

Forecasting Gold as a Commodity

- The monetary demand for gold has played a significant role in the large swings in gold prices over the past decade. The selling of gold from government central bank reserves in the late 1990s depressed gold prices, while the buying of gold for private investment has pushed prices up dramatically in the current financial crisis.
- It is therefore tempting to view gold prices as driven by the vagaries of government policy and the investor's view of financial distress.
- However, the rise in gold prices over the past decade falls within a longer cycle in gold prices, that has been driven more by the economics of gold supply.
- In this paper, we introduce a new approach to forecasting the price of gold based on the monetary demand for gold (specifically, the buying by gold-ETFs and the selling by central banks) and on the crucial role of real interest rates in the economics of gold supply.
- Consistent with the economics of an extraction industry, the rate of gold mine production increases in higher real interest rate environments, as the opportunity cost of leaving gold in the ground declines. Consequently, the current low real interest rate environment provides strong support for gold prices.

Important disclosures appear at the back of this document

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Forecasting Gold as a Commodity

The monetary demand for gold has played a significant part in the large swings in gold prices of the past decade, with the selling of gold from government central bank reserves in the late 1990s depressing gold prices and the buying of gold for private investment—including the new gold exchange traded funds (gold-ETFs)—sending gold prices through \$1,000/toz twice during the current financial crisis (Exhibit 1). Because the monetary demand for gold has had such a significant influence on gold prices over the past decade, it is tempting to view gold prices as driven simply by the vagaries of government policy and the investor’s view of financial distress; however, when viewed within the larger historical context, the past decade’s rise in gold prices falls within a longer cycle in gold prices, driven more by the economics of gold supply. This report introduces a framework for understanding the influence of both monetary demand and the economics of gold supply on the price of gold. Based on this framework, we present a new approach for forecasting the price of gold based on the monetary demand for gold (specifically, the buying by gold-ETFs and the selling by central banks) and on the crucial role of the real interest rate in determining the opportunity cost of mining.

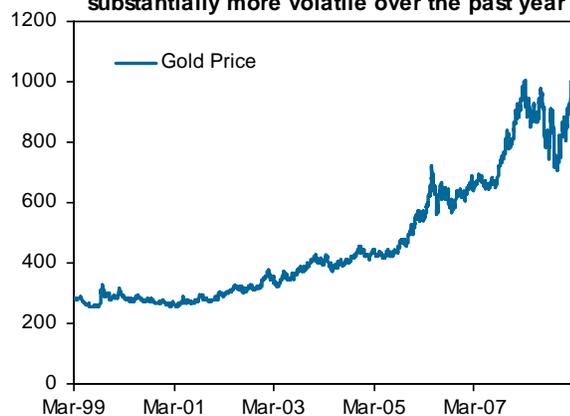
This “gold as a commodity” framework suggests that gold prices have strong support at and above current price levels should the current low real interest rate environment persist. Specifically, assuming real interest rates stay near current levels and the buying from gold-ETFs slows to last year’s pace, we would expect to see gold prices stay near \$930/toz over the next six months, rising to \$962/toz on a 12-month horizon. However, should real interest rates move lower or gold-ETF buying continue at its current torrid pace, the upside risk to gold prices would likely be significant.

Historically, we have viewed gold more as a currency than a commodity (see our February 4, 2009 report “Gold: The currency of last resort”), valuing gold (in US dollars) in relation to the US dollar price (or exchange rate) of a basket of currencies. We view the approach in this report as complementing, not replacing, the currency approach, with each framework providing a valuable perspective on gold pricing.

In terms of the approach to gold pricing, these frameworks can be described as follows:

- **Currency framework:** Gold priced in relation to the price of potential substitutes for use as a store of value and medium of exchange.

Exhibit 1: Gold prices have increased four-fold over the past decade, and have become substantially more volatile over the past year



Source: Commodities Exchange (COMEX)

Key price drivers: Exchange rates, financial risk as measured by credit default swap rates on high-risk sovereigns and financials.

- **Commodity framework:** Gold priced in relation to the marginal cost of supply and to the marginal willingness of consumers to pay.

Key price drivers: Real interest rates, the overall price level as measured by the consumer price index (CPI), and movements in monetary demand for gold.

The “gold as a commodity” framework explains three key “stylized facts” of gold prices in terms of the influence of real interest rates, inflation, and monetary demand for gold on the supply and demand for gold.

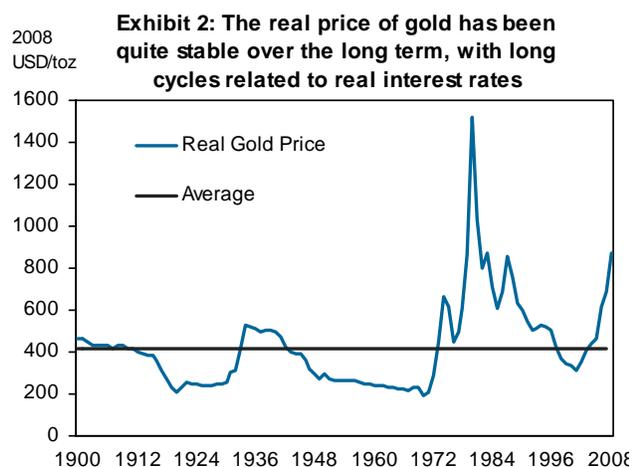
Three stylized facts of gold prices:

- **Long-term stability of purchasing power:** The real (inflation-adjusted) price of gold has been stable over extremely long periods of time (Exhibit 2). More specifically, over the past 100 years, the real price of gold (in 2008 dollars) has averaged roughly \$420/ toz, with an ounce of gold having the same purchasing power in 2005 as it did in 1900.
- **Negative correlation with real interest rates:** While stable over extremely long periods of time, real gold prices tend to move in long cycles, which are negatively correlated with the level of real interest rates.
- **Positive correlation with financial distress:** Gold prices tend to spike upward during financial crises, as the demand for monetary gold increases.

Interestingly, the historical behavior of supply, demand, and physical inventories in the gold market suggest that the first two “stylized facts” arise from the economics of gold supply, not gold demand, while the third arises from the monetary demand for gold. In particular, the following historical behavior is evident.

Historical behavior of gold fundamentals:

- World gold mine production has historically moved in roughly 30-year cycles over the past century or more, with mine production growing at a faster pace during periods of high real interest rates and at a slower pace during periods of low real interest rates.



Source: US Geological Service (USGS), GFMS and GS Global ECS Research

- Monetary demand for gold—the demand for physical inventories of gold bullion and coin—increases in periods of financial distress such as the current one.
- Non-monetary demand—the demand for gold to be used in the creation of jewelry, art, electronics, and dentistry, is relatively stable over time, reacting primarily to the movements in real gold prices, with increasing real gold prices decreasing the non-monetary demand for gold.

As discussed in detail below, these three “stylized facts” of gold prices and the historical behavior of gold supply, demand, and physical inventories are consistent with—and can be seen as arising from—the following view of the economics of the gold market. On the supply-side, the marginal cost of extracting gold from the ground consists of the realized cost of extracting the gold plus the opportunity cost of not leaving the gold in the ground to be extracted in the future. The fact that real gold prices are stable over extremely long periods of time suggests that the realized cost of extraction increases with the price level of the overall economy. The fact that the rate of world gold mine production increases with the real interest rate suggests that, as the real interest rate increases, the opportunity cost of extracting gold declines, leading to greater gold extraction today. To take an extreme example, imagine that the real rate of interest is extremely high, such that one does not care at all about the future; then one would want to extract as much gold today as possible, given the realized cost of extraction.

On the demand-side, monetary demand for physical inventories of gold bullion and coin increase with perceived financial distress. Increased monetary demand for gold must be met by increasing prices to motivate greater mine production or reduced non-monetary demand. Non-monetary demand—primarily jewelry demand—largely accommodates movements in gold supply and monetary demand, with higher real gold prices reducing non-monetary demand for gold and even inducing the scrapping of gold jewelry.

