The Golden Dilemma

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Gold objects have existed for thousands of years but gold has only been an actively traded object since 1975. Gold has often been described as an inflation hedge. If gold is an inflation hedge then on average its real return should be 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. As a result investors in gold face a daunting dilemma: 1) seek inflation protection by paying a high real gold price that almost guarantees a decline in future purchasing power or 2) avoid gold and run the risk of a decline in future purchasing power if inflation surges. 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.

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Introduction

In the world market portfolio, the global equity and fixed income markets have a combined value of about $90 trillion. 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% of the outstanding supply of gold. A move by investors to "market weight" gold holdings would probably send the price 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 try 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 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 establish long-run forward-looking expected returns, it is implausible that the expected long-run real rate of return on gold is 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."*

In contrast, Dalio[1] argues that 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. Dalio notes:

> *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*

[1] See Ward (2011).

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> *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.[3] Different perspectives, 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.[4] The Keynesian beauty contest framework suggests that the price of gold is not determined by what you think gold is worth. What matters is, for example, what others think others think others think others think gold is worth.

While the possible value of all the gold ever mined is about $9 trillion,[5] only a small amount of gold actually trades in financial markets. We show that the investment demand for gold is characterized by a 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").

1. Gold as an inflation hedge

Probably one of the most widely held beliefs about gold is that it is an inflation hedge. Jastram (1977) 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. Harmston (1998) built on Jastrom'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

[2] See World Gold Council (2010).
[3] See Saxe (1872).
[4] See Keynes (1936).
[5] The World Gold Council 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.

of gold.[6] "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.[7]

Exhibit 1 illustrates one literal version of the "gold as an inflation hedge" argument. Our initial sample starts in 1975 because for most of the 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 line 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.

Exhibit 1. Gold as an Inflation Hedge

[6] Harmston 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.

[7] See Greer (1997).

[8] U.S. President Nixon ended the gold standard for the U.S. in August 1971. U.S. citizens had few legal opportunities to own gold, outside of jewelry, between 1933 and the end of 1974. Modern exchange traded gold futures contracts began in the U.S. in January 1975. 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.

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 then the real price of gold should be a constant and exhibit no variability. If gold were merely a "good", but not perfect, hedge of short term inflation then the volatility of the real price of gold should be less than the volatility of the price of gold. The real price of gold might only periodically equal the average real price of gold. If gold is an inflation hedge, in the long run, gold should have a rate of return similar to inflation. Furthermore, if gold is just a "good" inflation hedge and not a perfect inflation hedge then deviations between the real price of gold and the expected, average, real price of gold should be corrected over time. Investing when the real price of gold is high, expensive, should act as a drag on future real returns and investing when the real price of gold is low, inexpensive, should enhance prospective real returns.

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). In January 1975, the month-end price of the nearby gold futures contract was $175 an ounce. The month-end January 1975 index value of the U.S. CPI index was 52.3. The ratio of the price of gold relative to the CPI index was 3.35. 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

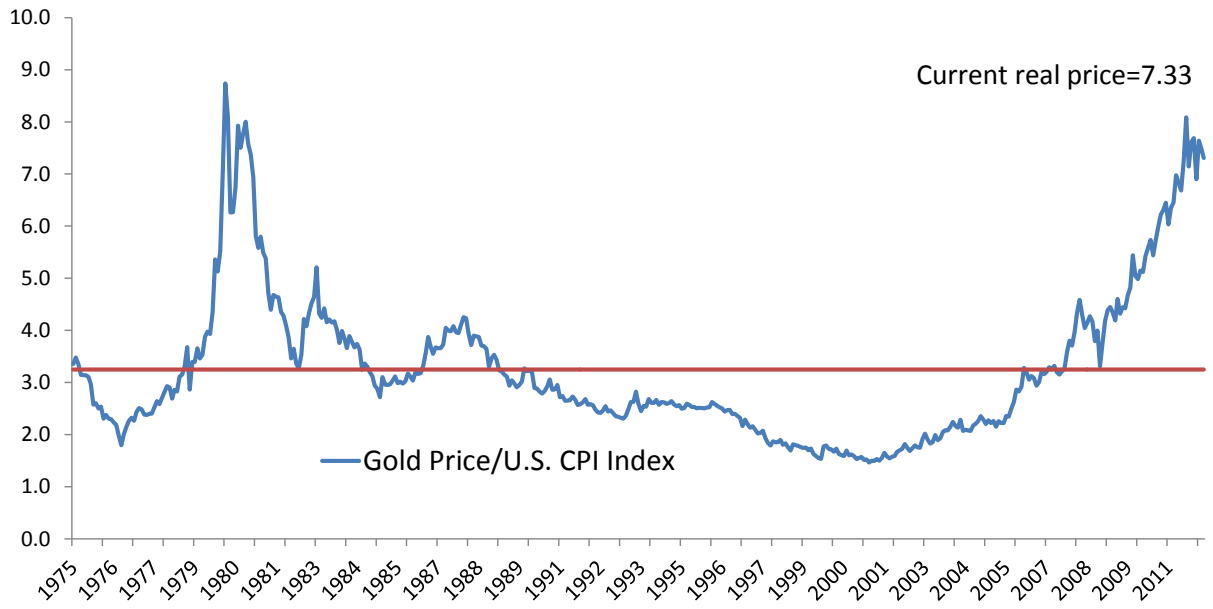
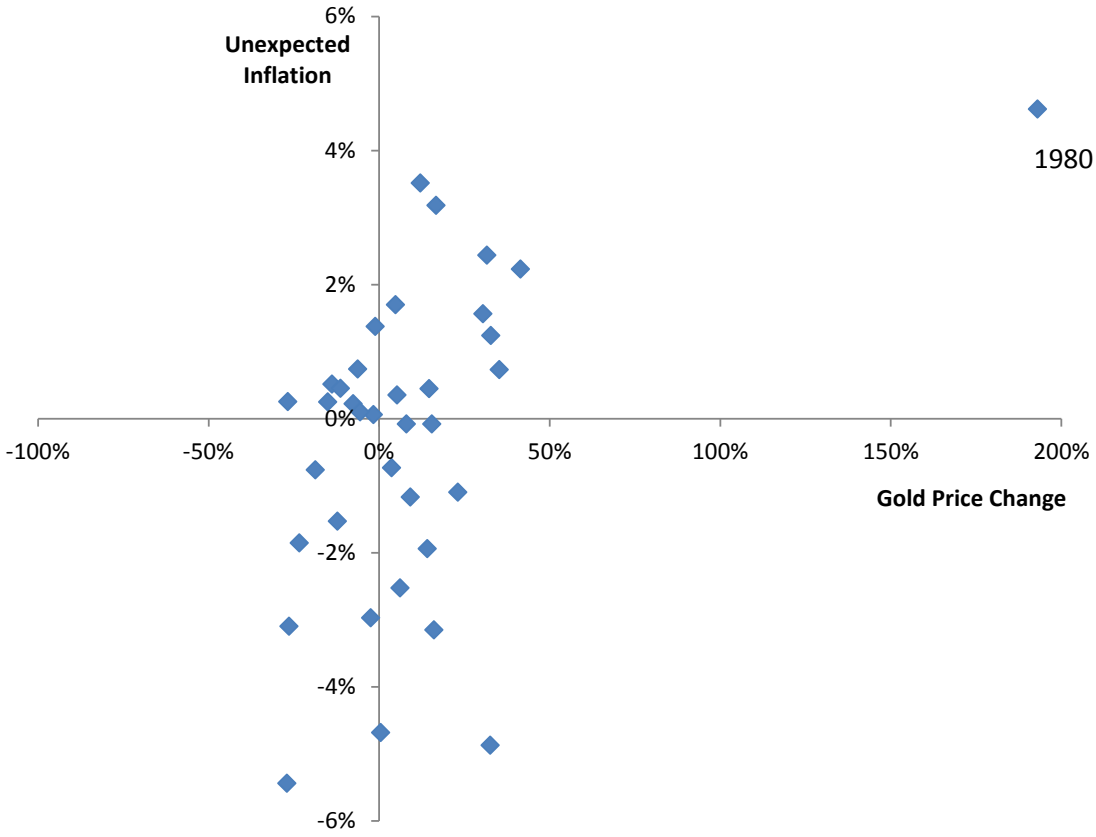


Exhibit 2 illustrates that the real price of gold has been quite volatile. In fact, the volatility of the real price of gold has been basically the same as the volatility of the price of gold and the real price of gold tended to mean revert over a time period of about ten years. The variability of the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

Investors really care about unexpected inflation. Exhibit 3 details the ability of gold to hedge against unexpected inflation (measured by the change in the annual inflation rate).

