has the world’s largest gold reserve. Switzerland is a model country for financial conservatism. How might the size of BRIC gold holdings evolve over time if they diversify their central bank holdings in a manner similar to either the U.S. or Switzerland?

Exhibit 26 examines this question by looking at two possible “keeping up with the Joneses” measures, gold holdings relative to the size of a country’s GDP as well as relative to its population. The BRIC countries currently hold 2,457 tons of gold. If these four countries each targeted the same ratio of gold holdings relative to GDP as exists in the U.S. then the gold holdings of the BRIC countries would rise to 6,233. If the BRIC countries targeted the U.S. ratio of gold holdings relative to population, then the BRIC countries would hold 77,811 tons of gold. If the BRIC countries targeted the Swiss ratio of gold holdings relative to GDP then the BRIC countries would hold 22,191 metric tons of gold. And finally, if the BRIC countries targeted the Swiss ratio of gold to population then the BRIC countries would own 415,812 tons of gold. Of course, this would suggest the challenging prospect of the BRIC countries owning more than twice the entire amount of gold in the world. Interestingly, if a country pursues a “keeping up with the Joneses” approach to owning gold, targeted holdings based on the size of population or GDP will not be affected by changes in the price of gold.

Exhibit 26. BRICs as Developed Markets and Gold

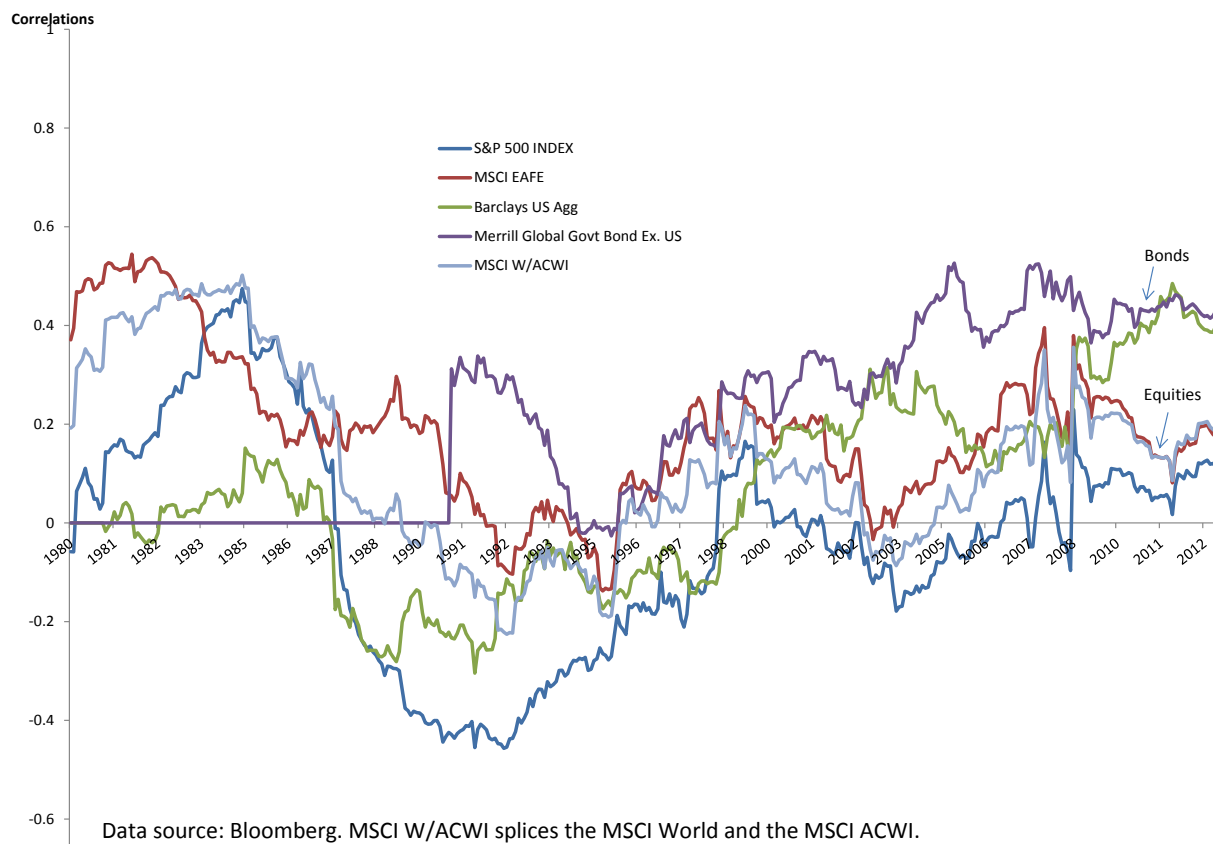
	2010	2010	2010	2010	2010	Estimated Reserves If move to US Gold/GDP Ratio (m tons)	Estimated Reserves If move to US Gold/Pop Ratio (m tons)	Estimated Reserves If move to CH Gold/GDP Ratio (m tons)	Estimated Reserves If move to CH Gold/Pop Ratio (m tons)
	GDP (US \$ Billions)	Population (Millions)	Central Bank Gold Reserves (m tons)	Gold/GDP Ratio	Gold/Pop. Ratio				
U.S.	14,582	317.6	8,133	0.56	25.61	8,133	8,133	28,957	43,464
Switz.	524	7.6	1,040	1.99	136.85	292	195	1,040	1,040
Brazil	2,088	199.5	34	0.02	0.17	1,165	5,109	4,146	27,302
Russia	1,480	140.4	811	0.55	5.78	825	3,596	2,939	19,214
India	1,729	1,316.3	558	0.32	0.42	964	33,709	3,433	180,139
China	5,879	1,382.2	1,054	0.18	0.76	3,279	35,397	11,673	189,157
Total			11,630			14,659	86,139	52,188	460,316
BRIC Only			2,457			6,233	77,811	22,191	415,812
CBGA Years						9	188	49	1033