In the next section of this report, the historical behavior of gold prices and fundamentals outlined above is discussed in more detail, providing the background for the conceptual framework of the economics of the gold market. In the section following, this conceptual framework is used as the basis for a new approach to forecasting gold prices. In the third and final section, the relationship between the frameworks of “gold as a currency” and “gold as a commodity” is discussed.

The Historical Behavior of Supply, Demand and Physical Inventories, and the Economics of the Gold Market

Gold mine supply: the economics of extraction and real interest rates

Since the beginning of the twentieth century, the production of gold from the world’s mines has ebbed and flowed in long cycles extending over the span of decades. As seen in Exhibit 3, world gold production has exhibited a fairly regular cycle, with roughly 30 years between each peak. Interestingly, real gold prices have been strikingly stable over this more than a century of history, although they have tended to be low when world gold production is near a peak and high when world gold production is near a trough, suggesting that it is the movements in supply that are driving real gold prices over these long cycles. If supply is driving the price of gold, then the question becomes what is driving supply?

As seen in Exhibit 4, changes in the rate of world gold mine production tend to move with the level of real interest rates, with high real interest rates leading to faster growth in gold mine production.

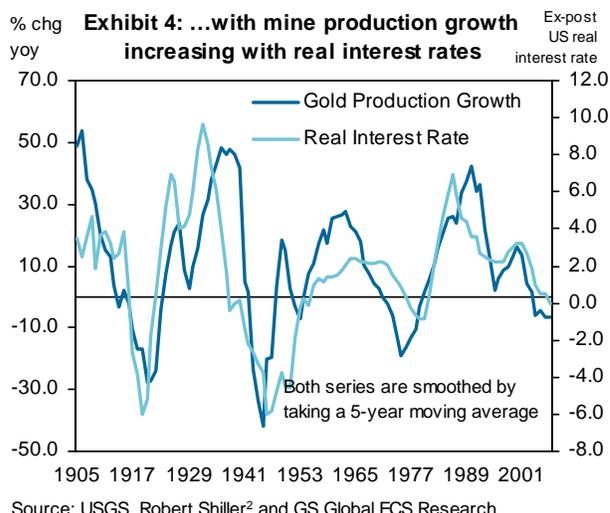
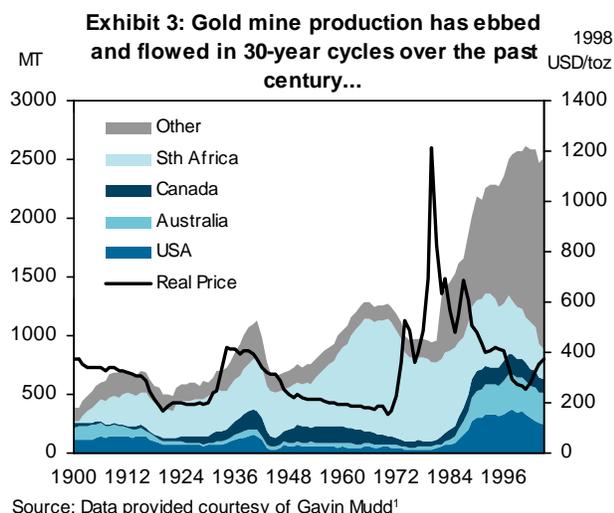


Exhibit 4 suggests that higher real interest rates increase the rate of gold mine production while lower real interest rates slow the rate of mine production. This is consistent with the economics of an extraction industry. The marginal cost of extracting today is not only the actual cost of mining, but the opportunity cost of not having the same gold to mine in the future. This suggests that higher interest rates lead one to discount the future more heavily, driving down the opportunity cost and leading one to extract at a faster rate. To take an extreme example, if one did not care at all about the future (i.e., an extremely high interest rate), one would extract the gold as quickly as possible.

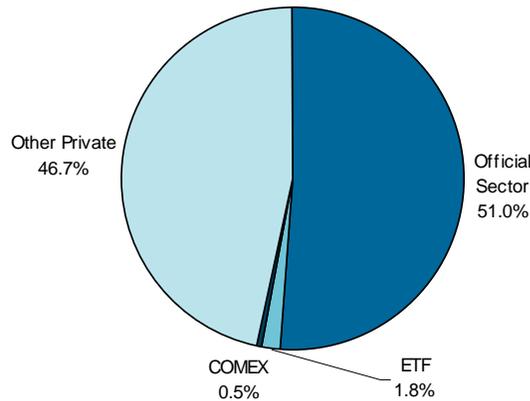
It is important to note, however, that the above economic behavior does not require that gold be viewed as an exhaustible resource. In fact, the economics of extraction can be seen as the mirror image of the economics of investment. It is conventional economic wisdom that high real interest rates discourage investment, as they increase the cost of capital. Consequently, one expects to see less investment in factories and manufacturing plants in high real interest rate environments. For a gold mine, however, extraction offers a second—more rapid—way to divest, by pulling the gold out of the ground today. Viewed in this way, the economics of extracting from an existing gold mine is the mirror image of the economics of investing in a new one. A high real interest rate reduces the motivation to invest and increases the motivation to extract. Consequently, higher real interest rates lower the marginal cost of extraction, which leads to greater supply and lower prices.

Monetary demand: Central bank reserves, gold-ETFs, and COMEX inventories

Once gold is extracted from the mine and refined, it can be used to satisfy both monetary and non-monetary forms of demand. The monetary demand for gold consists primarily of demand from the official sector for central bank gold reserves, from the private sector for holdings of gold bullion and coins (including those held by the gold-ETFs), and from the demand for warehouse stocks on the gold futures exchanges, principally the Commodity Exchange (COMEX).

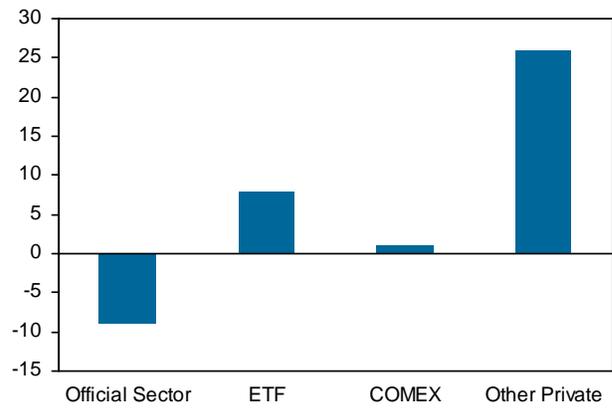
1. Mudd, Gavin M. Global trends in gold mining: Towards quantifying environmental and resource sustainability? Resources Policy 32 (2007) 42-56.
 Shiller, Robert J. Market Volatility. MIT Press. Cambridge, MA 1989.
 2. Shiller, Robert J. Market Volatility. MIT Press. Cambridge, MA 1989.

Exhibit 5: Futures exchange and gold-ETF inventories comprise a small part of overall inventory holdings...