Exhibit 3: Gold and Unexpected Inflation, 1975-2011

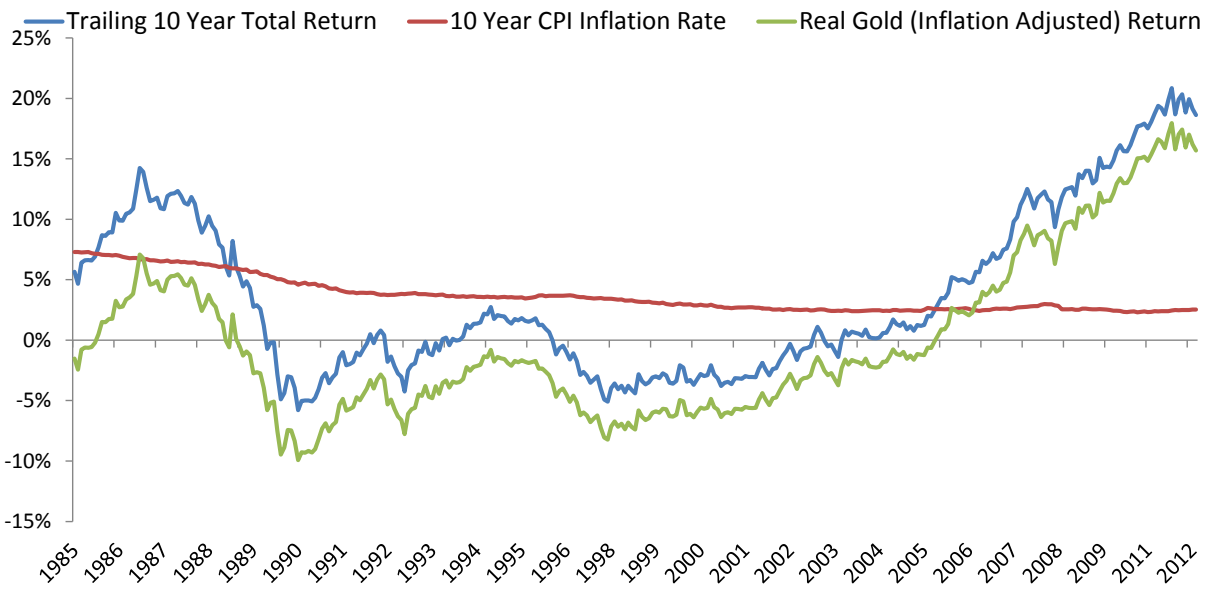


There is effectively no correlation here. Any observed positive relationship is driven by a single year, 1980.

What about the ability of gold to hedge longer-term inflation?

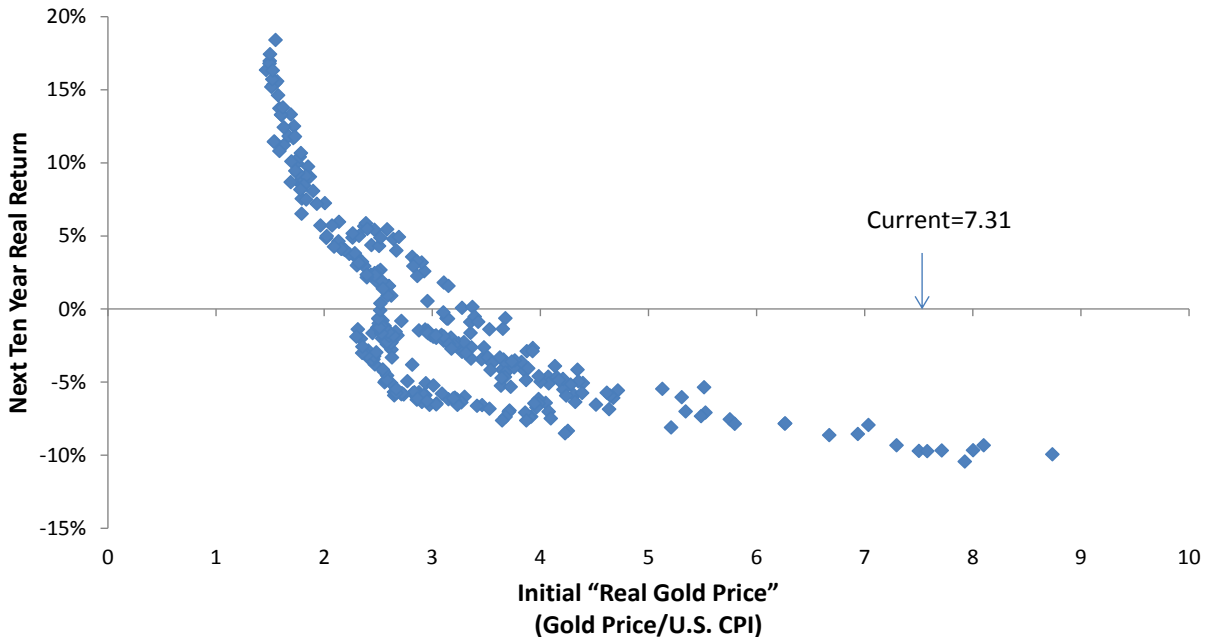
Exhibit 4 shows rolling monthly observations of trailing ten-year rates of inflation, as well as both nominal and real gold returns. There has been substantial variation in trailing ten year annualized gold returns: from as low as -6% per annum to as high as +20% per annum. Over the same time period the low and high inflation returns were +2.3% per annum and +7.3% per annum. The exhibit suggests that gold is not 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 real gold price returns since 1975. If the exhibit traced out a stable relationship then the current high real price of gold would suggest a future real price return of about -10% per year. However, it is dangerous to draw inference about the future based on what is essentially 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.[9] 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 ten year nominal Treasury bonds and ten year inflation linked Treasury bonds it is possible to back out a "market implied" ten-year inflation forecast. Currently the implied inflation rate over the next ten years is about 2% per year. Of course, there is no guarantee that ten year inflation will actually average 2% per year over the next ten years. If the real price 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%**
	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%
Ending	**7.2**	-0.09%	**1.90%**	3.90%	4.90%	5.90%	7.90%	9.90%	19.89%	39.87%
Real	**6.2**	-1.58%	**0.39%**	2.36%	3.34%	4.33%	6.30%	8.27%	18.11%	37.79%
Price	**5.2**	-3.29%	**-1.36%**	0.58%	1.54%	2.51%	4.44%	6.38%	16.05%	35.39%
Ratio	**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%

Note: Assumes an initial gold price of $1,665 an ounce and a March 2012 CPI level of 229

While Exhibit 2 traces the real price of gold since 1975, received gold lore suggests that gold has been mined since 3600 B.C.[10] Tversky and Kahneman (1971) warned of the "law of small numbers" which leads to "exaggerated confidence in the validity of conclusions based on small samples". 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

[9] See Norris (2010).
[10] See World Gold Council-About Gold (2012).

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 growth of the U.S. GDP price deflator since 1791. 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 1790 A.D. During the period 1791 to the present the U.S. has broadly operated under three different currency regimes: a generally fully convertible "metal" currency regime from 1791 to 1933, an officially convertible "metal" currency regime from 1933 to 1971, and a fiat currency system since 1971. During the first period of full convertibility the inflation rate was close to zero, and during the two subsequent periods the annual inflation rate was in excess of 3% per annum. The rate of inflation in the U.S. has increased over time.

