SPDR GOLD TRUST
Form FWP
October 06, 2010

Filed Pursuant To Rule 433
Registration No. 333-167132
October 6, 2010
WORLD GOLD COUNCIL
GOLD: HEDGING AGAINST TAIL RISK

About The World Gold Council

The World Gold Council s mission is to stimulate and sustain the demand for gold and to create enduring value for its stakeholders. The organisation represents the world s leading gold mining companies, who produce approximately 60% of global corporate gold mining production and whose Chairmen and CEOs form the Board of the World Gold Council (WGC).

As the gold industry s key market development body, WGC works with multiple partners to create structural shifts in demand and to promote the use of gold in all its forms; as an investment by opening new market channels and making gold s wealth preservation qualities better understood; in jewellery through the development of the premium market and the protection of the mass market; in industry through the development of the electronics market and the support of emerging technologies and in government affairs through engagement in macro-economic policy issues, lowering regulatory barriers to gold ownership and the promotion of gold as a reserve asset.

The WGC is a commercially-driven organisation and is focussed on creating a new prominence for gold. It has its headquarters in London and operations in the key gold demand centres of India, China, the Middle East and United States. The WGC is the leading source of independent research and knowledge on the international gold market and on gold s role in meeting the social and economic demands of society.

Contents

October 2010

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Gold: Hedging against tail risk

Executive summary

Gold plays many roles within an investor s portfolio. It serves as a portfolio diversifier: it tends to have low correlations to most assets usually held by institutional and individual investors. It preserves wealth: gold is typically considered a hedge against inflation, but it also acts as a currency hedge, in particular against the dollar with which gold correlates negatively. Moreover, it helps to manage risk more effectively by protecting against infrequent or unlikely but consequential negative events, often referred to as tail risks . Here we explore this particular role.

In periods of economic expansion, and especially prior to 2007, many investors concentrated on return seeking strategies at the expense of incurring higher risk. While these kinds of strategies may prove effective in some time periods, events such as the recent 2007-2009 financial crisis have brought back into perspective alternative strategies that place more emphasis on risk management. By using lessons learned during these tough times, investors may be better prepared when a new unforeseen event occurs. It is not a matter of being overly cautious; these events may not be very likely, but they can substantially impact investors capital and should be protected against. Moreover, there are cost-effective strategies that can provide such protection without sacrificing return. We show that gold can be an integral part of these strategies for both short- and long-term investors.

We believe gold s role extends beyond affording protection in extreme circumstances. In previous studies, the WGC has shown that including gold in a portfolio can reduce the volatility of a portfolio without necessarily sacrificing expected returns. However, we now find that portfolios which include gold are not only optimal in the sense of delivering better risk-adjusted returns, but that they can also help to reduce the potential loss. Specifically, we show that gold can decrease the Value at Risk (VaR). We find that even relatively small allocations to gold, ranging between 2.5% and 9.0%,[1] help reduce the weekly 1% and 2.5% VaR of a portfolio by between 0.1% and 18.5% based on data from December 87 to July 10. Moreover, looking at past events typically considered to be tail risks, such as Black Monday, the LTCM crisis, the recent 2007-2009 recession, etc., we find that in 18 out of 24 cases (75%) analysed, portfolios which included gold outperformed those which did not. In particular, in the period between October 07 and March 09, an asset allocation similar to a benchmark portfolio[2] which included an 8.5% allocation to gold, was able to reduce the total loss in the portfolio by almost 5% relative to an equivalent portfolio without gold. In other words, adding gold saved about US$500,000 on a US$10mn investment.

[1] *Gold allocations within this range are consistent with the findings of previous studies by the WGC. Importantly, investors who only have gold exposure in the form of a commodity index tend to be under allocated. Gold s typical weight in benchmark*

commodity indices, such as the S&P Goldman Sachs Commodity Index or the Dow-Jones UBS Commodity Index, is usually between 2% to 6%. Even a 10% allocation in one of these indices implies a much smaller effective gold exposure of 0.2% to 0.6%.

[2] *We refer to a benchmark portfolio as one which has a 50%-60% allocation to equities, 30%-40% to fixed income, and 5%-10% to alternative assets.*

4

Gold: Hedging against tail risk

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Why hedging against tail risk matters

Most investors would agree that one of the primary purposes of investment is to maximise returns, whether these are monetary or otherwise, and preserve capital. However, there is a trade-off an investor makes with every investment: return versus risk. In other words, risk is the price an investor has to pay in his or her quest for higher returns. There is, however, no unique definition of risk. The most obvious definition, and the one that many market participants associate with, is volatility, i.e., how much uncertainty or variability there is surrounding the expected return on an asset. There are, however, other kinds of risks that can prove very important, especially in times of economic distress; for example, liquidity, credit, counterparty, market and event risk.

It is common for investors, in times of economic expansion, to seek higher returns for their portfolios at the expense of taking on more risk, whether it is in the form of higher volatility, lower liquidity, etc. Some academics debate whether this so-called *risk appetite* gradually changes over time. However, there are events that create structural shifts in the perception of risk and provide a better understanding as to the extent of the damage that risk causes when highly unlikely but extremely negative events occur. The Great Recession which started to unfold by the end of 2007 and whose effects we continue to feel, is one example of these structural changes. After experiencing substantial losses in their portfolios, both institutional and private investors alike have increased their awareness of risk management. This is particularly true of long-term investors, such as pension funds, foundations and endowments, as well as individuals saving for retirement that need to preserve their capital to meet future claims . Partly, risk management can be achieved with careful analysis and portfolio diversification, but investors need to dig deeper when it comes to protecting against systemic risk. It is also here that gold comes into play.