Source: World Gold Council, GFMS, COMEX and the gold-ETFs

Exhibit 6: ...but the growth of gold-ETF holdings has been substantial in recent years

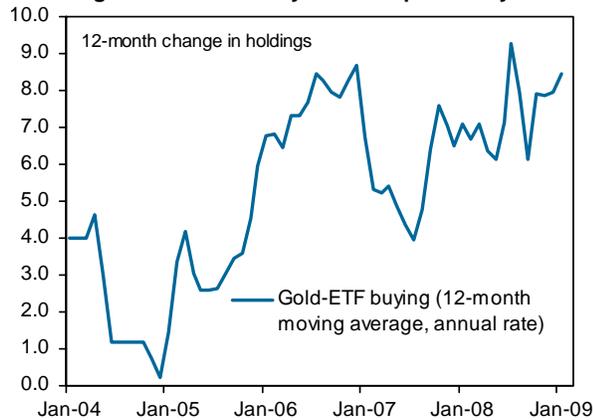


Source: World Gold Council, GFMS, COMEX and the gold-ETFs

When discussing the monetary demand for gold, it is important to distinguish between the overall level of physical inventory being held and the strain on the current supply-demand balance from changes in the level of physical inventory being held. For example, holdings by gold-ETFs were 33 million toz, representing only 3.0% of all monetary gold holdings at the end of 2008 (Exhibit 5); however, while gold-ETF holdings of physical inventories are a fraction of the amount held by the official sector and by other private investors, the rapid growth in gold-ETFs over the past five years has exerted a meaningful pull on supply. For example, from the end of 2007 to the end of 2008 ETF holdings increase by 8.0 million toz, comparable to central bank sales and almost one-third the size of all the other private sector investment purchases (Exhibit 6).

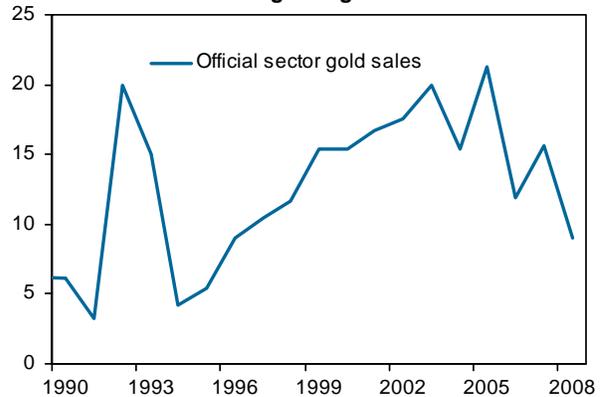
Consequently, changes in gold-ETF and central bank holdings can—and historically have—exerted a meaningful influence on the underlying supply and demand balance. As seen in Exhibit 7, gold-ETF holdings have increased rapidly over the past five years, likely tightening the underlying supply-demand balance and exerting upward pressure on gold prices. Conversely, as shown in Exhibit 8, central bank sales increased rapidly in the late 1990s, weakening the underlying supply-demand balance and putting downward pressure on gold prices. The extent of the downward pressure on gold prices eventually led to

Exhibit 7: Annual gold ETF demand has grown considerably over the past few years

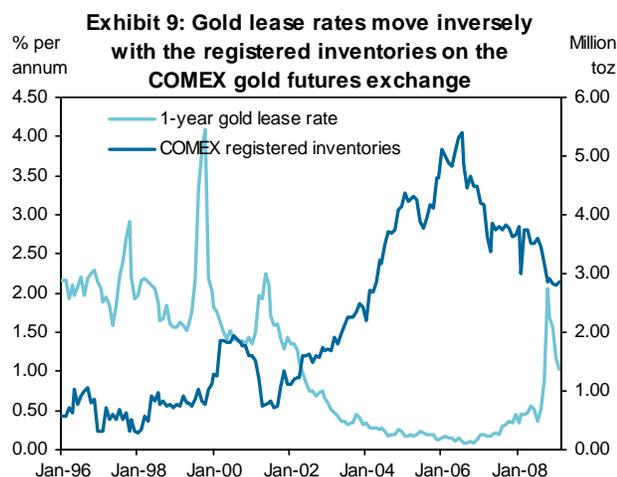


Source: The gold-ETFs and GS Global ECS Research

Exhibit 8: ...Central bank sales increased in the late 1990s, prompting the Washington Agreement



Source: GFMS and GS Global ECS Research



Source: COMEX, Bloomberg and GS Global ECS Research

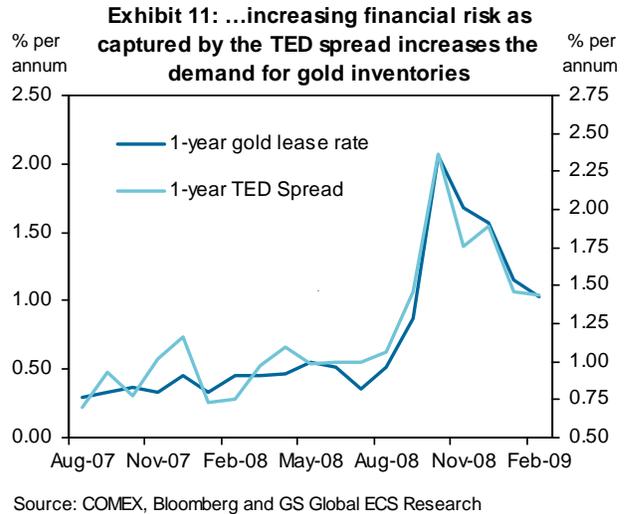
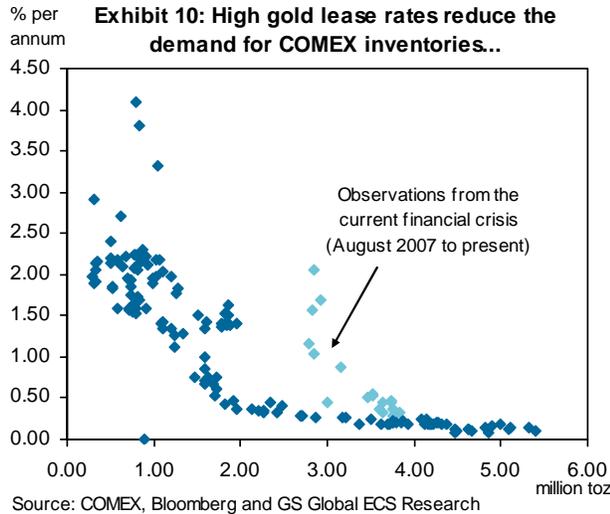
the signing of the Washington Agreement in 1999, limiting the combined annual sales of signatories to 400 tonnes (12.9 million toz).

Relative to these other forms of monetary demand, COMEX warehouse inventories of gold are small both in terms of levels and changes. Consequently, they tend to have little direct impact on the supply-demand balance; however, COMEX inventories do play an important role in determining gold lease rates and, consequently, the shape of the gold futures price curve.

The gold lease rate is the interest that must be paid (in our case in US dollars) to lease, or borrow, physical gold for a specified period of time. Consequently, this can be viewed as the explicit cost of borrowing gold to hold for a period of time or the opportunity cost of holding one's own gold and not lending it out to another. As seen in Exhibit 9, the one-year gold lease rate rose in the early 1990s to an average of between 1.50% and 2.00% by the late 1990s, with a spike to a high of 4.10% in October 1999 following the signing of the Washington Agreement, in which central banks agreed to limit sales of gold from their reserves. Gold lease rates then declined throughout the first part of the current decade, reaching a low of only 0.08% in September 2006, before rising with the current financial crisis. Throughout this time period the gold lease rate moved inversely with the level of COMEX gold inventories (see Exhibit 9), much as one would expect, given that the gold lease rate is the price of holding physical inventory.

Further, Exhibit 10 illustrates a nearly textbook "demand vs. price" relationship between the amount of physical gold inventories held on the COMEX and gold lease rates through August of 2007. The inventory-demand curve is quite stable and downward sloping, with less inventories of gold being held on the COMEX as gold lease rates increase. Following the onset of the current financial crisis in the second half of 2007, however, the gold lease rate began to climb to a much higher level than would have been expected, given the level of physical gold inventories. That is, the demand for physical gold appears to have shifted outward in response to the financial crisis.

The link between the current financial crisis and the increased demand for physical gold inventory can be seen explicitly by looking at the correlation between gold lease rates in the recent period and the TED spread or the difference in (one-year) interest rates between LIBOR and the US Treasury (Exhibit 11). Because the TED spread is the difference in borrowing rates between financial institutions and the US Treasury, it effectively captures the



degree of financial counter-party risk priced into the market. As the degree of counter-party risk increases, so too does the demand for physical gold.