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

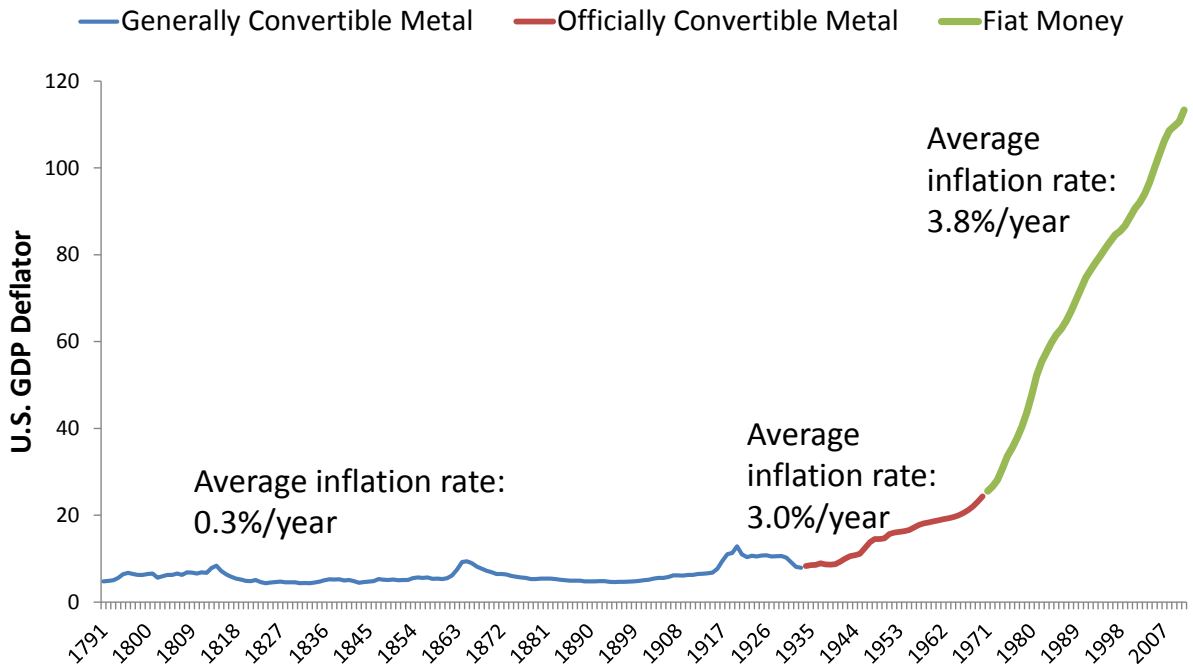


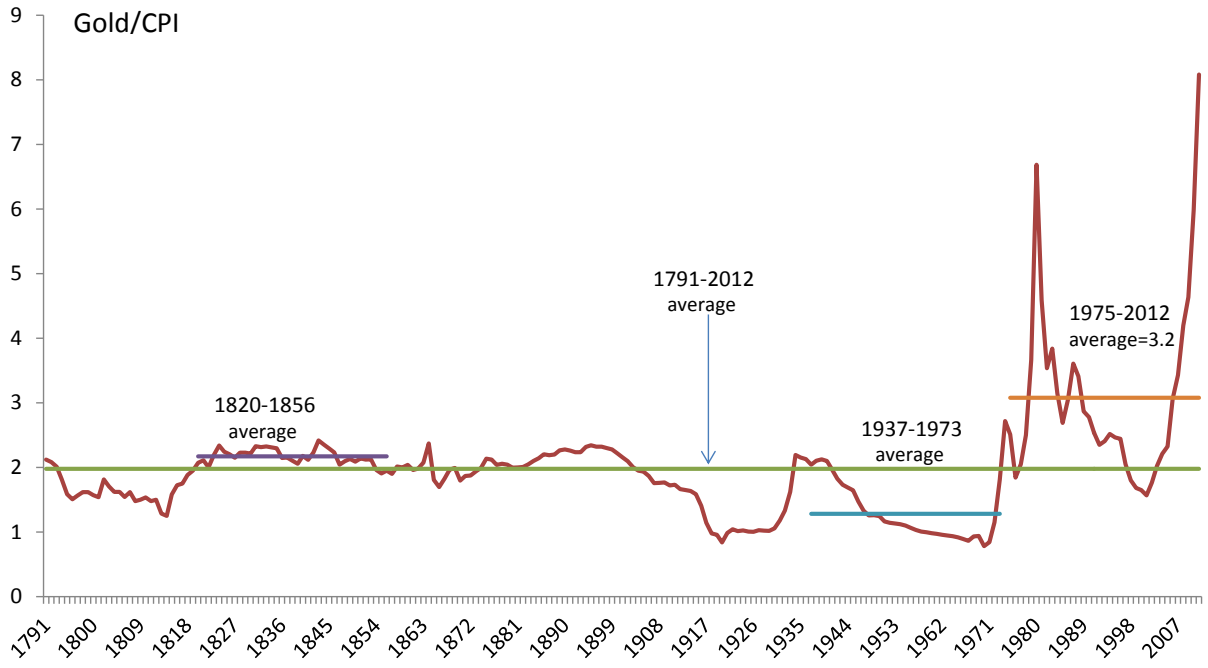
Exhibit 8 examines the real price of gold in U.S. dollars since 1791. Unlike Exhibit 1, which uses month-end closing prices for gold from a futures exchange, Exhibit 8 uses an annual gold time series that is cobbled together from a number of studies.[11] The price of gold in Exhibit 8 is deflated (divided) 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 significant. 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 estimates. Exhibit 8 shows that the real price of gold was fairly constant until the 1970s. This stability was the result of the fact that the U.S. operated with a variety of currency regimes "backed" by gold and silver

[11] See http://measuringworth.com/gold/

(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).

From the 1970s until today the real gold price has fluctuated wildly.[12] 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 1936 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 11 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.[13]

Exhibit 8. The Real Price of Gold over 200 Years



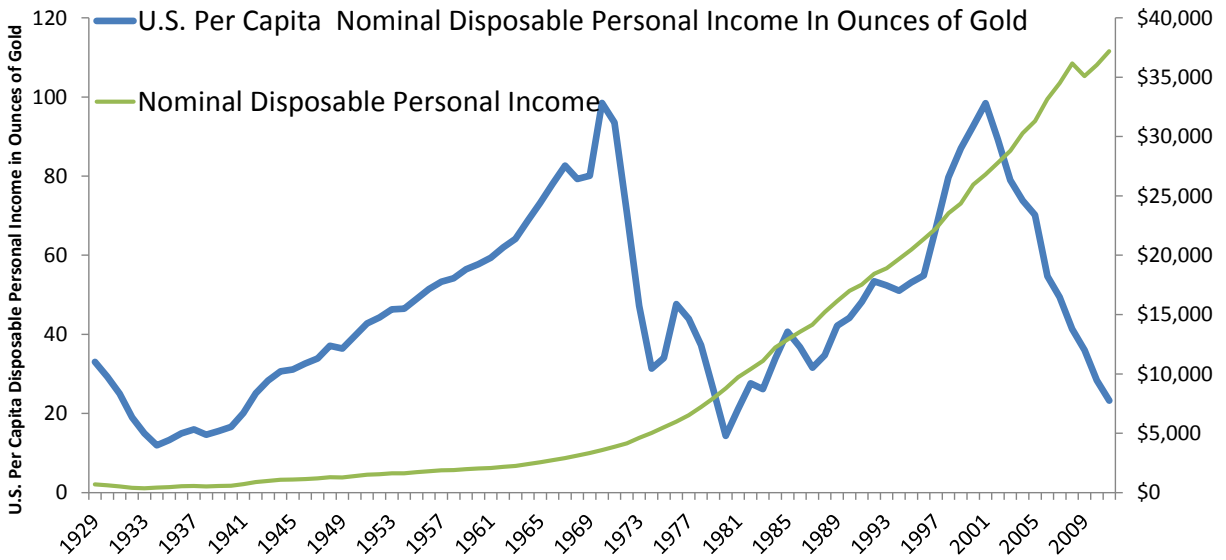
Related to the idea that gold is possibly a long-term inflation hedge is the "constant price in terms of gold" argument, the idea that for some items prices tends to hover around some constant amount of gold. For instance, some claim that over time the cost of a "high quality" man's suit has cost an ounce of

[12] In 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.
[13] Statistically speaking.

gold.[14] This statement is interesting but hard to pursue 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 are 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 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.[15] 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. Defining the value of one's life as an item, 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



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

[14] See Arends (2009).

[15] 1929 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).

Malthus that the trade-off between technology and population growth would lead to stagnant incomes.[16] A Malthusian explanation carries a lot of deadweight intellectual baggage since Malthus is often criticized for successfully describing life in the Dark and Middle 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 or a tendency to try to turn lemons into lemonade. 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". 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.

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 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 (27 B.C.-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).[17] Converted to U.S. dollars, the pay of a Roman legionary was about 20% that of a 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.

[16] See Hansen and Prescott (1985).
[17] See Speidel (1992).

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%

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, 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 compounding periods. A claim that gold could have "equity-like" returns in the future needs to be reconciled with the past. Starting 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 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 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.

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 right "expected" 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%.[18] 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 hedge the statistical fingerprint of this belief should be supported by high regression R^2s. 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.