Gold is first and foremost a portfolio diversifier. Gold is very liquid, with an estimated US$2.1tn in bullion form in the hands of investors, institutional and private, as well as central banks, the IMF, etc.[3] In addition, gold bullion has no credit or counterparty risk. Gold can also be shown to protect against events that are not necessarily frequent (or likely) but which, when they occur, can substantially erode the capital of an investor s portfolio in unexpected ways. These events are typically referred to as *tail risk,* as they produce observed returns that fall in the tail of a distribution. In this study we concentrate on returns that are more than two standard deviations away from the mean.[4]

In *Gold as a Strategic Asset* and *Gold as a Tactical Hedge and Long-Term Strategic Asset,* the WGC has shown how even moderate allocations to gold (2%-10%) can produce optimality in a portfolio. In other words, it helps increase the return per unit of risk in a portfolio (i.e. achieve a higher *information* ratio[5]). Here we show that gold does not only help increase expected (or average) risk-adjusted returns, it can also considerably mitigate the potential for loss in a portfolio.

The rationale is relatively simple. Firstly, most portfolio optimisers assume that the returns from an asset are close to a normal distribution (i.e., they are symmetric and the majority of the returns 95% to be exact fall within two standard deviations). In practice, this is rarely the case. Many asset returns have skewed distributions, commonly negatively skewed,[6] as well as *heavy tails* there are more observations that occur beyond two standard deviations than a normal distribution would predict. Secondly, correlations among assets are not necessarily constant and while average correlations can be used to compute the optimal weights in a portfolio, extreme conditions can change how assets interact with one another in unexpected and typically unwanted ways.

3 *Dempster, N. and J.C. Artigas (2010), An Investors Guide to the Gold Market, WGC.*

[4] *Depending on the likelihood of these occurrences (i.e. how far into the tail of the distribution they lie), they are known as 2-sigma (2*s*), 3-sigma (3*s*) or 6-sigma (6*s*) events, where s is the mathematical expression to denote standard deviation. While some definitions put tail risk as 3-sigma events, in this study, we concentrate on 2-sigma events to facilitate the statistical techniques used*

[5] *Information ratio is a measure of risk-adjusted returns. In passive investment strategies, it is usually defined as expected return of an asset or a portfolio divided by its corresponding volatility.*

[6] *Negatively skewed distributions have more outliers due to negative than*

due to positive returns.

6

Gold: Hedging against tail risk

Unlike other assets, gold tends to exhibit lower volatility on negative returns than it does on positive returns (chart 1). At an annualised volatility of 15.3% of weekly returns from January 87 to July 10, negative returns tended to be less volatile at an annual rate of 14.4% while positive returns had higher volatility of 16.2%. Whereas the S&P 500 had an annualised volatility of 17.3%, over the same period, in which negative returns varied at a rate of 19.2% and positive returns at 15.1%. In other words, based on historical performance, gold is less likely to fall by more than 2 x 15.3% = 30.6% (2-sigma) in a year than it is to rise by more than the same return. This is contrary to what tends to happen with equities. The economics behind this phenomenon are, in part, due to what is commonly known as flight-to-quality. As negative news hits the market (especially the equity market) and risk-aversion increases, investors usually retreat from equity and other risky assets into assets that tend to protect wealth, such as Treasuries and gold.[7]

Chart 1: Annualised volatility of positive and negative weekly returns for gold (US$/oz) and S&P 500; Jan 87-Jul 10

Source: London Bullion Market Association, Bloomberg, WGC

In risk management and portfolio theory, it is not only individual volatilities that matter; it is also how assets interact with each other, i.e., their correlation structure. Gold tends to have little correlation with many asset classes, thus making it a strong candidate for portfolio diversification. More importantly, unlike other assets typically considered diversifiers, gold s correlation to other assets tends to change in a way that benefits portfolio returns. For example, while gold correlation to US equities is usually not statistically significant, on average, historically it tends to decrease as US equities fall and increase when they rise (chart 2).

This behaviour is more evident when one compares the correlation of equities to gold and commodities

Chart 2: 1-year rolling correlation between weekly returns on gold (US$/oz) and equities compared to the S&P 500 Index level

Source: London Bullion Market Association, Standard & Poor s, WGC

[7] *For a more in depth analysis on negative economic news and gold, see Roach S.K. and M. Rossi (2009), The Effects of Economic News on Commodity Prices: Is Gold Just Another Commodity?,*

IMF Working Paper.

in periods when equity returns fall by more than two standard deviations from zero (chart 3). From January 87 to July 10, the average weekly-return correlation of the S&P 500 and the S&P Goldman Sachs Commodity Index was 0.13; while this correlation increased slightly in periods in which equity returns rose by more than 2s to 0.14, it increased even more to 0.47 when equities faltered. Put simply, in economic and financial downturns, most industrial-based commodities and equities tend to follow a similar pattern. On the other hand, history shows that gold s correlation to equities became more negative during these same periods. Between January 87 and July 10, the average correlation between gold and the S&P 500 stood at -0.17. In periods in which equity returns rose by more than 2s, the correlation turned positive to about 0.09, but when equities fell by more than 2s, the correlation coefficient dropped to -0.17. This is, by no means, a strong negative correlation, but it serves to exemplify the benefits that gold can offer when managing the overall risk of a portfolio.