The relationships in Exhibits 10 and 11 can be quantified through the use of a regression analysis. As seen in Exhibit 12, the gold lease rates are well-explained by the TED-spread and the level of COMEX registered gold inventories. Exhibit 13 reports the results of this regression analysis of the (log) one-year gold lease rate on COMEX registered gold inventories (in million troy oz) and the one-year TED-spread. The analysis was performed on the log of the gold lease rate in order to capture the non-linearity evident in Exhibit 10. As reported in Exhibit 13, a one million ounce increase in COMEX inventories decreases the gold lease rate by 0.68% while a 100 bp increase in the TED-spread increases the gold lease rate by 0.95%.³

The gold lease rate is also the amount investors are willing to pay to hold physical gold as opposed to a gold futures contract, which helps explain why the TED-spread is an important driver of the demand for physical gold. Specifically, investors can gain exposure to the movements in gold prices by

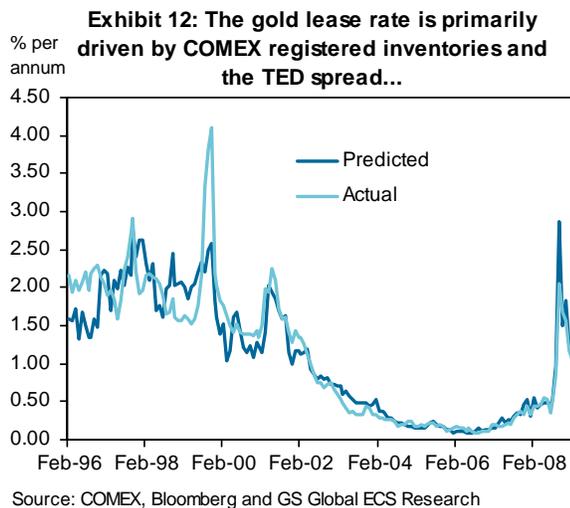


Exhibit 13: ...with the gold lease rate increasing in the TED spread and decreasing in COMEX inventories (regression results of log(Gold Lease Rate))

Parameter	Estimate	t-Statistic
Intercept	0.72	16.98
TED spread	0.96	17.43
Inventories: Registered	-0.68	-51.53
Standard Error	0.24	
R-square	0.95	

Source: COMEX, Bloomberg and GS Global ECS Research

3. Because the regression is performed on the log lease rate, the impact varies with the level of the lease rate. For example, at a 1% lease rate a one million toz increase in inventories lowers the lease rate to 0.32% while at a 2% lease rate the same increase in inventories would lower the lease rate to 0.64%.

holding physical gold or futures contracts, but investors will be willing to pay more to hold physical gold in periods of high counter-party risk when they are less certain about the ability to collect on the futures contracts. In this manner, perceptions of greater financial risk increase the monetary demand for gold. To supply this increased monetary demand, physical gold needs to be either bid away from its competing uses or extracted from the mines.

Non-monetary demand: Jewelry demand and the real price of gold

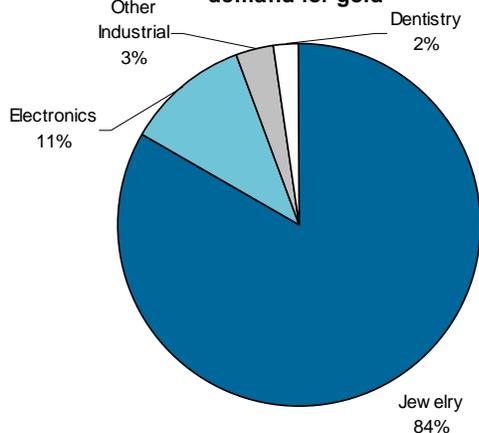
It is common practice to divide the “demand” for gold into monetary and non-monetary demand. As discussed, the monetary demand for gold is the physical inventory of gold bullion and coins. Because gold is not consumed in use (as is, for example, petroleum), one could conceptualize the non-monetary demand for gold as the physical inventory of gold jewelry and art for example; however, the evidence suggests that the more relevant measure of non-monetary demand is not the physical inventory of jewelry and art but the demand for gold for the creation of new jewelry and art. That is, the change in the physical inventory of gold jewelry and art. Consequently, our concept of the gold market supply-demand balance would be that the change in amount of physical gold inventories held for monetary reasons equals supply less non-monetary demand.

Supporting the idea that the more relevant measure of non-monetary demand is not the physical inventory of jewelry and art but rather the demand for gold for the creation of new jewelry and art is the fact that, once gold is embedded in high value jewelry and art, it is effectively locked up, much as it would be in a mine. Consequently, gold can either be held in a liquid monetary form, as inventory, or in illiquid jewelry. Gold for monetary holdings must either be sourced from the mine or from the scrapping of gold jewelry, both areas from which some expense is required to extract the gold.

Perhaps because gold jewelry is purchased with the idea it will be held for long periods of time, non-monetary gold demand is remarkably stable over time. As seen in Exhibit 14, the apparent gold consumption per capita in the United States has seemed to simply fluctuate inversely over time with the real price of gold. This suggests that, unlike many commodity markets, gold prices are not driven by non-monetary demand but that gold prices drive non-monetary demand.

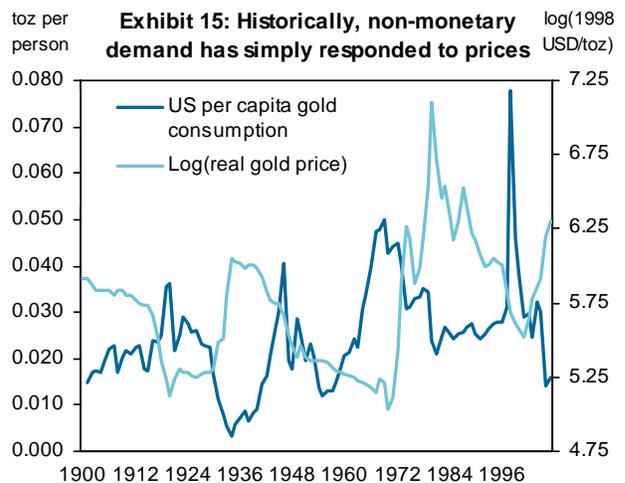
Highlighting the responsiveness of jewelry demand to gold prices is the fact that world jewelry demand fell in line with higher prices throughout the 1990s

Exhibit 14: Jewelry dominates non-monetary demand for gold

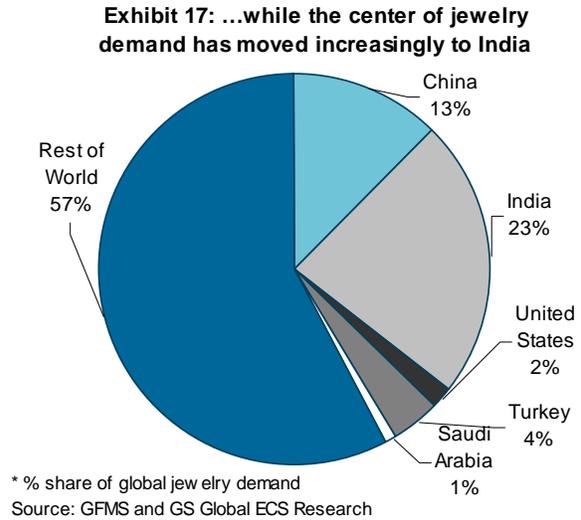
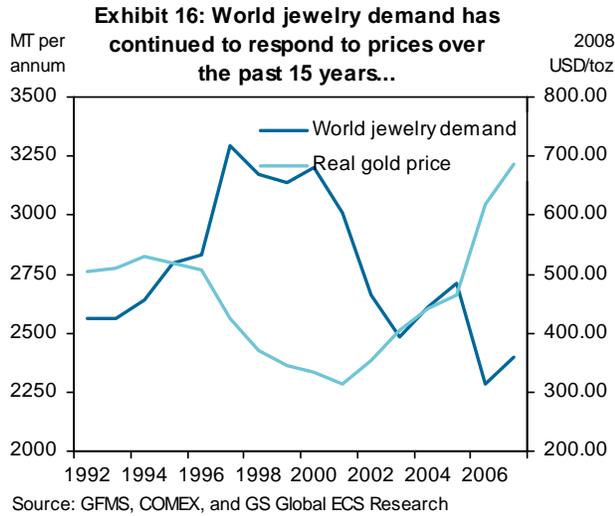