Data source: Bloomberg and World Gold Council

6.5 Gold in a diversified portfolio

There are at least two reasons one might consider gold in a diversified portfolio. First, gold has low correlations with other tradable assets. Exhibit 27 shows five-year rolling correlations of gold and a number of standard global equity and bond market benchmarks. While these correlations vary through time, they are on average low. The recent equity correlations with the MSCI ACWI, MSCI EAFE and the S&P 500 are around 0.2. The fixed income correlations are somewhat higher. The correlations with the Barclay's Aggregate and the Merrill Global Government ex U.S. are about 0.4. Historically, the fixed income correlations have been lower. The message here is that, on average, gold has low correlations with equity and fixed income benchmark returns. However, the correlations are unstable.

Exhibit 27. Gold's Correlation with Global Equity and Fixed Income Benchmarks



A second reason for holding gold in a diversified portfolio has to do with one of the key insights of the Capital Asset Pricing Model: investors should hold the “market portfolio”. This is one way to think of the “gold is under owned” argument. For instance, Exhibit 29 shows that the market value of all the stocks in the world was recently about \$48 trillion (the Bloomberg World Exchange Market Capitalization index) and the market value of all the bonds in the world was about \$41 trillion (the Barclays Capital Global Aggregate). This means that the “global stock and bond market” is about 54% stocks and 46% bonds. While some individual investors may own more than 46% bonds in their portfolios and some more than 54% stocks in their portfolios, the “average investor” has a 54%/46% stock-bond mix (even if no individual investor is an “average investor”). As a result, one portfolio asset allocation recommendation is that, on average, an investor’s portfolio should look like “market capitalization weights” because that is the aggregate market reality. Now for all intents and purposes, the average stock and bond investor owns about 0% gold. In a world in which all the above ground gold is already owned, how much gold should “market capitalization oriented stock and bond” investors own?

Depending upon how one defines the size of the gold market there are at least three “float-adjusted market capitalization weight” answers. One way to think about the size of the gold market is to think about the value of all the gold in the world (about \$9 trillion). Another is to think about the gold just held by central banks and other investors (about \$3.5 trillion) and yet another way is to think about the gold held by “investors” only (about \$1.8 trillion).