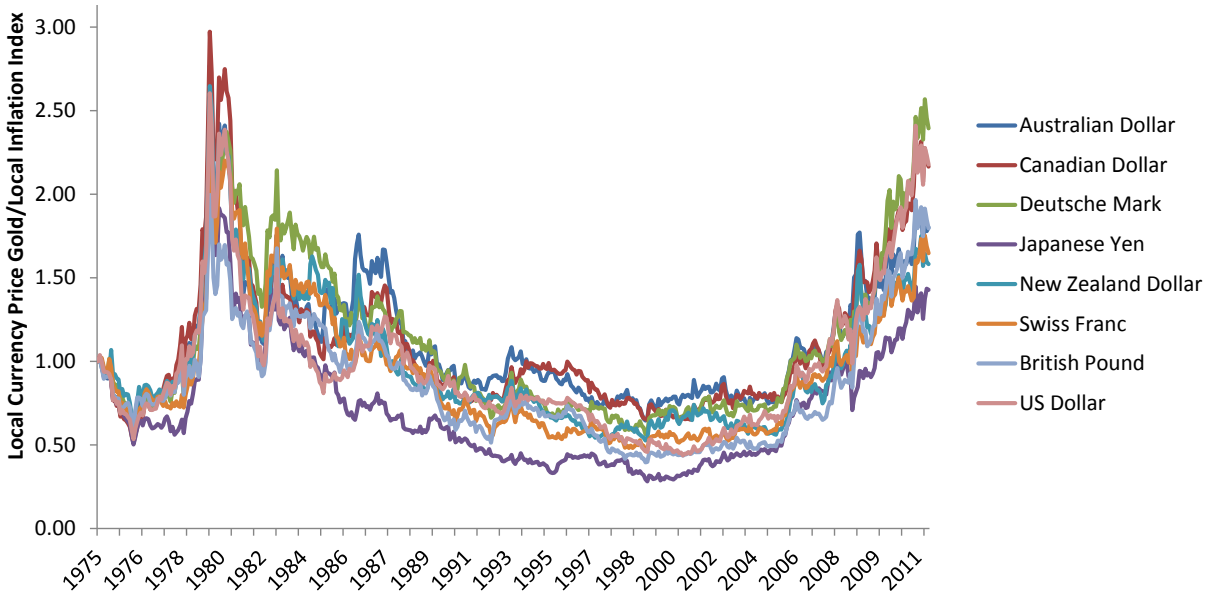
Exhibit 11. Gold as a Currency Hedge, 1975-2012

	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

[18] 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).

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[19] 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. 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.

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.

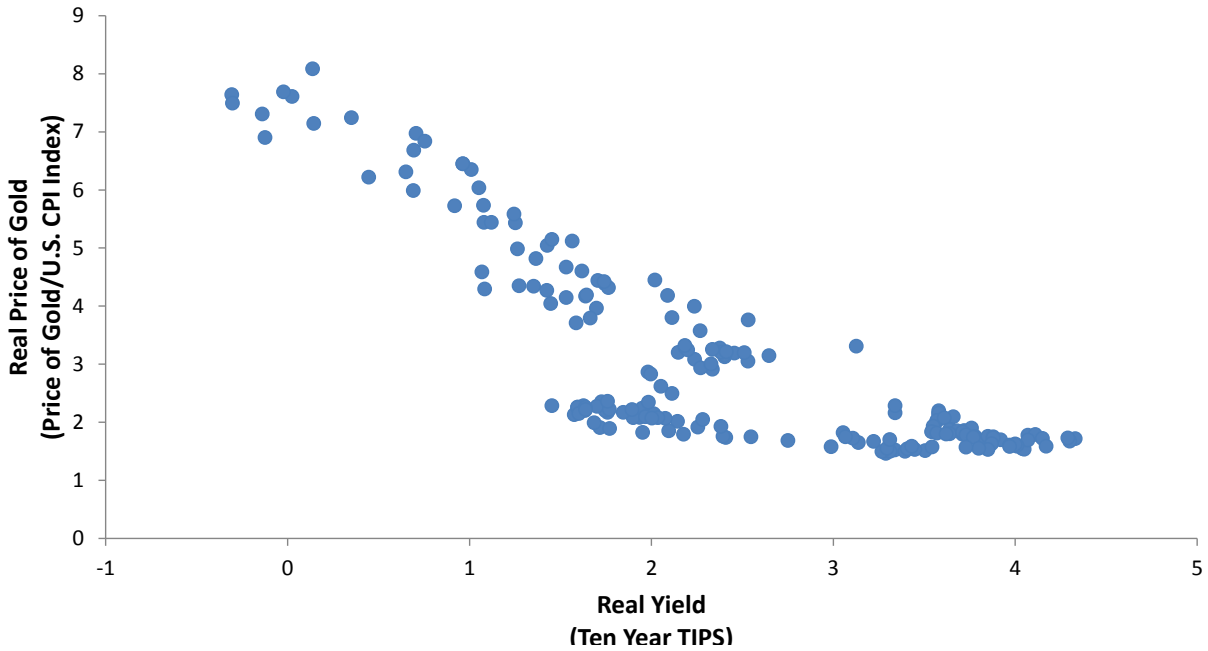
[19] Using inflation index data from the International Monetary Fund.

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.[20]

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. The message of Exhibit 13 seems to be fairly obvious. When real interest rates are high, as 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 -0.74. Is it possible to disagree with the view that low real yields caused the real price of gold to be high? Yes.

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



It is important to avoid the "correlation implies causation" trap. The negative TIPS real yield-gold real price correlation of -0.74 is a measure of the linear correlation of real yields with real gold prices. While it is possible to argue that low real yields "cause" high real gold prices, it is equally possible to argue that high real gold prices "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 an immeasurable fear of hyperinflation. This is a classic example of spurious correlation.

[20] See for example, http://www.commodityonline.com/news/Real-interest-rates-are-the-prime-driver-of-gold-price-24907-3-1.html.

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

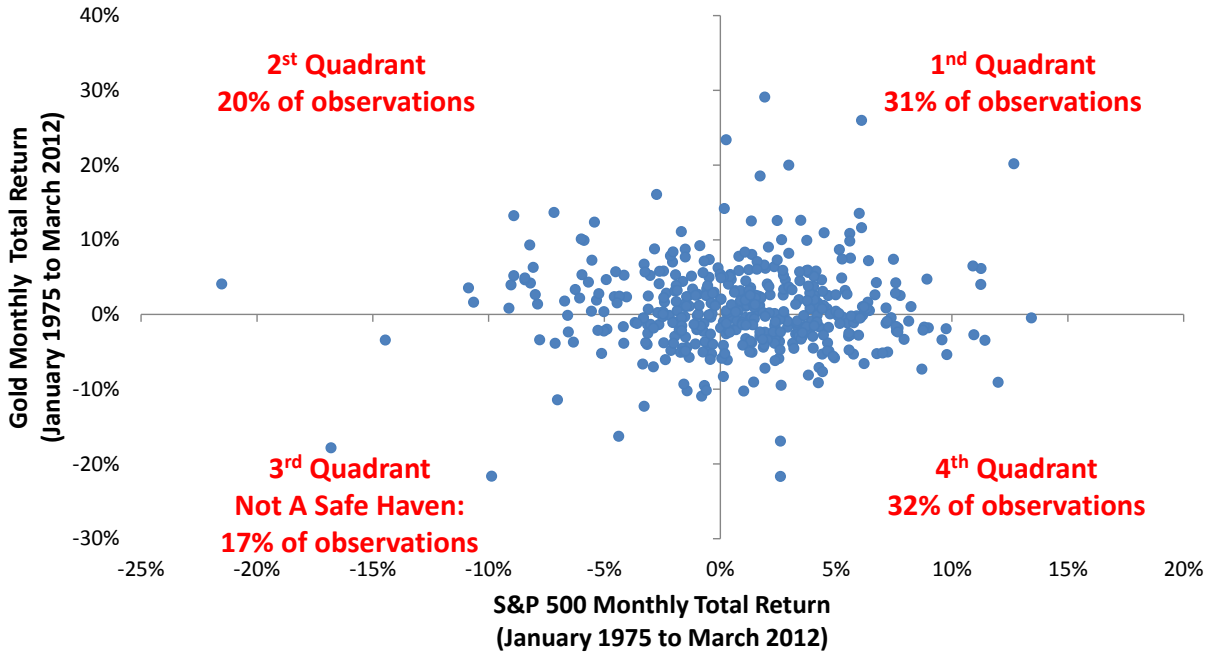
The safe haven/tail protect argument has already appeared three times. First, it is possible that gold does not hedge day-to-day inflation surprises but provides some protection in a hyperinflationary environment. Second, gold may not provide very effective hedging for currencies in usual circumstances 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 (2006) 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 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. 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. The 5th century A.D. was a time of great social stress and political turmoil in England as the Western Roman Empire unraveled. 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".