Chart 3: Weekly-return correlation between equities, gold and commodities when equities move by more than 2 standard deviations; Jan 87-Jul 10

Source: London Bullion Market Association, Bloomberg, WGC

The role of gold in reducing a potential loss

Intuitively, the characteristics that gold exhibits in terms of its performance, volatility and correlation to other assets should help reduce potential losses in a portfolio. In this paper we show how, using a common measure for maximum expected loss in a given period of time, gold can be used to manage risk more effectively and, ultimately, protect an investor s capital against potential losses in negative economic conditions. Specifically, we use *Value at Risk* to achieve this observation. While the analysis is based on historical performance and future uncertainty can affect the results, the data shows that gold s usefulness in protecting against systemic risk can be proven in multiple occasions.

In financial markets, *Value at Risk* or VaR is used to calculate the maximum loss expected (or worst case scenario) on an investment, over a given time period and given a specified degree of confidence [8].Beyond a more rigorous mathematical definition, conceptually, VaR is simply a way of measuring how much an investor could expect to lose in a given portfolio, in the case of an unlikely and sometimes infrequent, yet possible, event occurring.[9] There are many methods to estimate the VaR in a portfolio; we use the empirical distribution of the returns to allow for skewness (asymmetry) and kurtosis (heavy or light tails) typically found in financial data.[10] In other words, we compute the maximum possible loss for a given degree of confidence using the historical distribution of returns for each asset.

In general, VaR tends to be a function of volatility; the higher the variability, the more an investor may lose. However, the heaviness of the tails in the distribution of returns will also have an effect. The greater the number of unlikely events that fall beyond two or three standard deviations to the left of zero, the higher the value at risk.

Asset and period selection

As previously discussed, beyond individual measures of risk and return, portfolio theory relies on the covariance/correlation structure of multiple assets. Therefore, we use a collection of assets representative of a typical investment portfolio, namely: cash, US Treasury and corporate bonds, international debt from developed and emerging

[8] *http://www.investopedia.com/articles/04/092904.asp.*

[9]

In statistical terms, the VaR of a portfolio, at a given confidence level μ *between zero and one, is the minimum loss, such that the probability that any other loss exceeds that value, is not greater than (1* μ*) during a period of time.*

[10] *Alternatively, one can compute the mean and standard deviation of a portfolio, for a given set of weights, and estimate the corresponding critical value based on the desired confidence level using the assumption that returns follow a normal distribution. Another method involves Monte Carlo simulations; here multiple return samples are drawn from the empirical distribution of a given portfolio, to subsequently compute the expected critical value.*

8

Gold: Hedging against tail risk

markets, US and international equities, a commodity index as well as gold as an asset class. Ideally, we would use series going back as far as 72, the year by which the gold window had been closed and the yellow metal was allowed to float freely. However, a modern investor typically holds many more assets in a portfolio than those available in the 70 s and early 80 s, or for which data is unavailable or unreliable, such as high yield bonds, or emerging markets sovereign debt and equities. Thus, the period under consideration for this analysis spans from January 87 to July 10 for which most data series are available. Moreover, this period contains at least three business cycles[11] and includes multiple market crashes.[12]

Chart 4: Histograms of standardised weekly returns on gold and US equities

Source: London Bullion Market Association, MSCI Barra, WGC

Table 1: Performance of selected assets in a model portfolio; Jan 87-Jul 10[1]

	CAGR[2] (%)		Annualised volatility[3]		Weekly VaR (US$ 000s[5])	
	Real	Nominal	(%)	Inf. Ratio[4]	2.5%	1.0%
Gold (US$/oz)	1.8	4.7	15.3	0.31	451	590
JP Morgan 3-month T-Bill Index	2.1	5.0	1.0	5.05		
BarCap US Treasury Aggregate	4.0	7.0	4.8	1.46	130	166
BarCap Global ex US Treasury Aggregate	4.5	7.5	8.9	0.85	223	252
BarCap US Credit Index	4.6	7.6	5.2	1.48	138	175
BarCap US High Yield Index	5.3	8.3	8.2	1.01	209	338
JP Morgan EM Sovereign Debt Index[6]	10.2	13.0	12.8	1.02	358	566
MSCI US Equity Index	5.5	8.6	17.3	0.50	466	708
MSCI EAFE Equity Index	2.7	5.7	18.1	0.31	490	736
MSCI EM Equity Index	7.6	10.7	22.2	0.48	686	946
S&P Goldman Sachs Commodity Index	3.7	6.8	21.1	0.32	636	896

Note: Performance based on total return indices except for gold in which spot price is used.

1) MSCI EM from Dec 87 and JPMorgan EM sovereign debt index from Dec 90; 2) compounded annual growth rate; 3) estimated using weekly returns; 4) ratio of nominal return and volatility, also known as avg. risk-adjusted return (a higher number indicates a better return per unit of risk); 5) Expected maximum loss during a week at a given confidence level (1-a) from a US$10mn investment; 6) EMBI prior to Jan 00 and EMBI Global post due to data availability.