Roll (1977) points out that it is easier to invoke the phrase “market portfolio” than it is to get agreement on how to define and measure the “market portfolio”. Exhibit 29 shows that if the “gold market” is taken to be the non-central bank investment amount then this would represent about 2% of the total market capitalization of a narrowly defined “market portfolio” consisting of stocks, bonds and gold. There is good news and bad news in this measure that highlights some of the challenges of creating macro-consistent portfolio allocations. The good news is that the 2% represents already existing investment by what the World Gold Council calls investors, so it is possible to think in an abstract way that the world already follows a 53%/45%/2% stock/bond/gold allocation model. If this is the case then “investors” already own all the gold they need. The bad news is that the idea that investors in aggregate already have a “market allocation” to gold probably seems odd to those who argue that gold is “underowned”, such as Ray Dalio.

There are most likely very few pension plans, defined contribution plans or stock and bond investors pursuing what in aggregate looks like a 53%/45%/2% stock/bond/gold allocation. If these “underallocated” investors were to invest in gold they might use Exhibit 29 as a guide in moving to a 2% allocation to gold. Yet, if the data from the World Gold Council are to be trusted, other investors have already laid claim to this gold. Given the small size of the gold market relative to the stock and bond markets, this 2% portfolio allocation to gold would represent 19% of the gold market, or about 30,000 metric tons of gold. Given the illiquidity of the gold market indicated by the existence of the Central Bank Gold Agreements and a seeming positive elasticity of investment demand, a broad-based move by “underallocated” investors to a 2% portfolio allocation to gold would probably result in much higher nominal gold prices. What would happen if the price of gold doubled and the value of the stock and bond markets stayed the same? Gold’s target portfolio weight would rise to about 4% and the target number of tons of gold to own would be unchanged. What would happen if the price of gold fell by 50%? Gold’s target weight would decline to about 1% and the target number of tons of gold to own would be unchanged. Finally, if a 2% allocation were pursued by buying no more than 400 tons of gold per year it would take in excess of 70 years to complete the 2% allocation.

Exhibit 29: Gold in Asset Allocation

	"Global" Market Capitalization (US \$ Trillions) Available Gold			"Global" Market Capitalization (Share of Total) Available Gold		
	All Gold	Central Bank & Investment	Only Investment	All Gold	Central Bank & Investment	Only Investment
Global Equity	\$51.40	\$51.40	\$51.40	50.5%	53.5%	54.5%
Global Fixed Income	\$41.20	\$41.20	\$41.20	40.5%	42.9%	43.6%
Gold	<u>\$9.14</u>	<u>\$3.40</u>	<u>\$1.79</u>	<u>9.0%</u>	<u>3.5%</u>	<u>1.9%</u>
Total	<u>\$101.74</u>	<u>\$96.00</u>	<u>\$94.39</u>	<u>100.0%</u>	<u>100.0%</u>	<u>100.0%</u>
Required Ton	Data source: Bloomberg			171,300	63,614	33,588
Percent of Existing Gold Stock				100%	37%	20%
CBGA-like Annual Purchases (Years)				417	155	82
Likelihood				Impossible	Impractical	Unlikely

The “gold is underowned” argument has probably been an important driver of the increase in the real price of gold. A rising level of gold investment by emerging market central banks in an illiquid gold market could lead to a rising real price of gold. A rising level of “keeping up with the Joneses” motivated gold purchases could lead to a rising real price of gold. The rising real price of gold could act as a signal to momentum based investors to allocate capital to gold. As long as some central banks are insensitive to the real price they pay for gold the possible move into gold could drive the real price of gold much higher.

7. Conclusions

Investing in gold is potentially a way to maintain purchasing power. The purchasing power of gold rises and falls as the real price of gold rises and falls. Investing in gold entails a bet as to the future real price of gold, whether or not an investor even thinks about the bet. It is a fact that the real price of gold is very high compared to historical standards. A number of reasons have been advanced to explain the current real price of gold – some of these stories argue the real price of gold is too high and others suggest the real price could go even higher. The goal of this paper is to analyze these competing narratives.