Gundlach[21] astutely pointed out that the weight of gold limits its portability, both during normal times and during times of stress. Gold is viewed 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 Faber[22] 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."

4.2 Tail Risk and Hyperinflation

Does gold provide some protection from tail risk?[23] 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

[21] See Or and Phillips (2011). At the current price of $1,600 per ounce, $5 million dollars weighs 215 lbs.
[22] See Ash (2009).
[23] See World Gold Council (2010).

possible to define risk as the risk of unexpected inflation and ~~the~~ tail risk might be 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 and if gold moved with the inflation rate, then the price of gold would exceed $163 trillion U.S. dollars

So, does the price of gold provide hyperinflationary tail risk protection? In order to answer this question it might be helpful to also ask some subsidiary questions: what is the probability of hyperinflation, is there any reason to believe that hyperinflation is more likely now than in the past, does it matter which country is impacted by the hyperinflation, and what might be the magnitude of possible hyperinflation?

Exhibit 15 provides a list of 30 hyperinflationary experiences catalogued by Bernholz (2006) and McGuire (2010). Excluding the French 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 is: what is 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 informative.

First, we need to focus on major economies. The most recent hyperinflation occurred in Zimbabwe. Gold was not the obvious safe haven in this country. The Zimbabwean currency was effectively displaced by the U.S. dollar.

Second, we need to be careful drawing inference from the observed frequencies in the past. Take the case of Germany. According to Bernholz, Germany experienced hyperinflation in four years: 1920, 1921, 1922 and 1923 – which would imply a 4% probability of hyperinflation. But looking forward what is the probability of hyperinflation in Germany? If we expand the list of countries to all major countries involved in WWI, the historical probability of hyperinflation is 1.1%. What is the forward looking risk of hyperinflation for a country with a fiat currency regime? Is it 0%? Perhaps that is too low. Is it 1.1%? It could be.

Exhibit 15. Hyperinflation Risk

Country	Start Year	End Year	Country	Start Year	End Year
Argentina	1989	1990	**Hungary**	1945	1946
Armenia	1993	1994	**Kazakhstan**	1994	1994
Austria	1921	1922	**Kyrgyzstan**	1992	1992
Azerbaijan	1991	1994	**Nicaragua**	1986	1989
Belarus	1994	1994	**Peru**	1988	1989
Bolivia	1984	1986	**Poland**	1921	1924
Brazil	1989	1993	**Poland**	1989	1990
Bulgaria	1997	1997	**Serbia**	1992	1994
China	1947	1949	**Soviet Union**	1922	1924
Congo (Zaire)	1991	1994	**Taiwan**	1945	1949
France	1789	1796	**Tajikistan**	1995	1995
Georgia	1993	1994	**Turkmenistan**	1993	1996
Germany	1920	1923	**Ukraine**	1992	1994
Greece	1942	1945	**Yugoslavia**	1990	1990
Hungary	1923	1924	**Zimbabwe**	2008	2008

Exhibit 16 provides a way to think about the "gold as a tail risk hedge" argument by focusing on one's subjective likelihood of hyperinflation. Taleb (2008) proposes a dichotmous way to think about the world: those events that live in Mediocristan and those that live in Extremistan.

Somewhat predictable events with seemingly calculable probabilities and no extreme consequences, such as a "normal" level of inflation reside in Mediocristan. The current 10-year TIPS real yield of about 2% suggests that there are many investors who are willing to bet on U.S. inflation staying firmly ensconced in Mediocristan. For purposes of illustration assume that the ten year in the future inflation driven price of gold, consistent with Exhibit 1, is about $877.

Largely unpredictable events with impossible to caluculate probabilities and far reaching and inestimable consequences live in Extremistan. Hyperinflation lives in Extremistan. Extremistan is populated with "I don't know" events. For instance, if hyperinflation occurs it is likely that no one knows ahead of time how long the hyperinflation will last and how significant the magnitude of the hyperinflation will be. In Extremistan, it is impossible to tell how bad things might be so any example, such as how bad things were during the German inflation, is as good, and arbitrary, as any other possibility. In Extremistan the price of gold ten years in the future might be $72,092,964,539,007.

Exhibit 16 illustrates a simple "mixture model", a way of thinking about financial market outcomes by looking at a combination of models that describe outcomes during "normal" times (Mediocristan) and during stressful times (Extremistan). Given the assumptions, a one-in-a-billion chance of ending up in Extremistan yields a 10 year in the future expected value for gold in excess of $72,000. A one-in-a-hundred chance of ending up in Extremistan yields an expected gold price in excess of $720 billion. The Mediocristan-Extremistan framework does not provide any insight into the probability of hyperinflation. In addition, the Mediocristan-Extemistan framework does not provide an explanation for the currently

high real price of gold. Its main value is that it highlights the dilemma faced by investors: how even extraordinarily remote probabilities of hyperinflation could have a large impact on the possible future price of gold.[24]

Exhibit 16. Gold in Hyperinflation Scenarios

Mediocristan Expected Value of Gold	Extremistan Expected Value of Gold	Probability of Being in Mediocristan	Probability of Being in Extremistan	Extremistan Probability "One-In-a X"	Expected Value
$877	$72,092,964,539,007	100.0000000000000000%	0.0000000000000000%	-	$877
$877	$72,092,964,539,007	99.9999999999999999%	0.0000000000000001%	Quintillion	$877
$877	$72,092,964,539,007	99.9999999999999000%	0.0000000000001000%	Quadrillion	$877
$877	$72,092,964,539,007	99.9999999999000000%	0.0000000001000000%	Trillion	$949
$877	$72,092,964,539,007	99.9999999000000000%	0.0000001000000000%	Billion	$72,970
$877	$72,092,964,539,007	99.9999000000000000%	0.0001000000000000%	Million	$72,093,841
$877	$72,092,964,539,007	99.9000000000000000%	0.1000000000000000%	Thousand	$72,092,965,415
$877	$72,092,964,539,007	99.0000000000000000%	1.0000000000000000%	Hundred	$720,929,646,258
$877	$72,092,964,539,007	96.0000000000000000%	4.0000000000000000%	Twenty-five	$2,883,718,582,402

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 world's default currency".[25] 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. 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 grain of gold.[26]

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.

[24] This Mediocristan-Extremistan way of looking at things shares some similarities with Pascal's Wager. Bernstein (1998) suggests that Pascal's Wager can be stated as: the consequences of decisions should dominate the probabilities of outcomes. Bernstein (2000) philosophically noted that "those who believed that gold was a hedge against the uncertainties of life failed to understand that the pursuit of eternity is not to be satisfied by gold, or by anything else we choose to replace gold-dollars, euros, whatever. Gold as an end in itself is meaningless."

[25] See Regent (2011).

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

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 focuses on the work of Eichengreen and Peter 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.[27]