Source: GFMS and GS Global ECS Research

Exhibit 15: Historically, non-monetary demand has simply responded to prices



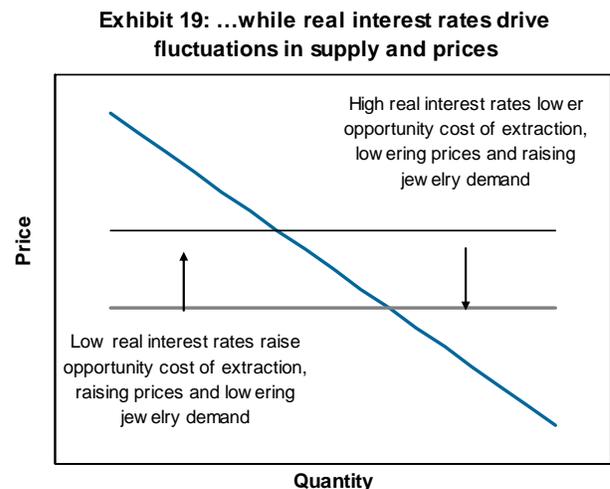
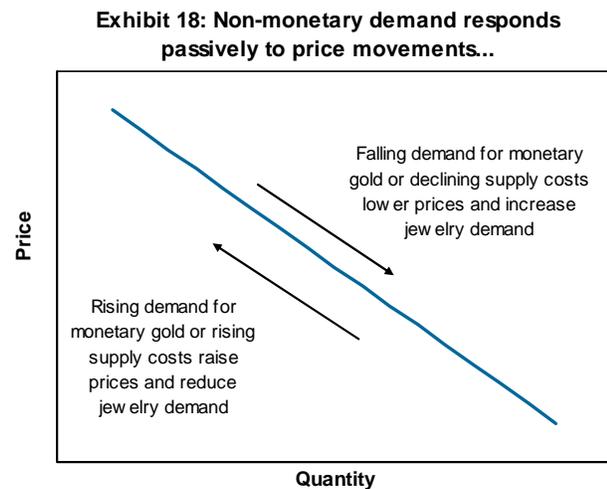
Source: USGS and GS Global ECS Research



despite the rapid rise in jewelry demand from India (Exhibit 16). The strong growth in income in India, matched with a cultural proclivity for gold, has led India’s share of annual gold jewelry demand to more than double over the past 15 years, increasing from 9.4% in 1993 to 23.0% in 2008 (Exhibit 17). Interestingly, Chinese jewelry demand was roughly flat over the same period, with its share of gold jewelry demand increasing only slightly, from 11.9% in 1993 to 12.6% in 2008.

Assembling the evidence: a conceptual framework of gold as a commodity

The empirical evidence suggests the following conceptual framework for supply and demand in the gold market. Recalling Exhibits 15 and 16, one has the distinct impression that one is looking at price induced movements up and down a relatively stable demand curve (Exhibit 18). The origin of these price movements lie in shifts in the monetary demand for gold and from fluctuations in the cost of supply. Recalling Exhibit 4 suggests that most of the movements in supply seem to come from fluctuations in real interest rates, with some role played by higher prices calling forth greater supply in the short run (Exhibit 19), while the shifts in monetary demand are driven primarily by central bank sales and private investment in monetary gold, notably by the gold-ETFs.



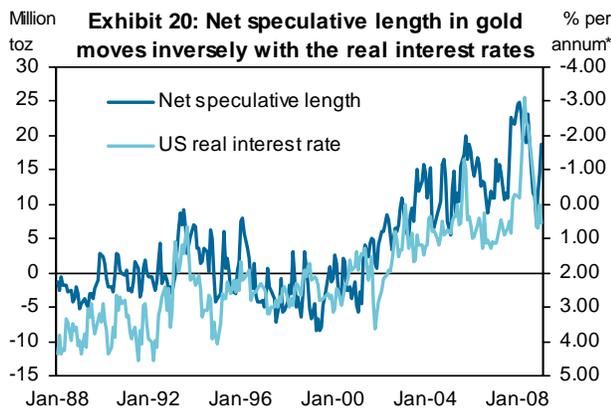
Forecasting Gold Prices

From the framework of “gold as a commodity,” the evolution of gold prices is determined by the movements in the underlying gold supply-demand balance. As in other commodity markets, such as copper and petroleum, inventories in the gold market act to smooth out the variability in the supply-demand balance. This role for inventories suggests that gold prices are driven by primarily two factors: physical gold inventory levels and the forward supply-demand balance. Like the other commodity markets, physical inventory levels drive the shape of the gold forward curve while movements in the forward balance are reflected in the movements in the prices of long-dated futures contracts.

Consequently, a commodity pricing framework can be applied to forecasting gold prices by employing the following relationships.

- **Gold forward price spreads:** COMEX inventories and nominal interest rates drive the shape of the gold forward curve, specifically the price spread between near- and long-dated contracts. High inventory levels place downward pressure on near-dated prices relative to long-dated prices, as the market anticipates inventories returning to more normal levels over time.
- **Long-run gold prices:** Long-dated futures prices “look through” the near-term impact of inventories on prices to give a cleaner read on the long-run forward supply-demand balance and the long-run price of gold. The real long-run price of gold has been stable over the long term with deviations driven by real interest rates and monetary demand.
- **COMEX inventories:** COMEX inventories tend to be too small to exert a meaningful influence on the supply-demand balance. Further, COMEX inventories tend to move in anticipation of forward fundamentals, rather than the current supply-demand balance.

In estimating these relationships, the role of speculative positions in capturing the forward balance of the market is crucial. Speculative positions convey information to the market on forward fundamentals. In this way, speculative positions can drive prices and weighted COMEX inventories. As expected, the information conveyed by speculative positions in the gold market primarily concerns the real interest rate, with net speculative length being inversely correlated with the real interest rate (Exhibit 20). Consequently, in employing these relationships to forecast gold prices, speculative positions are the channel through which forward fundamentals, notably real interest rates, drive gold prices and inventories.



*Note: ex-ante real interest rate calculated as 10-year US Treasury yield less inflation expectations from University of Michigan Survey
 Source: CFTC, the US Federal Reserve, the University of Michigan, and GS Global ECS Research

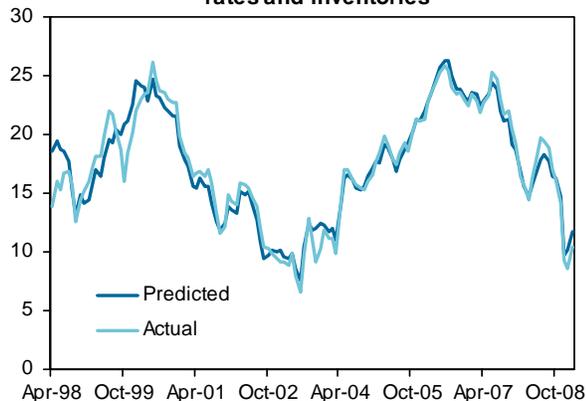
Gold forward price spreads: COMEX inventories and interest rates drive the shape of the gold forward curve

The relationship between COMEX inventories and the gold lease rate implies a relationship between COMEX inventories and the shape of the gold forward curve. This is because gold can be leased indirectly through a set of futures market transactions, creating the potential for arbitrage between the gold lease rate and the gold forward curve. In order to lease gold indirectly through the gold futures market, an investor could engage in the following set of transactions. First, borrow funds at the interest rate to purchase physical gold. At the same time, sell short a futures contract (corresponding to the period of the lease). At the end of the lease period, deliver the purchased gold to close the short futures position, changing the purchase of the physical commodity into a lease. Because this set of transactions is equivalent to leasing gold directly, its cost must equal the gold lease rate. Consequently, the cost of leasing the gold must equal the price of physical gold plus the interest paid, less the price received on the short sale of the commodity futures contract. In short, the gold lease rate is inversely related to the carry in the gold forward curve.

