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The price of shelter - Downside risk reduction with precious metals

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ABSTRACT

Investor aversion to extreme losses may motivate them to seek out investments perceived to function as a safe haven during times of crisis. In this study, we consider the potential for precious metals to mitigate downside risk when combined with equities, and evaluate the impact on portfolio risk-adjusted returns. Each of gold, silver and platinum are found to contribute to downside risk reduction at short horizons, but diversification into silver and platinum may result in increased long horizon portfolio risk. The price of sheltering an equity portfolio from downside risk is a relative reduction in portfolio risk-adjusted returns. Variance and kurtosis properties of precious metals are identified as marginal contributors to downside risk reduction. Futures markets on precious metals are also shown to present an interesting and viable diversification alternative to physical metals.

1. Introduction

The aversion of investors to extreme downside risk has been heavily documented.[1] In particular, aversion to acute losses may lead investors to seek a risk premium for bearing extreme downside risk, (Bali, Demirtas, & Levy, 2009; Ang, Chen, & Xing, 2006), and also impact their optimal allocation strategy, (Jarrow & Zhao, 2006; Liu, Longstaff, & Pan, 2003). Recent literature has considered the safe-haven properties of precious metals, and gold in particular, illustrating the capacity of gold to act as a strong short-run hedge for traditional assets during times of extreme market turbulence (Baur & Lucey, 2010; Baur & McDermott, 2010).[2] Gold has also been considered as a hedge against inflation, (Beckmann & Czudaj, 2013; Gorton & Rouwenhorst, 2006), and as a currency safe-haven (Reboredo, 2013; Capie, Mills, & Wood, 2005).

Our paper first examines the ability of three precious metals, gold, silver and platinum, to reduce portfolio downside risk when held together with equities. While investors require a risk premium to bear extreme downside risk, (Bali et al., 2009; Ang et al., 2006), they may also be willing to cede expected returns in order to negate such risks. In this light, we also explore the price of diversifying a traditional portfolio with precious metals. Specifically, we examine the change in the risk-return profile of an equity portfolio with a proportional allocation to precious metals, relative to an equity-only portfolio. In contrast to previous studies, focussed predominantly on the unadjusted reward-to-risk ratio (for example, Hillier, Draper, and Faff (2006)), we consider both the relative Sharpe ratio and relative modified Sharpe ratio as performance metrics, explicitly accounting for the risk-free rate. The latter point is noteworthy, as any relationship, positive or negative, between gold and interest rates might alter the investment implications.[3] This analysis helps to reconcile conflicting previous evidence regarding the performance implications of portfolio diversification using precious metals.

This paper adopts a methodology appropriate for understanding infrequent but dangerous tail events. Downside risk measures are concerned with quantifying only the potential losses that a portfolio might be exposed to.[4] In measuring the downside risk of an investment it is vital to consider higher-order moments of the distribution for two reasons; first, financial returns are extensively shown to be non-normal, implying that variance alone is not a suitable measure of risk. Second, investors have preferences over higher-order moments of returns such as skewness and kurtosis (Dittmar, 2002; Kraus & Litzenberger, 1976). In this paper, risk is characterized

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[1] A large body of theoretical work proposes that investors trade-off between risk and skewness, in an attempt to avoid situations with potential for extreme downside losses (see, for example, Chiu (2005), Keenan and Snow (2002) and Menezes, Geiss, and Tressler (1980)). Moreover, experimental evidence also suggests that investors consider potential for extreme losses when making investment decisions (Unser, 2000; Olsen, 1997).

[2] A detailed review of the role of gold as an investment asset may be found in Batten, Baur, Lucey, and O'Connor (2015).

[3] Various arguments have been put forward regarding the perceived relationship between gold and interest rates (Erb & Harvey, 2013).

[4] A variety of measures to quantify downside have been proposed, including semi-variance, lower partial moments and value-at-risk. In this study, we focus on the latter as it facilitates the quantification of the level of extreme losses to which an investor might be exposed.

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using a four-moment downside risk measure, accounting for the skewness and kurtosis of the empirical distribution. These higher-order moments are captured by way of the Cornish-Fisher expansion (Favre & Galeano, 2002). This methodology offers new insights relative to previous safe haven analysis, including facilitating analysis of any potential trade-off between moments of a portfolio when holding precious metals.