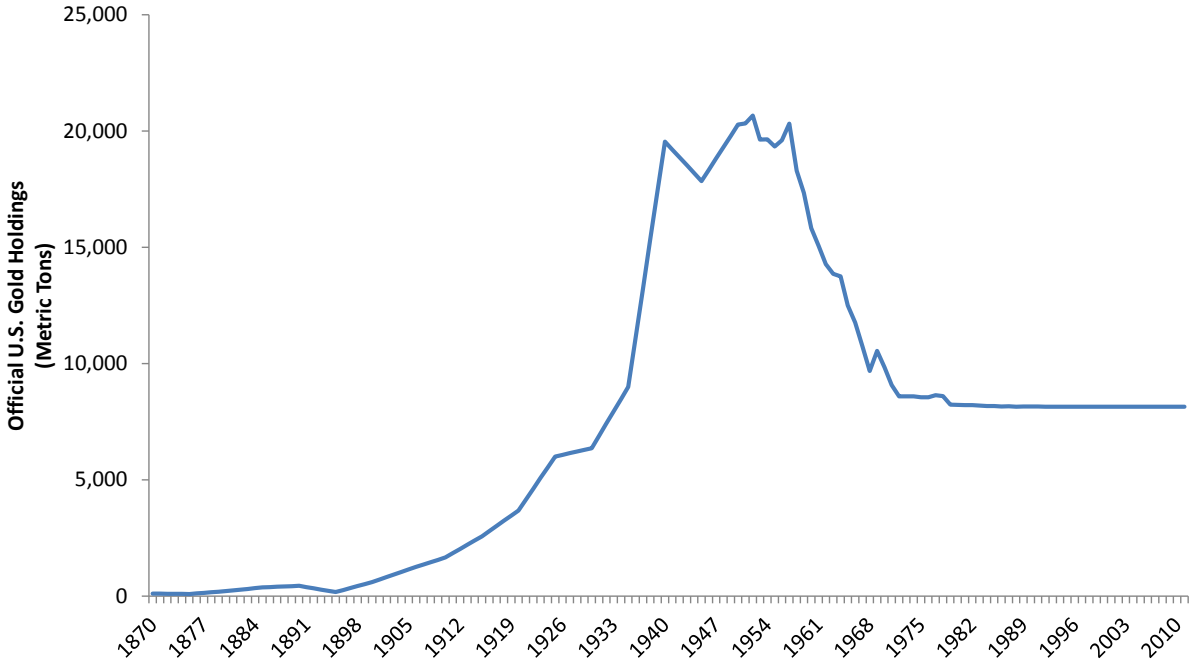
If a gold standard exists then gold is money, but the "gold is money" argument does not require the existence of a gold standard. The "gold is money" argument is essentially another way of stating the "constant price when measured in gold" argument. For instance, investors Brodsky and Quaintance (2009) and hedge fund manager Dalio (2012) have argued that "gold is money" without arguing that the world is on a de facto gold standard. For Brodsky and Quaintance (2011), the "shadow price of gold", 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[28] thinks that "the price of gold approximates the total amount of money in circulation divided by the size of the gold stock".

The "shadow price of gold", "gold is money", argument is an intriguing concept. The "gold is money" argument is influenced by Friedman's assertion that "inflation is always and everywhere a monetary phenomenon". 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", "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. Official gold holdings peaked at about 20,000 metric tons following implementation of President Roosevelt's Executive Order 6102, which outlawed the private ownership of gold in the U.S. Official gold holdings entered a period of decline during the Eisenhower administration that continued until 1971, when President Nixon officially took the U.S. off the gold standard. Since that time, the official gold holdings of the U.S. have been slightly greater than 8,000 metric tons.

[27] 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."
[28] See Cassidy (2011).

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.[29] 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

[29] 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".

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.

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. [30] 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 (2012) estimates that 171,300 metric ton 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". [31] 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. [32] But technology might change in the future and usher in opportunities to mine more than the 51,000 metric tons of gold reserves. For instance, the near Earth asteroid Eros might contain up to 125,000 metric tons of gold suggesting the possibility, however remote, of even greater potential gold production. [33] Or 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 billion tons of gold in the world's oceans. [34]

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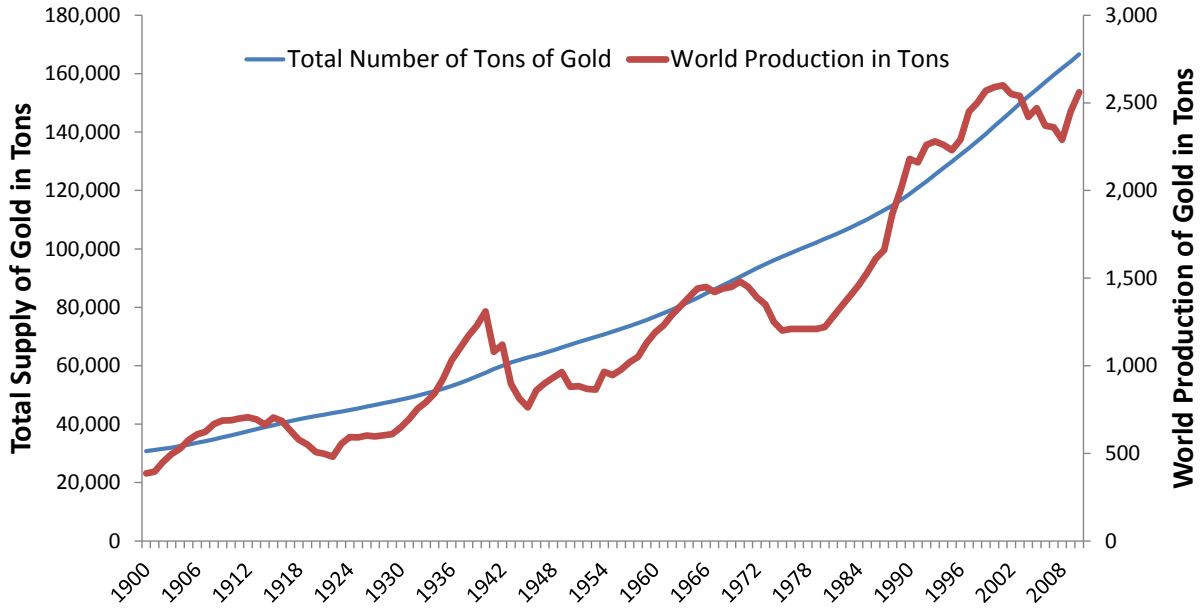
[30] See Madura (2011).
[31] See Evans-Pritchard (2009).
[32] Gold mining company Barrick reported 2011 cash gold mining costs of $460/ounce and expects 2012 cash gold mining costs in the range of $520-560/ounce (http://www.barrick.com/company/profile/default.aspx).
[33] See Whitehouse (1999).
[34] See 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



There are basically three uses for the above ground supply of gold: jewelry, investment and technology. The investment category is 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%.

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

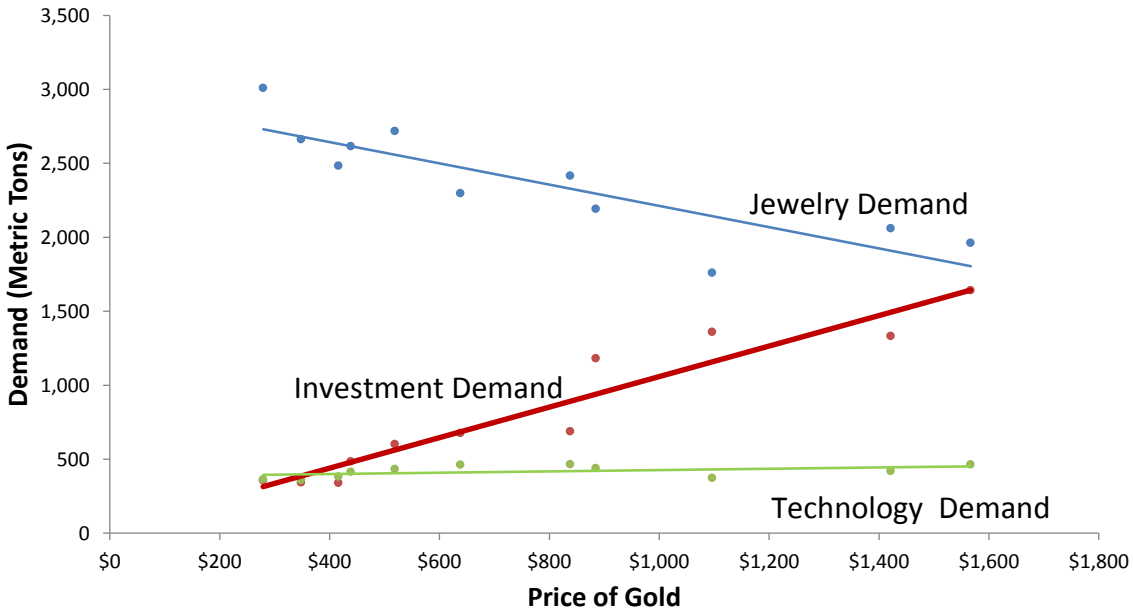
Year	Demand (Metric Tons) Jewelry	Investment	Technology	Production (Metric Tons)	Implied Scrap (Metric Tons)	U.S. Dollar Gold Price
2001	3,009	357	363	2,600	1,129	$279
2002	2,662	343	358	2,550	813	$348
2003	2,484	340	382	2,540	666	$416
2004	2,616	485	414	2,420	1,095	$438
2005	2,718	601	433	2,470	1,282	$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	-0.08	0.78	0.06	0.02	0.02	

Exhibit 19 also provides an 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 -0.08. This means that a 10% increase in the price of gold is associated with less than a 0.8% decrease in demand for gold. However, this is likely overstated because we do not control for wealth increases and population changes.[35] The price elasticity of investment demand is *positive* and has a value of 0.67. This means that a 10% increase in the price of gold was met with about a 6.7% 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 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.