We find little evidence that gold has been an effective hedge against unexpected inflation whether measured in the short term or the long term. The gold as a currency hedge argument does not seem to be supported by the data. The fluctuations in the real price of gold are much greater than foreign exchange rate changes. We suggest that the argument that gold is attractive when real returns on other assets are low is problematic. Low real yields, say on TIPS, do not mechanically cause the real price of gold to be high. While there is possibly some rational or behavioral economic force, perhaps a fear of inflation, influencing variation in both TIPS yields and the real price of gold, the impact may be more statistically apparent than real. We also parse the safe haven argument and come up empty-handed. We examine data on hyperinflations in both major and minor countries and find it is certainly possible for the purchasing power of gold to decline substantially during a highly inflationary period. When the price of gold is high in one country it is probably high in other countries. Keynes pointed out “that the long run is a misleading guide to current affairs”. Even if gold is a “golden constant” in the long run, it does not have to be a “golden constant” in the short run. Conversely, current affairs are possibly a misleading guide to the long run.

We analyze the demand for and the supply of gold in search of “new era” explanations for the current and future real price of gold. The USGS estimates that using current technology only 20 years supply of gold exists below the ground. Indeed, gold mine output has not significantly increased even though the price of gold has substantially appreciated over the past decade. A common commodity cliché is that “the best cure for high prices is high prices”. Yet the deluge of price-incented-supply conjured up by this bit of wisdom has yet to manifest itself. Interestingly, the investment demand for gold has increased dramatically as the price of gold has gone up. A single exchange traded fund, GLD, holds more gold than the official reserves of China. Our paper asks the question of what happens if key emerging market countries boost their gold holdings, on both a per capita and per GDP basis, to levels that more closely reflect the experience of more developed markets? Our calculations suggest that such a move would exert substantial upward pressure on the nominal and real price of gold. Finally, we examine the asset allocation problem of the average investor in a world subject to macro-consistency. The estimated value of all the gold in the world is about 9% of today’s combined capitalization of world stock and bond markets. If we look at investible gold, the share is about 2%. It is also a fact that very few investors hold 2% of their portfolio in gold. A widespread move to increase gold in diversified portfolios would lead to upward pressure on the real and nominal price of gold.

In the end, investors are faced with a golden dilemma. Will history repeat itself and the real price of gold revert to its long-term mean – consistent with a “golden constant”? Alternatively, have we entered a new era, where it is dangerous to extrapolate from history? Those are the uncertain outcomes that gold investors have to grapple with and the passage of time will do little to clarify which path investors should follow.