As implied from the discussion above and as seen in Exhibit 21, the shape of the gold price forward curve is well explained by nominal interest rates and COMEX inventories. Exhibit 22 reports the results of a regression analysis of the percentage spread between 60-month and 1-month forward gold prices on US Treasury yields and COMEX inventories, including registered and eligible. As reported in Exhibit 22, the carry in the gold forward price curve mirrors the carry in the US Treasury curve, with the coefficients on the 1-year and 10-year summing to five, reflecting the interest rate for the 5-year period of the gold price spread. The coefficients on the 1-year and 10-year US Treasuries reflect the weightings required to create a proxy for a 5-year zero coupon yield, with this relevant interest rate being roughly 20% the 1-year rate and 80% the 10-year rate over time. The carry in the forward curve also increases with the level of COMEX inventories, with a one million troy ounce increase in COMEX registered inventories increasing the carry by 1.5%.

Interestingly, Exhibit 22 implies that both registered and eligible COMEX inventories affect the long-dated timespreads, while only registered COMEX inventories affect the lease rate (Exhibit 13). In other words, COMEX eligible inventories are increasingly important as one looks further out the forward curve, suggesting that the gold market is pricing them as available inventory, given time. Their effect on the timespreads is only two-thirds the effect of registered inventories, however. As will be discussed below, a weighted measure of the COMEX inventories equal to registered inventory plus two-

Exhibit 21: The spread between 5-yr and 1-m forward gold prices in driven by interest rates and inventories

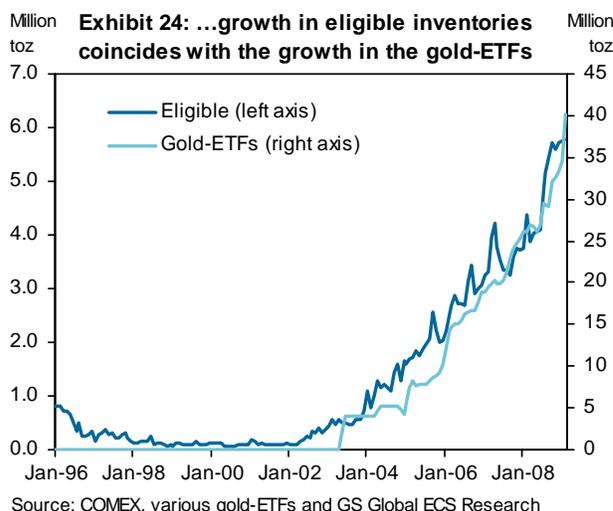


Source: COMEX, Bloomberg and GS Global ECS Research

Exhibit 22: ...with the carry increasing with interest rates and COMEX inventory levels

Parameter	Estimate	t-Statistic
Intercept	-10.21	-36.05
US Treasury: 1-yr	1.11	11.35
US Treasury: 10-yr	3.89	39.64
Inventory: Registered	1.53	13.75
Eligible	0.99	10.82
Standard Error	1.25	
R-square	0.93	

Source: COMEX, Bloomberg and GS Global ECS Research



thirds of the eligible inventories has the strongest connection to gold market fundamentals and prices. For now, note that because COMEX eligible gold inventories have tracked the growth in gold-ETF funds, this suggests that the growth of gold-ETFs will lead to lower registered inventories levels than have been observed historically in similar market environments (Exhibits 23 and 24).

Long-dated gold prices: stable in real (inflation adjusted) terms over the long run but driven by real interest rates and monetary demand fluctuations in the medium term

The influence of COMEX inventories on the shape of the gold forward curve suggests that long-dated gold futures prices provide a clearer reflection of the forward supply-demand balance than do near-dated prices. Consequently, similar to the other commodity markets it is useful to decompose the prompt price of gold into the shape of the forward curve and the long-dated futures price. In this way, the present value of long-dated futures prices can be viewed as a proxy for the long-run gold price; however, in contrast to other commodity markets, the variation in the shape of the forward curve driven by inventories is very small, implying that the real long-dated price of gold⁴ is quite similar to the real price of prompt gold contracts (Exhibit 25). In other words, most of the



4. In the discussion that follows, we refer to the real present value of the long-dated futures price as the “real long-dated price” for the sake of brevity.

variation in gold prices is driven by changes in the long-dated price of gold, not COMEX inventories.

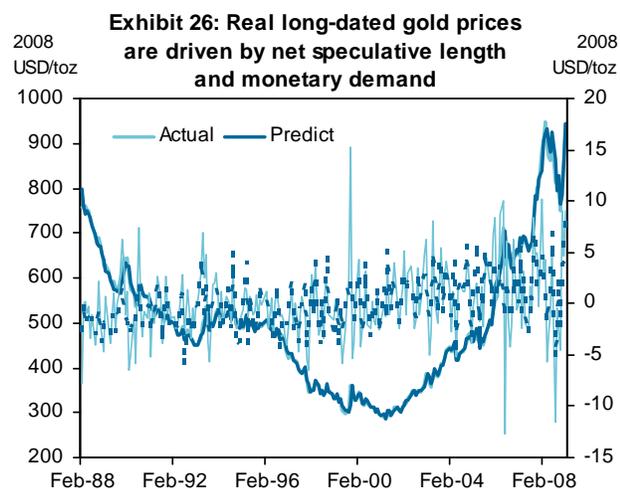
Given the historical economic behavior of gold prices and fundamentals, one expects the real long-dated gold price to behave as follows.

- Real long-dated gold price is stable over long horizons.
- Over medium horizons, the real long-dated gold price is high when real interest rates are low and low when real interest rates are high, with the impact of real interest rates influencing it through the movements in net speculative long positions.
- Over shorter horizons, real long-dated gold price moves with changes in the forward fundamentals as reflected in changes in net speculative length as well as with gold-ETF buying and net central bank selling.

We seek to capture these aspects of real long-dated gold prices by specifying that the percentage monthly change in the real long-dated price of gold is determined by the (log) real long-run gold price one-month earlier, the level of net speculative length one-month earlier, the change in the level of net speculative length, gold-ETF buying, and net central bank selling (all of which are measured in million toz). The results of this regression are reported in Exhibits 26 and 27. As seen in Exhibit 26, this model fits both the level and monthly changes in real long-dated gold prices quite well, capturing over 50% of the variation in monthly price changes. Further, as reported in Exhibit 27, each of the variables has a statistically significant impact on real long-dated gold prices, and in the expected direction.⁵

The model specified in Exhibit 27 suggests that there is a long-run equilibrium between the real long-dated price of gold and the level of net speculative length. This suggests that high levels of net speculative length (corresponding to low real interest rates) will lead to high real gold prices. Further, when real long-dated gold prices are high, or net speculative length is low, relative to this equilibrium, real long-dated gold prices will tend to fall, which restores the equilibrium. The relationship of real long-dated gold prices to the real interest rate is discussed in more detail in the text accompanying Exhibit 31 below.