[35] Batchelor and Gulley (1995) estimate the price elasticity of demand for gold to be between -1.0 and -0.5.

Exhibit 20. Demand Price Elasticity



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 behavioral 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 firm 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.

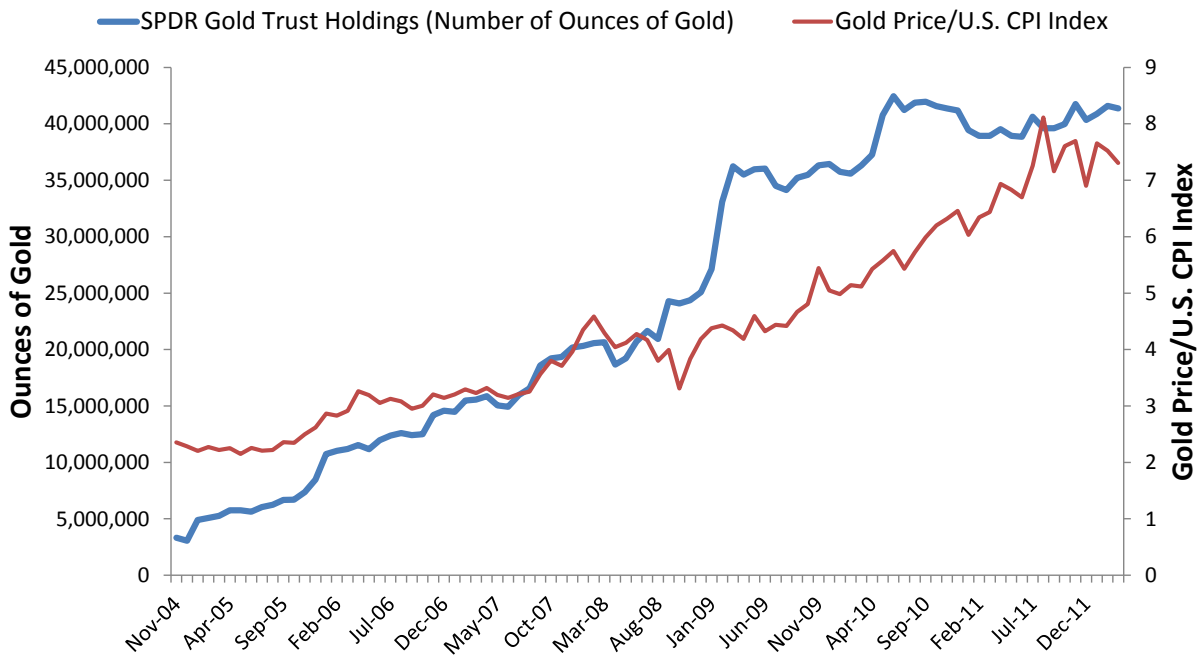
A momentum investor faces an upward sloping demand curve: the higher the past return of an asset the higher momentum investor's demand for the asset. There is another type of momentum investor, one who attempts to replicate the pay-off from a call option. As Perold and Sharpe (1995) show, an investor 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 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 that 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 "non-traditional 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

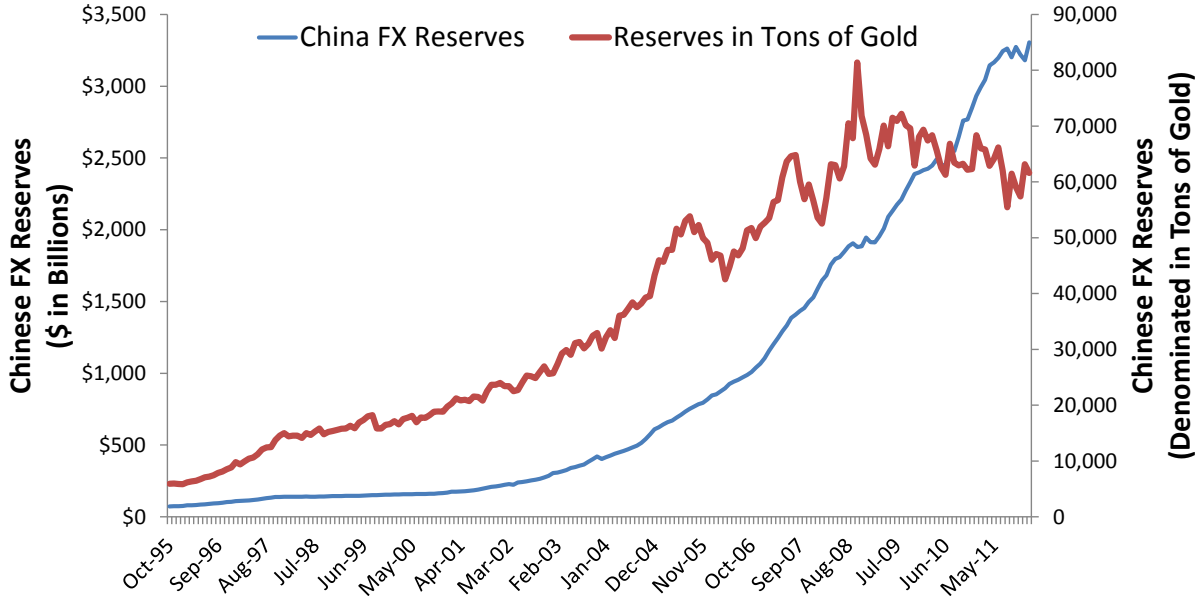


6.3 BRICs and gold

One possible source of "too much demand" for the price of 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 number of ounces of gold those reserves would have been worth over time. For instance in 1995, if 100% of China's foreign

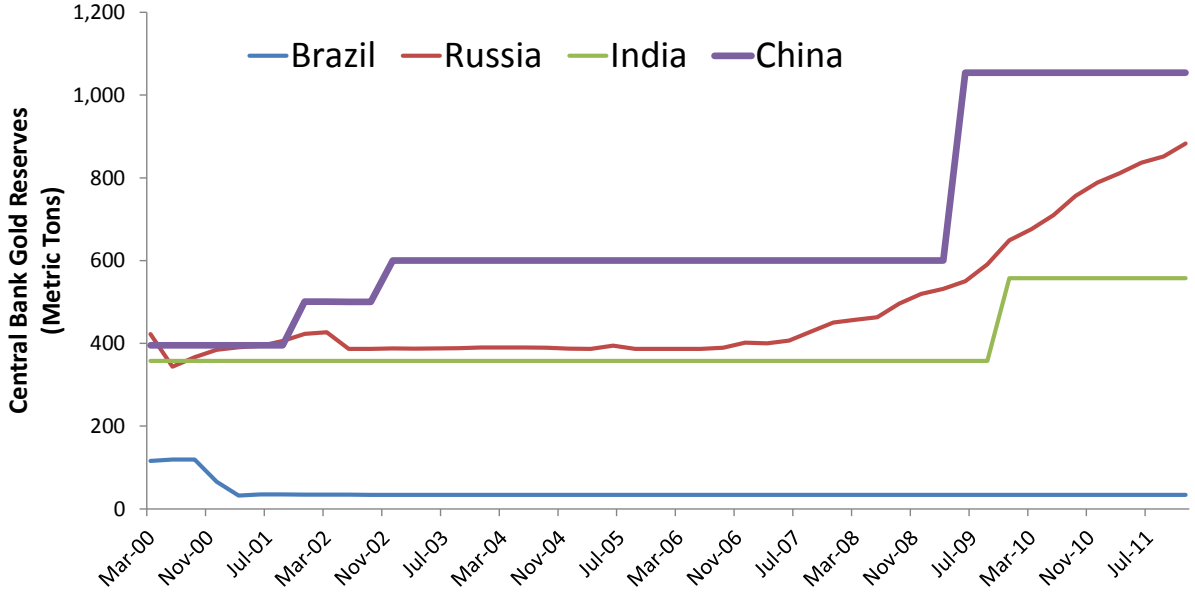
exchange reserves had been invested in gold China would have owned about 6,000 tons of gold. Using the same sort of hypothetical framework, China's current foreign currency reserves would "buy" about 66,000 tons of gold. This would represent about one-third of the total above ground stock of gold.

Exhibit 22. Chinese U.S. Dollar Reserves and Ounces of Gold



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.

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 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.