References

- Adkins, Lesley and Roy A. Adkins. 1998. *Handbook to Life in Ancient Rome*. Oxford University Press, New York.
- Anderson, Richard G., Robert H. Rasche and Jeffrey Loesel. 2003. "[A Reconstruction of the Federal Reserve Bank of St. Louis Adjusted Monetary Base and Reserves](#)." *Federal Reserve Bank of St. Louis Review*, (September): 39-69.
- Arends, Brett. 2009. "[What Price Suits Gold](#)." *Wall Street Journal*, September 16.
- Ash, Adrian. 2009. "[The Golden Constant](#)."
- Asness, Clifford S. 2003. "Fight the Fed Model", *Journal of Portfolio Management*, vol. 30, no. 1: 11-24.
- Asness, Clifford S. 2011. "Equity Risk Premiums (Take 15 Series)", CFA Institute.
- Asness, Clifford S. 2012. "[An Old Friend: The Stock Market's Shiller P/E](#)", AQR working paper.
- Asness, Clifford S., Tobias J. Moskowitz and Lasse Heje Pedersen. 2012. "[Value and Momentum Everywhere](#)." *Journal of Finance*, forthcoming.
- Bank for International Settlements. 1970. [Annual Report](#).
- Barro, Robert J. and Sanjay P. Misra, 2013, Gold Returns, Working paper 18759, National Bureau of Economic Research: Cambridge, MA.
- Barsky, Robert B. and Lawrence H. Summers. 1988. "Gibson's Paradox and the Gold Standard", *Journal of Political Economy*, vol. 96, no. 3: 528-550
- Batchelor, Roy and David Gulley, 1995. "Jewelry Demand and the Price of Gold." *Resources Policy*, vol. 21, no. 1 (March): 37-42.
- Baur, Dirk G. and Brian Lucey. 2010. "[Is Gold a Hedge or a Safe Haven: an Analysis of Stocks, Bond and Gold](#) ." *Financial Review* vol. 45, no. 2: 217-229.
- Bekaert, Geert and Xiaozheng Wang. 2010. "[Inflation Risk and the Inflation Risk Premium](#)", *Economic Policy*, vol. 25, no. 64: 755-806.
- Bernholz, Peter. 2006. *Monetary Regimes and Inflation: History, Economic and Political Relations*. Cheltenham: Edward Elgar Publishing.
- Bernstein, Peter. 2000. *The Power of Gold: The History of an Obsession*. New York: Wiley.
- Black, Fischer. 1995. "Universal Hedging", *Financial Analysts Journal*, vol. 51, no. 1 (January/February): 161-167.
- Bordo, Michael D. and Finn E. Kydland. 1995. "The Gold Standard as a Rule: An Essay in Exploration", *Explorations in Economic History* vol. 32, no. 4: 423-464.
- Brenan, James M. and William F. McDonough. 2009. "Core Formation and Metal-Silicate Fractionation of Osmium and Iridium from Gold." *Nature Geoscience* 2, 798-801.
- Brodsky, Paul and Lee Quaintance. 2009. "[Trade of the Century](#)."
- Brodsky, Paul and Lee Quaintance. 2011. "[Your Gold Teeth](#)."
- Buffett, Warren. 2012. "[2011 Berkshire Hathaway Shareholder Letter](#)."
- Buffett, Warren. 2011. [Warren Buffett CNBC Interview](#) .
- Cagan, Philip. 1956. "The Monetary Dynamics of Hyperinflation", in Milton Friedman (Editor), *Studies in the Quantity Theory of Money*, Chicago: University of Chicago Press.
- Campbell, John Y., and Robert J. Shiller. 2001. "Valuation Ratios and the Long-Run Stock Market Outlook: An Update." NBER Working Paper 8221, April 2001.
- Cassidy, John. 2011. "[Mastering the Machine](#)." *New Yorker Magazine*, July 25.
- Christensen, Jens H. E. and James M. Gillan, 2012. A Model-Independent Maximum Range for the Liquidity Correction of TIPS Yields. Working paper, Federal Reserve Bank of San Francisco.
- Dalio, Ray. 2011. "[A Template for Understanding What's Going On](#)."
- Dalio, Ray. 2012. [CNBC Interview with Andrew Ross Sorkin](#), September 21 (about 16 seconds into the interview)
- DeLong, Bradford. 1996. "[Why Not The Gold Standard?](#)."
- DeLong, Bradford. 2011. "[Gibson's Paradox and the Gold Boom](#)".