Source: LBMA, JP Morgan, Barclays Capital, MSCI Barra, Standard & Poor s, WGC

[11] *http://www.nber.org/cycles.html*

[12] *Not all data series are available going back to 72; however, we used the modified likelihood ratio test of equality of covariances (also known as Box test) to verify the equivalence of the correlation structures of the available data series (namely, gold, commodities, US equities and US Treasuries) for the longer time period. All tests were performed at the 5% significance level, thus, we conclude that the analysis of this paper is robust and that the conclusions should hold using estimates over a longer time*

period.

Table 1 shows the assets selected to construct the model portfolio, as well as their summary statistics over the period, such as average return, volatility, information ratio (defined as nominal return divided by volatility) and *Value at Risk* (VaR). While gold exhibits a lower information ratio than other assets listed in the table, gold s diversification properties make it a valuable asset to hold in a portfolio. Furthermore, the maximum expected loss in a given week from a US$10mn investment in gold is US$590,000 with 99% certainty (also called 1% VaR). In the case of the MSCI US Equity Index, the weekly 1% VaR is US$708,000 even though its information ratio is higher at 0.50. Moreover, the equivalent 1% VaR for emerging markets (EM) sovereign debt is US$566,000, only 4% lower than gold despite the fact that gold s annualised volatility is 20% higher than EM debt and its information ratio is considerably higher at 1.02. Indeed, this is due to the fact that EM debt, among many assets, has heavier tails than gold.

As informative as the individual performance statistics are, a portfolio is comprised of a collection of assets. In general, diversification allows an investor to obtain a desired (expected) return without taking as much risk as with an individual security. This principle is based on the correlation structure of multiple assets, or the way they react to economic, financial and geopolitical news, and perhaps more relevant for our discussion, their behaviour in times of unprecedented and systemic risk.

Gold s reaction to external factors such as financial and economic conditions tends to benefit investors and, in particular, helps them manage risk more effectively. Charts 5 and 6 show the correlation of gold to the assets relevant for our analysis. During the January 87 to July 10 period, chart 5 shows the average correlation between weekly returns for gold and returns for all the other assets. In general, gold tends to have low correlations to most assets including other commodities. For example, the correlation of gold to US equities was -0.07 during that period and 0.27 to commodities, as represented by the S&P Goldman Sachs Commodity Index (S&P GSCI). The highest correlation to gold among the selected assets is with global Treasuries excluding the US at 0.35. Chart 6 shows the weekly-return correlation between gold and other assets in periods in which equity returns fall by more than two standard deviations, our proxy for an unlikely risky event.[13] Unsurprisingly, most correlations fall. More importantly, the correlation to many risky assets, such as corporate debt and developed market equities, turns negative, and gold s low correlation to other commodities at 0.05 becomes statistically insignificant. Unexpectedly, perhaps, the correlation to emerging markets sovereign debt increases to 0.30 from 0.13.

*Chart 5: Correlation of weekly returns between gold (US$/oz) and selected asset classes (US$); Jan 87-Jul 10**

*Chart 6: Conditional correlation of weekly returns between gold (US$/oz) and selected asset classes (US$) in periods when US equity returns drop by more than two standard deviations; Jan 87-Jul 10**

* *Except for MSCI EM index (Dec 87-Jul 10) and JPMorgan EM sovereign debt index (Dec 90-Jul 10) due to data availability.*

Source: London Bullion Market Association, Barclays Capital, JP

Morgan

[13] *There are 30 such occurrences between Jan 87 and Jul 10.*

10

Gold: Hedging against tail risk

Finding optimal portfolios

In previous studies, the WGC has demonstrated that adding gold to a portfolio tends to increase risk-adjusted returns, in many cases expanding the efficient frontier.[14] In other words, by adding gold, an investor can obtain a desired expected return while incurring less risk than an equivalent portfolio without gold. We now find that those portfolios which include gold are not only optimal in the sense of producing better risk-adjusted returns, but that they also tend to reduce the potential loss in a portfolio, i.e., they decrease the *Value at Risk*.

To find the optimal weights employed to construct different sample portfolios, we use Resampled Efficiency (RE) optimisation developed by Michaud and Michaud.[15] We concentrate on two alternative scenarios. For each scenario, we apply projected long-term real returns, consistent with previous research notes, to remove a potential period bias. We then use the volatility and correlation estimates based on weekly returns from January 87 to July 10. In the first scenario, we use average correlations for the whole period as inputs for the optimiser. This scenario produces portfolios designed to maximise expected returns over the long run. For the second scenario, we use the correlation structure observed in periods of higher risk, or when US equities fell by more than two standard deviations, as explained in the previous section. This scenario creates portfolios constructed to maximise expected returns by taking advantage of asset interactions observed during periods of higher risk. A summary of the projected returns and volatilities used during portfolio optimisation can be found in table 6 in the Appendix.