The model specified in Exhibit 27 also suggests that, over shorter horizons, changes in gold market flows tend to move the real long-dated gold price



Source: COMEX, CFTC, Bloomberg and GS Global ECS Research

Exhibit 27: Regression Results

Parameter	Estimate	t-Statistic
Intercept	17.59	4.92
Real long-dated price (prior month)	-0.03	-4.87
Net speculative length (prior month)	0.18	8.07
Net speculative length increase	0.87	16.03*
Gold-ETF purchases	0.87	16.03*
Central bank sales	-0.87	16.03*
Standard Error	2.41	
R-square	0.53	

Source: COMEX, CFTC, Bloomberg and GS Global ECS Research
 Note: *coefficients constrained to be equal to each other

5. A preliminary regression indicated that the coefficients on the change in the net speculative length, gold-ETF buying, and central bank sales were roughly equal in size. In the regression presented here they are constrained to be exactly equal in size. The constraint was not rejected by the data.

relative to this equilibrium. In particular, a one million toz monthly increase in net speculative length, increase in gold-ETF purchases, or decrease in central bank sales raises real long-dated gold prices by 0.87% over the course of the month. This implies that a one million toz increase in the annual rate of gold-ETF purchases, for example, would raise the real long-dated price of gold by over 10.0% over one year.

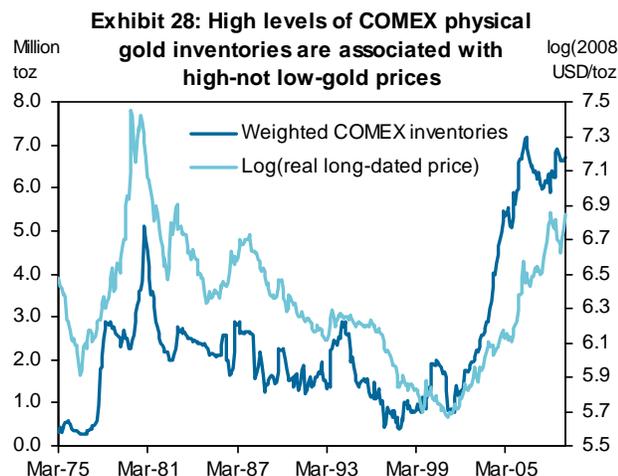
COMEX inventories: COMEX inventories driven by anticipated forward fundamentals, not the current supply-demand balance

The influence of COMEX inventories on the shape of the gold forward curve also implies that, in order to translate the real long-dated gold price back into a forecast of the spot price of gold, we need a forecast of COMEX inventories. Interestingly, COMEX inventories have shown a consistent positive correlation with the level of real long-dated gold prices over the history of the COMEX gold futures market (Exhibit 28).

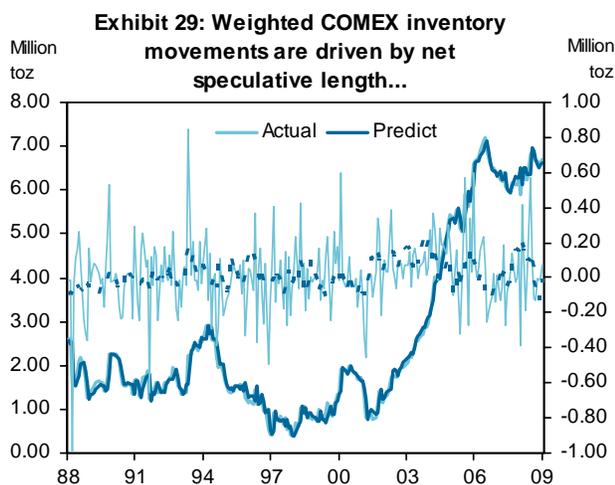
In commodity markets, high inventory levels typically coincide with low prices, with high levels of inventory representing an excess of supply that needs to be worked through the market. While this is typically the case, however, it is not always the case. The correlation between inventory levels and commodity prices is determined by whether the market is being driven by changes in the current supply-demand balance or the anticipated forward supply-demand balance. For example, suppose that the gold market anticipates a rise in the future marginal cost of supply, perhaps driven by lower real interest rates, speculators will likely begin bidding up longer-dated contracts, increasing the carry in the curve. The higher carry motivates investors to hold more inventories. Consequently, the anticipation of higher prices in the future leads to higher inventory levels today.

This same phenomenon was observed in the oil market during the run-up in long-dated oil prices (see GS Energy Watch: “Long-term shortages create near-term surpluses” July 5, 2006). Interestingly, because the near-term gold supply and demand balance is relatively stable, leaving little need for gold inventories as a buffer stock, the role of inventories in anticipating price movements is far more evident.

As implied from the discussion above and as seen in Exhibit 29, the level and changes in weighted COMEX inventories are reasonably well explained by the net speculative length in the gold market. As reported in Exhibit 30, a one million toz increase in net speculative length increases weighted COMEX inventories by only 0.02 million toz in one month but, if maintained, increases weighted COMEX inventories 0.40 million toz over the long term.



Source: COMEX, Bloomberg and GS Global ECS Research



Source: COMEX, CFTC, Bloomberg, and GS Global ECS Research

Exhibit 30: ...with more speculative length increasing the level of weighted COMEX inventories

Parameter	Estimate	t-Statistic
Intercept	0.09	3.85
Inventory (prior month)	0.95	88.81
Net speculative length	0.02	6.56
Standard Error		0.19
R-square		0.99

Source: COMEX, CFTC, Bloomberg and GS Global ECS Research

Given the relationships described above, the strategy for forecasting gold as a commodity is simply as follows.

- Start with a view on real interest rates, inflation, gold-ETF purchasing and central bank selling.
- Translate the view on real interest rates into a view on net speculative length using the relationship in Exhibit 20.
- Translate the view on net speculative length, gold-ETF purchasing and central bank sales into a view on real long-dated gold prices and weighted COMEX inventories using the results in Exhibits 27 and 30.
- Translate the view on real long-dated gold prices, weighted COMEX inventories, and inflation into a view of nominal spot gold prices using the results in Exhibit 22.

The outlook for gold prices in the current market

The framework for assessing real long-dated gold prices developed above suggests that the level of real interest rates plays a central part in determining real gold prices over fairly long horizons. Assuming a long-run equilibrium where the gold-ETF inventories and the central bank reserves are stable (i.e., no buying or selling), the relationships above imply an equilibrium between real interest rates⁶ and gold prices (in 2008 USD), supported by a level of net speculative length, weighted COMEX inventories, and long-run gold prices as detailed in Exhibit 31 below.

Exhibit 31 implies that in the current low real interest rate environment, with US 10-year TIPS yielding under 1.5% and real interest rates as defined above close to zero, gold prices will likely have support at or above current prices, should this real rate environment persist.

Further, while low real interest rates will likely provide good support to gold prices at and above current levels, we expect that continued buying from the gold-ETFs will likely lend additional support to gold prices over the next 12 months—more specifically, under the following assumptions, the “gold as a commodity” framework suggests that gold prices at \$923/toz are modestly

6. Results are based on the real interest rate defined as the 10-year US Treasury yield less inflation expectations from the University of Michigan survey. This measure of the real rate has historically averaged roughly 1.50% below the 10-year TIPS yield.