- DeLong, Bradford. 2012. "[Campbell-Shiller Regressions: Future S&P Price Changes Regressed on Ratios of Prices to Long-Run Moving Averages of Past Earnings](#)".
- Eichengreen, Barry and Peter Temin. 2010. "[Fetters of Gold and Paper](#)".
- Elfenbein, Eddy. 2012. "[Reprise: The Elfenbein Gold Model](#)", blog article, April 5 2012.
- Elwell, Craig K. 2011. "[Brief History of the Gold Standard in the United States](#)", Congressional Research Service.
- Erb, Claude B. and Campbell R. Harvey, 2012a, "[An Impressionist View of the Real Price of Gold Around the World](#)", <http://ssrn.com/abstract=2148691>.
- Erb, Claude B. and Campbell R. Harvey, 2012b. "[Sound Economic Policies Outweigh Big Gold Reserves](#)", *Shanghai Daily*, November 2.
- Evans-Pritchard, Ambrose. 2009. "[Barrick shuts hedge book as world gold supply runs out](#)." *The Telegraph*, November 11.
- Fama, Eugene F. and Kenneth R. French. 1987. "Commodity Futures Prices: Some Evidence on Forecast Power, Premiums and the Theory of Storage", *Journal of Business*, vol. 60, no. 1: 55-73
- Fisher, Irving. 1928. *The Money Illusion*. New York: Adelphi Company.
- Fleckenstein, Matthias, Francis A. Longstaff and Hanno N. Lustig, 2012. Why Does the Treasury Issue TIPS? The TIPS-Treasury Bond Puzzle. *Journal of Finance*, forthcoming.
- Goldsworthy, Adrian. 2003. *The Complete Roman Army*. Thames & Hudson Ltd., London
- Green, Timothy. 1999. "Central Bank Gold Reserves: An Historical Perspective Since 1845", World Gold Council, Research Study No. 23.
- Greer, Robert J. 1997. "[What is an Asset Class, Anyway?](#)" *Journal of Portfolio Management*, vol. 23, no.2 (Winter): 86-91.
- Hammond, P. Brett, Martin L. Leibowitz and Laurence B. Siegel. 2011. *Rethinking the Equity Risk Premium*, CFA Institute, Research Foundation Publications.
- Hanke, Steve H. and Nicholas Krus. 2012. "[World Hyperinflations](#)", Cato Institute, working paper, August 15, 2012.
- Hansen, Gary D. and Edward C. Prescott. 2002. "[Malthus to Solow](#)." *American Economic Review* Vol. 92, No. 4: 1204-1217.
- Harmston, Stephen. 1998. "[Gold as a Store of Value](#)." World Gold Council, Research Study No. 22, November.
- Ibbotson, Roger G. and Paul D. Kaplan. 2000. "Does Asset Allocation Policy Explain 40, 90, or 100 Percent of Performance?", *Financial Analysts Journal*, vol. 56, no. 1 (January/February):26-33.
- Ibbotson, Roger G. and Peng Chen. 2003. "Long-Run Stock Returns: Participating in the Real Economy", *Financial Analysts Journal*, vol. 59, no. 1 (January/February):88-98.
- International Monetary Fund. 1999. "[Twelfth Meeting of the IMF Committee on Balance of Payment Statistics](#)", Santiago Chile, October 27-29
- Jastram, Roy W. 1978. *The Golden Constant-The English and American Experience 1560-1976*. New York: John Wiley and Sons.
- Johnston, Louis D. and Samuel H. Williamson. 2011. "What was the U.S. GDP Then?" *MeasuringWorth.com*
- Keynes, John Maynard. 1924. [A Tract on Monetary Reform](#). London: Macmillan.
- Keynes, John Maynard. 1930. [A Treatise on Money](#). London: Macmillan.
- Keynes, John Maynard. 1936. *The General Theory of Employment, Interest and Money*. London: Macmillan.
- Krugman, Paul. 2011. "Treasuries, TIPS and Gold (Wonkish)", *New York Times*, September 6, 2011.
- Leinweber, David J. 2007. "[Stupid Data Miner Tricks: Overfitting the S&P 500](#)", *Journal of Investing*, vol. 16, no. 1 (Spring): 15-22.
- Madura, Liana. 2011. "[IVA's de Vault: Gold Still Seems Underowned](#)." *Morningstar Advisor*, September 16.
- Malmesbury, William (of). 1847. [Chronicle of the Kings of England from the Earliest Period to the Reign of King Stephen](#). London: Henry G. Bohn.
- Malkiel, Burton G. 2003. "The Efficient Market Hypothesis and its Critics", *Journal of Economic Perspectives*, vol. 1, no. 1 (Winter): 59-82.
- MacMullen, Ramsay. 1974. *Roman Social Relations: 50 B.C. to A.D. 284*. Yale University Press, New Haven.
- Marks, Howard. 2013 "[Howard Marks Interview](#)", *Outlook India*, February 2.
- McGuire, Shayne. 2010. *Hard Money: Taking Gold to a Higher Investment Level*. Hoboken: Wiley.

McKinnon, Ronald I. 1993. "The Rules of the Game: International Money in Historical Perspective", *Journal of Economic Literature*, vol. 31, no. 1 (March): 1-44

Miller, John W. 2012. "[Exhausting the Earth's Resources? Not So Fast.](#)" Wall Street Journal, June 5.

Mitchell, Wesley Clair. 1903. [A History of the Greenbacks](#). Chicago: University of Chicago Press.

Montier, James. 2011. "[A Value Investor's Perspective on Tail Risk Protection: An Ode to the Joy of Cash.](#)" GMO white paper, June.