Portfolio optimisation produces a myriad of different combinations that form the efficient frontier. While each asset allocation that falls upon this frontier is considered optimal, for simplicity, we choose to compare a finite number of portfolios. For each scenario, we find optimal asset allocations with and

Table 2: Summary statistics and asset weight allocation for each of the selected portfolios

	Scenario 1: average correlation[1]				Scenario 2: high risk correlation[3]			
	Max. Inf. Ratio*		Benchmark		Max. Inf. Ratio*		Benchmark	
	w/o gold	with gold	w/o gold	with gold	w/o gold	with gold	w/o gold	with gold
Expected annual return (%)	3.4	3.3	7.0	7.0	3.2	3.1	6.9	6.9
Annualised volatility (%)	3.4	3.3	11.8	11.8	2.4	2.3	11.9	11.7
Information ratio[2]	1.002	1.002	0.589	0.591	1.301	1.342	0.583	0.586
				Portfolio weights				
Gold (US$/oz)		3%		6%		4%		9%
JP Morgan 3-month T-Bill Index	29%	30%	0%	0%	30%	34%	0%	0%
BarCap US Treasury Aggregate	36%	35%	8%	7%	37%	33%	15%	14%
BarCap Global ex US Treasury Agg	7%	6%	7%	7%	9%	7%	10%	9%
BarCap US Credit Index	3%	2%	2%	2%	0%	0%	1%	1%
BarCap US High Yield Index	11%	11%	5%	7%	17%	18%	7%	8%
JP Morgan EM Sovereign Debt	3%	3%	10%	8%	4%	3%	6%	5%
	4%	4%	19%	17%	0%	0%	21%	19%

MSCI US Equity Index								
MSCI EAFE Equity Index	2%	2%	15%	14%	0%	0%	9%	9%
MSCI EM Equity Index	3%	3%	25%	26%	2%	1%	25%	24%
S&P Goldman Sachs Commodity Index	2%	1%	8%	7%	0%	0%	5%	3%

1) Correlation estimation using all weekly returns from Jan 87 to Jul 10; 2) expected return divided by volatility, also known as avg. risk-adjusted return (a higher number indicates a better return per unit of risk); 3) correlation estimation using only weekly returns in which the MSCI equity index fell by more than 2 std. deviations over the same period.

* *Portfolio selection based on allocations that achieved the maximum information ratio available.*

Portfolio selection based on allocations that resembled benchmark portfolio of 55%

equities, 40% fixed income, and 5% alternative assets, with similar expected returns.

Source: *LBMA, JP Morgan, Barclays Capital, MSCI Barra, Standard & Poor s, WGC*

[14] *Dempster, N. and J.C. Artigas (2009), Gold as a Tactical Hedge and Long-Term Strategic Asset, WGC, among others. For a comprehensive list of our publications, go to http://www.gold.org.*

[15] *Michaud, R. and R. Michaud (2008) Efficiency Asset Management: a practical guide to stock and portfolio optimization and asset allocation, 2nd edition, Oxford Press, New York.*

without gold. We then choose: 1) the portfolio with the maximum risk-adjusted return; and 2) a portfolio with a similar composition to a typical benchmark allocation (50%-60% equities, 30%-40% fixed income and 5%-10% alternative assets), such that the portfolio with and without gold during the optimisation have similar expected returns. Therefore, we compare a total of eight portfolios.

Table 3 shows the expected return, volatility and information ratio for each portfolio, as well as the weight assigned to each asset. On one hand, the selected portfolios with maximum information ratios produced more conservative asset allocations, with heavy weights in cash and fixed income.[16] On the other hand, optimal benchmark-like portfolios weighted fixed income assets evenly among various classes when average correlations were used, while increasing exposure to cash and Treasuries in the high risk scenario, as one would expect. Finally, allocations to gold ranged from 3% to 9%, consistently with findings in previous analysis. Considering that gold s correlations to other assets generally dropped in the high risk correlation scenario, it is not surprising that this scenario had the largest weight for gold at about 9%. More interestingly, gold, unlike the commodity index, had positive (and statistically significant) allocations not only in the selected portfolios but throughout the whole efficient frontier.

Reducing expected losses in a portfolio by using gold

Relatively small allocations to gold can be shown to help investors reduce potential losses without substantially sacrificing expected return. Using the empirical distribution of all asset returns from January 87 to July 10, we compute average returns, volatilities and VaRs for each of the selected portfolios. We consistently find that including gold in a portfolio delivers similar expected returns with lower volatilities, while reducing weekly VaR by between 0.1% and 18.5%. For example, using average correlation estimates, adding gold to the portfolio mix reduces the weekly 2.5% VaR by 6.9% for a maximum information ratio allocation and by 18.5% when using a high risk portfolio allocation. Similarly, using a benchmark-like portfolio, including gold reduces the weekly expected loss by between 2.8% and 5.8% at a 97.5% confidence level (2.5% VaR). Only in the benchmark-like portfolio using average correlation estimates, the weekly 1% VaR is similar in both cases.

Table 3: Weekly Value at Risk (VaR) on a US$10mn investment for selected portfolios with and without including gold; Jan 87-Jul 10

		Scenario 1: average correlation[1]				Scenario 2: high risk correlation[2]			
		Max. Inf. Ratio*		Benchmark		Max. Inf. Ratio*		Benchmark	
		w/o gold	with gold	w/o gold	with gold	w/o gold	with gold	w/o gold	with gold
Gold weight			3%		6%		4%		9%
Expected annual return (%)		6.6	6.5	8.1	8.0	6.6	6.5	7.9	7.7
Annualised volatility (%)		3.2	3.1	12.1	11.7	2.9	2.6	11.0	10.4
Information ratio[3]		2.06	2.13	0.67	0.68	2.31	2.50	0.72	0.74
2.5% VaR (US$ 000)		76	71	348	338	69	58	318	301
Gain (loss) by including gold in US$ 000 and %	US$ 000		4.9		9.6		10.7		17.5
	%		6.9%		2.8%		18.5%		5.8%
1.0% VaR (US$ 000)		108	96	478	477	95	83	443	429
			12.2		0.5		12.2		14.0

Gain (loss) by including gold in US$ 000 and %	US$ 000 %	12.7%	0.1%	14.7%	3.3%

1) Correlation estimation using all weekly returns from Jan 87 to Jul 10; 2) correlation estimation using only weekly returns in which the MSCI equity index fell by more than 2 std. deviations over the same period; 3) expected return divided by volatility, also known as avg. risk-adjusted return (a higher number indicates a better return per unit of risk).