Exhibit 31: The current low real interest rate environment suggests strong support for gold prices at current levels

Real Interest Rate* % per annum	Net Speculative Length million toz	Wtd COMEX Stocks million toz	Long-dated Gold Price** 2008 USD/toz	Front-Month Gold Price 2008 USD/toz
-1.50	20.8	8.5	1832	1780
-1.00	18.5	7.8	1582	1555
-0.50	16.2	7.0	1365	1358
0.00	13.9	6.2	1178	1186
0.50	11.5	5.5	1017	1036
1.00	9.2	4.7	878	905
1.50	6.9	3.9	758	790
2.00	4.6	3.2	654	690
2.50	2.3	2.4	564	603
3.00	0.0	1.6	487	526
3.50	-2.3	0.9	421	460
4.00	-4.7	0.1	363	401

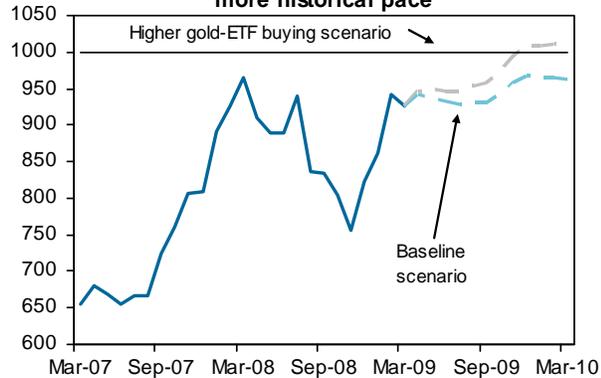
Source: COMEX, CFTC, Bloomberg and GS Global ECS Research

Note: *see footnote 5 above for definition of real interest rate

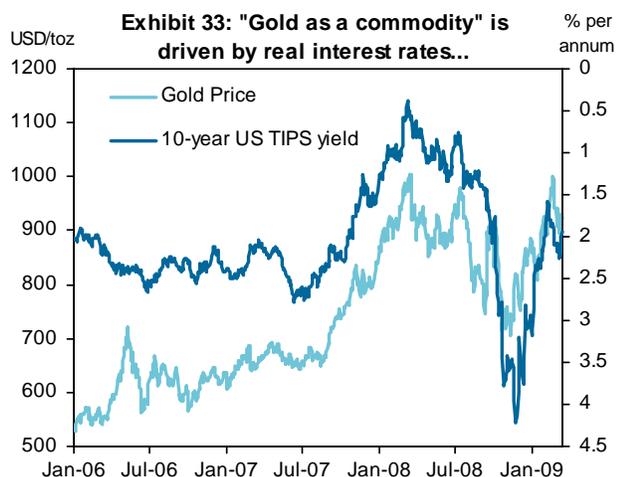
undervalued, with the model indicating a price closer to \$940/toz, and we would expect to see gold prices at \$933/toz on a 3-month horizon, staying at \$931/toz on a 6-month horizon, and rising to \$962/toz on a 12-month horizon.

- Real interest rates remain low, near 0.50%, with lower real rates an upside risk to gold prices.
- US inflation remains subdued, with consumer price inflation near zero.
- Buying by gold-ETFs reverts to the same pace as 2008 (8 million toz per year), which, given the quick pace since the start of the year, would imply a doubling of the pace of gold-ETF buying in 2009 over 2008.
- Selling by central banks and other official sector institutions remains near 9.0 million toz per annum, the same pace as 2008. Of course, IMF gold sales represent an upside risk to this assumption while increased buying by the emerging market central banks represents downside risk.

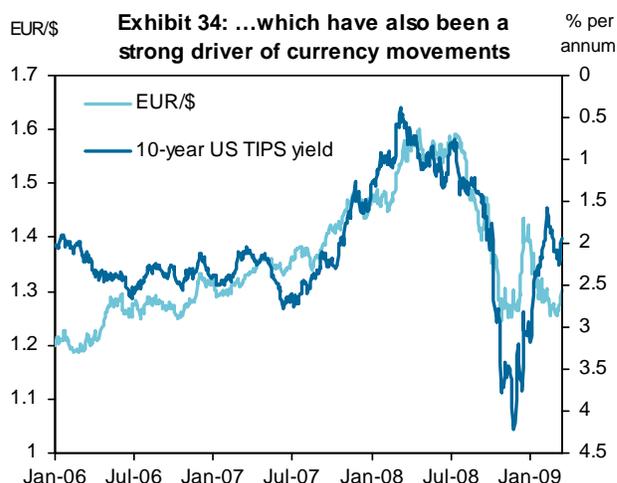
Exhibit 32: We expect gold prices to move modestly higher from current levels, provided gold-ETF buying slows back to a more historical pace



Source: COMEX and GS Global ECS Research



Source: COMEX, Bloomberg and GS Global ECS Research



Source: COMEX, Bloomberg and GS Global ECS Research

These assumptions are broadly consistent with our US economist’s views. Interestingly, despite the lack of inflation, the low real rate environment is still expected to provide support for gold prices over the next 12-months. In addition, should the buying from gold-ETFs continue at a faster pace of 22 million toz this year, which is 50% of the current pace and three times last year’s pace, we would expect gold prices to rise above \$1,000/toz on a nine-month horizon (Exhibit 32). Should real interest rates fall to zero, we would expect gold prices to rise above \$1,000/toz on a 12-month horizon even under the first scenario of a greater slowdown in the pace gold-ETF buying.

Real Interest Rates and the Pricing of Gold as a Currency

Although we believe the framework of “gold as a commodity” complements the view of “gold as a currency,” with each providing valuable perspective, we also believe that the two should be consistent with one another. Consistency between the two views comes from the role of US real interest rates in driving both US dollar-denominated gold prices and US dollar exchange rates.

We would expect movements in relative real interest rates between the United States and other countries to drive currency movements. In fact, in the GSDEER model of exchange rates, currency movements are very closely related to relative productivity growth, which is clearly related to relative real interest rates. The question then becomes, why would the movements in US real interest rates alone be expressed as movements in the US dollar exchange rates? The answer is that, because the US real interest rate has historically been more volatile than those of other countries, movements in the US real interest rates have often been movements in relative exchange rates. In particular, in the gold as a currency framework, the relationship between the EUR/\$ and US dollar denominated gold prices has tended to be the most stable. This makes sense when one considers that European real interest rates—and German rates in particular—have historically been more stable than in the United States. This has historically allowed movements in US real interest rates to be more often observed in movements in the EUR/\$.

As seen in Exhibits 33 and 34 below, both gold prices and the euro have been correlated with movements in US real interest rates over the past several years. Interestingly, the recent breakdown in the correlation between gold prices and currencies coincided with the breakdown in the correlation between EUR/\$ and US real interest rates. The breakdown has coincided with increased movement in both US and European real interest rates.

David Greely and Jeff Currie

GOLDMAN SACHS GLOBAL RESEARCH CENTRES

New York

Goldman Sachs & Co.
New York Plaza, 45th Floor
New York, New York 10004, USA
Tel: +1 212 902 1000

Washington

Goldman Sachs & Co.
101 Constitution Ave, NW
Suite 1000 East
Washington, DC 20001
Tel: +1 202 637 3700

London

Goldman Sachs International
Peterborough Court
133 Fleet Street
London, EC4A 2BB, England
Tel: +44 (0)20 7774 1000

Frankfurt

Goldman Sachs & Co. oHG
MesseTurm
D-60308 Frankfurt am Main,
Germany
Tel: +49 (0)69 7532 1000

Moscow

Goldman Sachs OOO
14th floor, Ducat III
6, Gasheka Street
Moscow 125047
Russian Federation
Tel: +7-495-645-4000

Paris

Goldman Sachs Inc et Cie
2, rue de Thann
75017 Paris, France
Tel: +33 (0)1 4212 1341

Hong Kong

Goldman Sachs (Asia) L.L.C.
Cheung Kong Center,
68th Floor
2 Queen's Road Central
Hong Kong
Tel: +852 2978 1000

Tokyo

Goldman Sachs Japan Co, Ltd.
Roppongi Hills Mori Tower
47th Floor, 10-1, Roppongi 6-chome
Minato-ku, Tokyo 106-6147, Japan
Tel: +81 (0)3 6437 9960

Singapore

Goldman Sachs (Singapore) Pte.
1 Raffles Link, #07-01 South Lobby,
Singapore 039393
Tel: +65 6889 1000

South Africa

Goldman Sachs International
13th Floor, The Forum
2 Maude Street
Sandton 2196
South Africa
Tel: 27-11-303-2700

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