Exhibit 24. Central Bank Gold Reserves

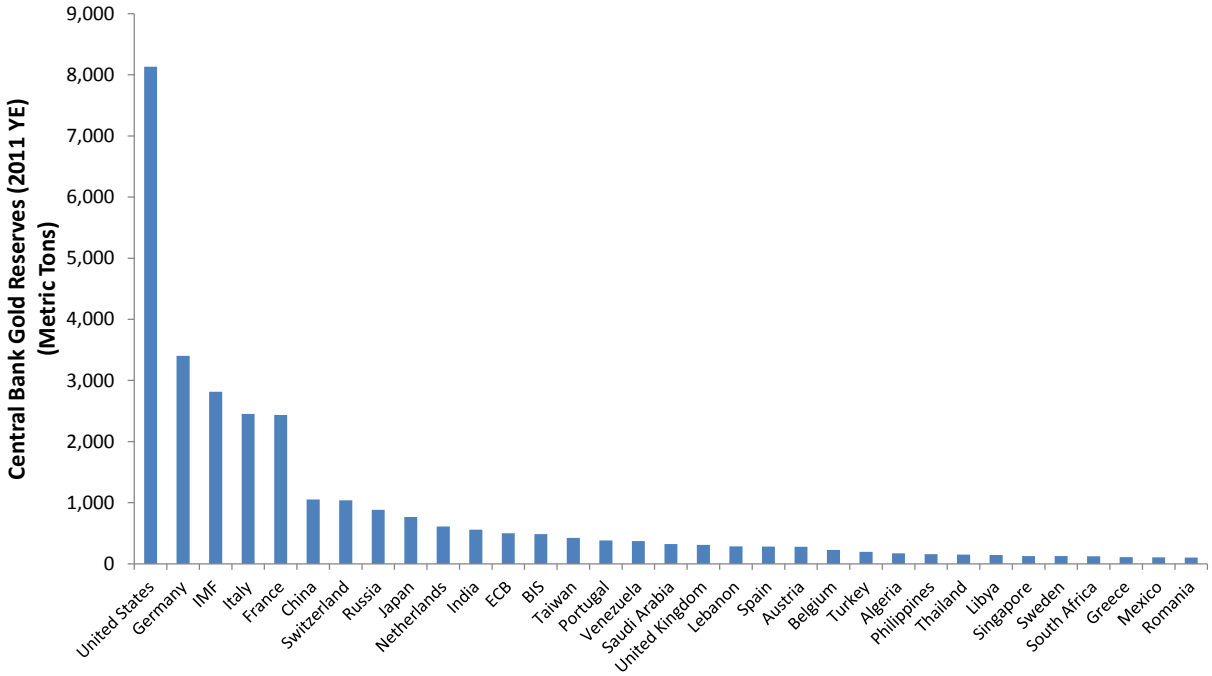
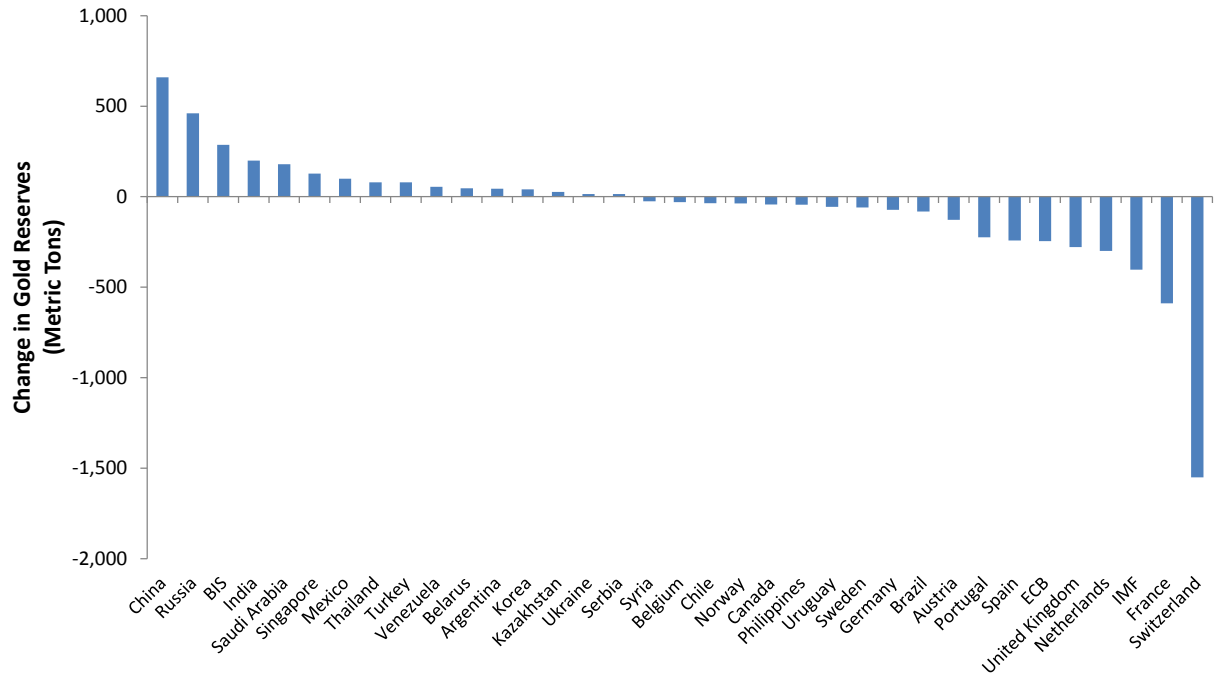


Exhibit 25 profiles the entities that have either purchased or disposed of the largest gold holdings since 2000. China, Russia and Saudi Arabia have been enthusiastic purchasers of gold and the Netherlands, France and Switzerland lightened up on their gold holdings. For many years the central banks of the Western countries viewed gold as a "barbarous relic" that cluttered up their balance sheets. 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 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 possible gold holdings relative to the size of a country's GDP as well as 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 GDP 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.

Exhibit 26. BRICs as Developed Markets and Gold

	2010 GDP (US $ Billions)	2010 Population (Millions)	2010 Central Bank Gold Reserves (m tons)	2010 Gold/GDP Ratio	2010 Gold/Pop. Ratio	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)
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

6.5 Gold in a diversified portfolio

Exhibit 27 addresses the "gold is under owned" argument from a different angle. One of the key insights of the Capital Asset Pricing Model is that investors should hold the "market portfolio". For instance the market value of all the stocks in the world was recently about $48 trillion and the market value of all the bonds in the world was about $41 trillion. 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. 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 investors own?

Depending upon how one defines the size of the gold market there are at least three "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).

Exhibit 27 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 stock/bond/gold market. There is good news and bad news in this measure. This 2% represents already existing investment by investors, so it is possible to think that the world already follows a 53%/45%/2% stock/bond/gold allocation model. However, 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 stock and bond investors were to invest in gold they might use Exhibit 27 as a guide to moving to a 2% allocation to gold. Given the small size of the gold market relative to the stock and bond markets, this

2% portfolio allocation to 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 to a 2% portfolio allocation to gold would probably result in much higher gold prices. 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 27: 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 Incom	$41.20	$41.20	$41.20	40.5%	42.9%	43.6%
Gold	$9.14	$3.40	$1.79	9.0%	3.5%	1.9%
Total	$101.74	$96.00	$94.39	100.0%	100.0%	100.0%
Required Tons of Gold				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. 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 price they pay for gold the possible move into gold could drive the real price of gold much higher.

7. Conclusions

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 price – some of these stories argue the price of gold is too high and others suggest the price could go even higher. The goal of this paper is to analyze these reasons.

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 FX changes.

Anyways, for a particular currency pair, even if gold hedges one country's currency, it cannot hedge the other's. We suggest that the argument that gold is attractive when real returns on other assets are low is spurious. Low real yields, say on TIPS, do not cause the real price of gold to be high. There is some other economic force, perhaps a fear of inflation, driving variation in both TIPS and the real price of gold. We also deconstruct the safe haven argument. We focus on hyperinflations in major countries (because smaller countries that fall into hyperinflationary episodes might simply adopt another currency, such as the U.S. dollar, as their de facto currency). Our analysis shows that the price of gold is very sensitive to even a remote possibility of another Weimar Republic-like inflation episode.

We analyze the demand for and the supply of gold. The USGS estimates that using current technology only 20 years supply of gold exists below the ground. Indeed, mining production has not significantly increased even though the price of gold has substantially appreciated over the past decade. 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 per capita and per GDP gold holdings 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 price of gold. Finally, we examine the asset allocation problem of the average investor. Gold is about 9% of today's 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.

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