* *Portfolio selection based on allocations that achieved the maximum information ratio available.*

Portfolio selection based on allocations that resembled benchmark portfolio of 55% equities, 40% fixed income, and 5% alternative assets, with similar expected

returns;

Source: *LBMA, JP Morgan, Barclays Capital, MSCI Barra, Standard & Poor s, WGC*

[16] *Traditionally, a conservative portfolio is one with little exposure to equities (domestic or international) and other alternative assets. These portfolios typically concentrate on cash and other fixed income assets. Conversely, an aggressive portfolio places more weight to equities and alternative investments.*

12

Gold: Hedging against tail risk

The golden touch: managing risk in periods of financial stress

We have established that, in general, there is a good case to be made for adding gold to a portfolio. Indeed, expected losses tend to diminish without necessarily sacrificing return. We now show that, in most periods of financial stress, portfolios which include gold tend to perform better (by either posting gains or reducing losses) than those without. To achieve this, we look back to periods, starting in January 87, in which financial markets experienced an unexpected and negative shock that affected more than one asset class. We concentrate on six such events: 1) the market crash around October 87, also known as Black Monday , looking at the performance between August 25 and December 12 of that year; 2) the Long-term Capital Management (LTCM) crisis, between July 20 and August 26, 1998; 3) the Dot-com bubble burst in the period surrounding the dramatic drop in the NASDAQ index, between March 10, 2000 and April 4,[17] 2001; 4) September 11 terrorist attack, in the period between August 24 and September 21, 2001; 5) 2002 market downturn, as stocks fell sharply between March and July 2002; and 6) the financial crisis of 2007-2009, also known as the Great Recession , between October 12, 2007 and March 6, 2009.

Table 4: Observed gain (loss) on a US$10mn investment for selected portfolios with and without including gold during various tail-risk events

		Portfolio using average correlation[1]							
		Max. Inf. Ratio*				Benchmark			
		Portfolio gain (loss) in US$ 000		Difference	Difference	Portfolio gain (loss) in US$ 000		Difference	Difference
		w/o gold	with gold	in US$ 000	in %	w/o gold	with gold	in US$ 000	in %
Black Monday	Aug 97 - Dec 87	88	111	22	25%	-1,046	-868	178	17%
LTCM crisis	Jul 98 - Aug 98	-194	-181	12	6%	-1,258	-1,222	36	3%
Dot-com bubble	Mar 00 - Apr 01	528	496	-32	-6%	-1,420	-1,506	-86	-6%
9/11	Aug 01 - Sep 01	-184	-149	35	19%	-1,174	-1,083	91	8%
02 downturn	Mar 02 - Jul 02	151	171	20	13%	-534	-463	71	13%
Great Recession	Oct 07 - Mar 09	-211	-79	132	63%	-4,049	-3,719	330	8%
Gold weight			3%				6%		
Annualised return (%)	Jan 87 - Jul 10	6.6	6.5			8.1	8.0		

		Portfolio using high risk correlation[2]							
		Max. Inf. Ratio*				Benchmark			
		Portfolio gain (loss) in US$ 000		Difference	Difference	Portfolio gain (loss) in US$ 000		Difference	Difference
		w/o gold	with gold	in US$ 000	in %	w/o gold	with gold	in US$ 000	in %
Black Monday		293	285	-9	-3%	-893	-721	172	19%

	Aug 97 - Dec 87								
	Jul 98 -								
LTCM crisis	Aug 98	-160	-138	22	14%	-1,084	-1,028	55	5%
	Mar 00 -								
Dot-com bubble	Apr 01	684	624	-59	-9%	-1,296	-1,363	-67	-5%
	Aug 01 -								
9/11	Sep 01	-63	-34	30	47%	-1,055	-934	121	12%
	Mar 02 -								
02 downturn	Jul 02	242	232	-10	-4%	-467	-385	81	17%
	Oct 07 -								
Great Recession	Mar 09	148	225	77	52%	-3,481	-3,014	467	13%
Gold weight			4%				9%		
Annualised	Jan 87 -								
return (%)	Jul 10	6.6	6.5			7.9	7.7		

1) Correlation estimation using all weekly returns from Jan 87 to Jul 10; 2) correlation estimation using only weekly returns in which the MSCI equity index fell by more than 2 std. deviations over the same period.

* *Portfolio selection based on allocations that achieved the maximum information ratio available.*

Portfolio selection based on allocations that resembled benchmark portfolio of 55% equities, 40% fixed income, and 5% alternative assets, with similar expected

returns.