Nixon, Richard M. 1971, "Address to the Nation Outlining a New Economic Policy: 'The Challenge of Peace.'", August 15, 1971. Online by Gerhard Peters and John T. Woolley, [The American Presidency Project](#).

Norris, Floyd. 2010. "[Strange Tales in the Land of No Return](#) ." *New York Times*, October 28.

Officer, Lawrence H. 2006. "[What Was the Price of Gold Then? A Data Study](#)", working paper, University of Illinois at Chicago.

Or, Amy and Matt Phillips. 2011. "Forget Gold. How About Gemstones?" *Wall Street Journal*, May 25.

Paul, Ron and Lewis Lehrman. 2007. *The Case for Gold*, Ludwig von Mises Institute.

Perold, Andre F. and William F. Sharpe. 1995. "[Dynamic Strategies for Asset Allocation](#)." *Financial Analysts Journal*, Vol. 51, No. 1 (January/February): 149-160.

Perold, Andre F. 2012. "Negative Real Interest Rates: The Conundrum for Investment and Spending Policies", *Financial Analysts Journal*, vol. 68, no. 2 (March/April): 6-12.

Polleschi, Ilaria. 2012. "[Italian Caught at Swiss Border with 50 kg of Gold](#)", Reuters, June 18.

Pukthuanthong, Kuntara and Richard Roll. 2011. "Gold and the Dollar (and the Euro, Pound, and Yen)", *Journal of Banking and Finance*, vol. 35, no. 8: 2070-2083.

Regent, Aaron. 2011. "[Investor Day Presentation](#)."

Rockwell, Llewellyn H. 2002. "[Is the Gold Standard History?](#) "

Roll, Richard. 1977. "A Critique of the Asset Pricing Theory's Tests; Part 1: On Past and Potential Testability of the Theory", *Journal of Financial Economics*, vol. 4: 129-176.

Roth, Jean-Pierre. 1999. "A View on Switzerland in the Run up to the Demonetization of Gold." 22nd Annual FT World Gold Conference, London, June 14.

Saad, Lydia. 2012. "[Still Americans' Top Pick Among Long-Term Investments](#)." Gallup. April 27.

Saxe, John Godfrey. 1872. "[The Blind Men and the Elephant](#)."

Schwartz, Anna J. 1987. *Alternative Money Regimes: The Gold Standard*, Chicago: University of Chicago Press for the National Bureau of Economic Research.

Speidel, M. Alexander. 1992. "Roman Army Pay Scales." *Journal of Roman Studies*, vol. 82: 87-106.

Stoke-on-Kent Museum. 2013. "[How Much Did Things Cost](#)".

Szabo, Tom. 2007. "[Gold and Silver "Leasing" Examined](#)." September 17.

Taleb, Nassim Nicholas. 2008. "[The fourth quadrant: A map of the limits of statistics](#)."

Tversky, Amos and Daniel Kahneman. 1971. "Belief in the Law of Small Numbers." *Psychological Bulletin*, vol. 76, no. 2: 105-110.

United States Federal Reserve. 1967. [Memorandum of Discussion](#). December 12.

United States Geological Service. 2011. "[Gold: Mineral Commodity Summaries](#)."

von Mises, Ludwig. 1953. "Gold Versus Paper", *The Freeman*, July 13, 1953.

Wacher, John. 2002. *The Roman World*. Routledge, London

Ward, Sandra. 2011. "[Observing a Biplar World](#)". *Barron's*, March 12.

Whitehouse, David. 1999. "[Gold Rush in Space?](#)" *BBC Online*, July 22.

World Bank. 1994. "[Brazil: An Assessment of the Private Sector](#)", research report.

World Gold Council. 2010. "[An investor's guide to the gold market \(US edition\)](#)."

World Gold Council. 2012. "[About Gold](#)."

World Gold Council. 2012. "[Facts About Gold](#)."

World Gold Council. 2012. "[Latest World Official Reserves](#)." December 3.

World Gold Council. 2010. [“Gold: Hedging Against Tail Risk.”](#)

Zhang, Zhouxiang. 2012. [“Does China Need to Buy More Gold?”](#) *China Daily*, October 9.