Source: LBMA, JP Morgan, Barclays Capital, MSCI Barra, Standard & Poor s, WGC

[17] *It is arguable that the effects of the Dot-com extended longer; however, we only consider this 1-year portion, given the slight recovery in the markets after that as we had to accommodate 9/11 as a different event.*

Table 4 summarises gains (losses) experienced by selected portfolios during the periods under consideration. In general, we find that, except for the Dot-com bubble, portfolios which included gold fared much better, as they increased the return over period. In some instances, this implied that adding gold to the mix produced higher positive returns, while in others, it reduced the losses. For example, investors would have either gained or saved between US$22,000 and US$178,000 for US$10mn invested during Black Monday by including 3% to 6% in gold, in portfolios whose asset allocations were determined by using average correlations. Similarly, they would have saved between US$35,000 and US$91,000 during 9/11 and between US$132,000 and US$330,000 during the recent financial crisis of 2007-2009. They would have lost, however, between US$32,000 and US$86,000 during the Dot-com bubble. A possible explanation is that the Dot-com bubble was heavily concentrated towards one particular sector of the economy; hence, the added benefits of gold as a diversifier to the selected portfolios may have been lessened.

Portfolios constructed using allocations based on high risk correlations, tended to outperform those using average correlations (except for the LTCM crisis). This is not surprising given that they were optimised for similar situations, and while they were not immune from losses, these portfolio allocations would have saved considerable amounts for investors. This was especially the case assuming a benchmark-like portfolio. By adding allocations to gold of about 9%, for example, investors would have reduced their losses by almost US$500,000 (on a US$10mn investment) during the Great Recession. This is equivalent to savings of around 13% between the loss in the portfolio with gold and the one without.

Moreover, long-run average returns for the portfolios with and without gold were similar. In other words, average gains remained consistent, but extreme losses were, in most occasions, reduced. Thus, gold not only helps to manage risk for expected or theoretical losses, but in multiple occasions it was shown to reduce the observed loss of an investment while keeping a similar average return profile.

Out-of-sample considerations: past and present

A clear constraint of this analysis is that the portfolios used to show the properties of gold as a tail-risk hedge were constructed using information that may not have been available to investors prior to the event s occurrence. In other words, we are using an in-sample approach to compute returns, volatilities and expected losses. This does not invalidate the analysis, but it does raise the question of whether selecting a portfolio allocation using only information available during a specific period of time, will still deliver similar results (i.e. if adding gold to the portfolio mix allows investors to manage risk more effectively) for events that happen outside of that period.

The answer is that it does. Gold can be shown to reduce losses even in out-of-sample analysis for most cases. We estimate average correlations and volatilities using weekly returns between January 87 and June 07, excluding the most recent period. Subsequently, we find optimal portfolios using the same methodology as before: with and without gold we select the portfolio with the maximum information ratio, as well as a portfolio with allocations similar to a typical benchmark portfolio for a total of four portfolios.[18] We concentrate on five different periods: 1) the early 70s recession between December 72 and September 74; 2) the Iran-Iraq war in the late 70s and early 80s from January to March 1980; 3) the 80s recession between July 81 and August 82; 4) the Great Recession, between October 07 and March 09; and, finally, 5) the European sovereign debt crisis, between November 09 and June 10.

In all, seven out of ten times, adding gold to the portfolio mix helped either reduce losses or increase gains during those market events (table 5). For example, during the early 70s recession, including a 2.3% allocation to gold in a conservative portfolio increased gains by US$502,000 on a US$10mn investment; a 4.6% gold allocation in a more aggressive portfolio, increased gains by US$552,000 on a similar investment. The portfolios which included gold did not fare as well during the early 80 s crisis and 82 recession because the price of gold moved up rapidly during 1980 just to drop sharply thereafter, but it had a much more positive impact during the recent global and European crises.

18

In this case, we do not estimate correlations based only on high-risk events given that there are few such observations during that period, making the estimates less reliable.

14

Gold: Hedging against tail risk

Table 5: Observed gain (loss) on a US$10mn investment for selected portfolios with and without including gold during various out of sample tail-risk events prior to 87 and post 07

		Portfolio using average correlation[1]							
		Max. Inf. Ratio[2]				Benchmark[3]			
		Portfolio gain (loss) during various financial downturns in US$ 000				Portfolio gain (loss) during various financial downturns in US$ 000			
		w/o gold	with gold	Difference in US$ 000	Difference in %	w/o gold	with gold	Difference in US$ 000	Difference in %
Early 70s recession	Dec 72 - Sep 74	505	1,210	705	140%	-295	1,068	1,363	462%
Iran-Iraq war	Jan 80 - Mar 80	-534	-635	-101	-19%	-995	-1,158	-163	-16%
80s recession	Jul 81 - Aug 82	2,018	1,917	-101	-5%	33	33	1	2%
Great Recession	Oct 07 - Mar 09	99	272	173	175%	-3,619	-3,193	426	12%
European sovereign debt crisis	Nov '09 - Jun '10	62	81	19	31%	-454	-373	81	18%
Gold weight			3%				6%		
Annualised return (%)	Jan 87 - Jun 07	6.7	6.6			8.1	8.0		

1) Correlation estimation using all weekly returns from Jan 87 to Jul 10; 2) portfolio selection based on allocations that achieved the maximum information ratio available; 3) portfolio

selection based on allocations that resembled benchmark portfolio of 55% equities, 40% fixed income, and 5% alternative assets, with similar expected returns.

Source: LBMA, JP Morgan, Barclays Capital, MSCI Barra, Standard & Poor s, WGC

Conclusion

Gold is first and foremost a consistent portfolio diversifier. Moreover, we find that gold effectively helps manage risk in a portfolio, not only by means of increasing risk-adjusted returns, but also by reducing expected losses incurred in extreme circumstances. Such tail-risk events, while unlikely, can be seen to have a damaging effect on an investor s capital. On one hand, short- and medium-term holders, individual and institutional alike, can take advantage of gold s unique correlation to other assets to achieve better returns during times of turmoil. This is especially true given that gold s correlation tends to change in a way that benefits investors who hold it within their portfolios. On the other hand, by including gold in their portfolios,[19] long-term holders, such as retirement savings accounts, pension plans, endowments and other institutional investors, can manage risk without necessarily sacrificing much sough-after returns.

Our analysis suggests that even relatively small allocations to gold, ranging from 2.3% to 9.0%, can have a positive impact on the structure of a portfolio. We find that, on average, such allocations can reduce the Value at Risk (VaR) of a portfolio, while maintaining a similar return profile to equivalent portfolios which do not include gold. For the eight portfolios analysed using data from January 87 to July 10, adding gold reduced the 1% and 2.5% VaR by between 0.1% and 18.5%. Moreover, we found that portfolios which included gold outperformed those which did not in 18 out of 24 occasions (75%) when doing an in-sample analysis, and in seven out of ten (70%) in out-of-sample tests. A summary can be found in table 7 in the Appendix.

We also note that investors who hold gold only in the form of a commodity index are likely to be under-allocated.[20] There is a strong case for gold to be allocated as an asset class on its own merits. It is part commodity, part luxury consumption good and part financial asset and, as such, its price does not always behave like other asset classes and especially other commodities.

Finally, while most of this analysis concentrates on risk in the form of tail-risk and volatility, gold has other unique characteristics that make it very useful in periods of financial distress. For example, the gold market is highly liquid and many gold bullion investments have neither credit nor counterparty risk.

[19] *Concretely, average gold correlations to most other assets held in a portfolio tend to be small; more importantly, correlation to equities, corporate debt and even other commodities*

tends to fall in economic downturns.

[20] *Gold s weight in typical benchmark commodity indices, such as the S&P Goldman Sachs Commodity Index or the Dow-Jones UBS Commodity Index, tends to be small, usually between 2% to 6%. Even if an investor holds a 10% allocation in one of these indices, their effective gold exposure is between 0.2% and 0.6%.*

Appendix

*Chart 7: Historical distribution of weekly returns for selected assets; Jan 87-Jul 10**
Histograms of standardised monthly returns

* *Except for MSCI EM index (Dec 87-Jul 10) and JPMorgan EM sovereign debt index (Dec 90-Jul 10) due to data availability.*

Source: LBMA, JP Morgan, Barclays Capital, MSCI Barra, Standard & Poor s, WGC

16

Gold: Hedging against tail risk

Table 6: Projected returns and volatilities used during portfolio optimisation

	Return (%)	Standard Deviation (%)	Information Ratio[1]
Gold (US$/oz)	2.0	15.3	0.13
JP Morgan 3-month T-Bill Index	0.0	1.0	0.00
BarCap US Treasury Aggregate	4.0	4.8	0.84
BarCap Global ex US Treasury Aggregate	4.0	8.9	0.45
BarCap US Credit Index	4.0	5.2	0.77
BarCap US High Yield Index	5.0	8.2	0.61
JP Morgan EM Sovereign Debt Index	6.0	12.8	0.47
MSCI US Equity Index	8.0	17.3	0.46
MSCI EAFE Equity Index	8.0	18.1	0.44
MSCI EM Equity Index	10.0	22.2	0.45
S&P Goldman Sachs Commodity Index	2.0	21.1	0.09

1) Ratio of return and volatility, also known as avg. risk-adjusted return (a higher number indicates a better return per unit of risk).

Source: WGC

Table 7: Summary of tail-risk events in which a portfolio containing gold observed a gain (+) or a loss (-) relative to a similar portfolio without gold

		Portfolio using average correlation[1]		Portfolio using high risk correlation[2]	
		Max. Inf. Ratio*	Benchmark	Max. Inf. Ratio*	Benchmark
Gold weight		3%	6%	4%	9%
Portfolio gains (+) or losses (-) during various financial downturns in sample					
Black Monday	Aug 97 - Dec 87	+	+		+
LTCM crisis	Jul 98 - Aug 98	+	+	+	+
Dot-com bubble	Mar 00 - Apr 01				
9/11		+	+	+	+

	Aug 01 - Sep 01				
	Mar 02 - Jul 02	+	+		+
02 downturn					
	Oct 07 - Mar 09	+	+	+	+
Great Recession					
Gold weight		3%	6%		
Portfolio gains (+) or losses (-) during various financial downturns out of sample					
	Dec 72 - Sep 74	+	+		
Early 70s recession					
	Jan 80 - Mar 80				
Iran-Iraq war					
	Jul 81 - Aug 82		+		
80s recession					
	Oct 07 - Mar 09	+	+		
Great Recession					
	Nov 09 - Jun 10	+	+		
European sovereign debt crisis					

1) Correlation estimation using all weekly returns from Jan 87 to Jul 10; 2) correlation estimation using only weekly returns in which the MSCI equity index fell by more than 2 std. deviations over the same period;

* *Portfolio selection based on allocations that achieved the maximum information ratio available.*

Portfolio selection based on allocations that resembled benchmark portfolio of 55%

equities, 40% fixed income, and 5% alternative assets, with similar expected returns.

Source: LBMA, JP Morgan, Barclays Capital, MSCI Barra, Standard & Poor s, WGC

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WGC-HO-INVE-007 October 2010

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