Our paper incorporates a number of innovations. In contrast to previous studies which have examined the hedging and safe-haven potential of gold, our paper is the first known study to explicitly examine the downside risk reduction possibilities from a portfolio perspective. Given the extent of non-normality in asset returns (see Cont (2001) and Pagan (1996), for example), only an evaluation taking account of higher-order moments can provide an accurate assessment of the risk reduction opportunities. Second, while a growing literature examines the safe-haven properties of gold, little attention has been paid to the downside risk reduction properties of silver and platinum. We examine both silver and platinum, and contrast their risk reduction potential with that of gold. Third, taking account of higher-order moments enables identification of the individual contributions from distributional moments on risk reduction. This issue has also not been considered previously in the literature.

Next, the level of risk reduction achievable may vary across different return intervals, in keeping with previous findings for risk (Bandi & Perron, 2008; Gençay, Selcuk, & Whitcher, 2005), hedging (Conlon & Cotter, 2012, 2013) and risk management (Rua & Nunes, 2009). We build upon previous papers examining the temporal dimension of risk reduction, (Bredin, Conlon, & Potì, 2015; Baur & McDermott, 2010; Baur & Lucey, 2010; Lucey, Potì, & Tully, 2006), providing a detailed analysis of the risk-return relationship at each horizon. Fifth, investors are unlikely to consider an investment in precious metals for downside risk reduction purposes in isolation. Instead, they will consider the tradeoff between risk (or downside risk) and return in their allocation decision. In this paper, we determine the price of investing in precious metals, by examining relative risk-adjusted returns. Our findings shed new light on the benefits of precious metals as an investment asset, as results are based upon a more appropriate performance metric over a longer sample than previously considered. Finally, building on previous studies focussed almost exclusively on physical gold, we examine the diversification potential of precious metal futures and exchange traded funds (ETF's).

Our results indicate that the risk reduction opportunities from gold are, in fact, larger than previously indicated by the literature, but only for short investment horizons (less than 15 days). Similar findings are also reported for silver and platinum, although not consistently as substantial as those for gold. At longer horizons, gold retains some downside risk-reduction properties, while those for silver and platinum are attenuated. These findings imply that an investor concerned with short horizon risk can achieve downside risk reduction benefits from precious metals, but the choice of precious metal is of first order importance for those seeking longer term diversification.

Building on this, we find that find that investors must pay a price to achieve downside risk reduction, contrary to much previous research.[5] An investor must surrender some proportion of their risk-adjusted returns to mitigate negative returns in traditional assets. This is in keeping with the notion that downside risk has an associated risk-premium (Bali et al., 2009; Ang et al., 2006). Instead of earning a risk-premium for bearing downside risk, investors must pay a risk-premium to negate downside risk.

Our identification approach illustrates that precious metal kurtosis is a key contributor to portfolio downside risk reduction, while the skewness properties of precious metals do not help in mitigating such risks. Again, this result is specific to short horizons. The benefits from kurtosis are suggested to be a consequence of low co-kurtosis between precious metals and equities, a consequence of non-coincident tail risks. When the analysis is extended to both futures and exchange traded funds (ETF's) relating to precious metals, we also find evidence of downside risk reduction properties. In particular, we find that the proportion of risk-adjusted returns surrendered to achieve downside risk reduction is lower for futures markets. The source of this additional performance is increased returns, rather than risk reduction and is attributed to roll yield from futures markets.

The paper is organized as follows: Section 2 describes the measurement of downside risk reduction, while Section 3 details the data examined in the study. Empirical results are reported in Section 4 and Section 5 concludes.

2. Downside risk reduction

2.1. Downside risk measurement

Two-moment value-at-risk (VaR) may be employed to measure the level of tail- or downside risk associated with an asset, provided that the asset's returns are normally distributed. For a given confidence level, two-moment VaR is defined as the maximum expected loss on a portfolio over a given time interval or horizon (τ) and is given by

$$VaR_p\left(1-\alpha,\tau\right)=\mu_p-\sigma_p z(\alpha) \tag{1}$$

where $z(\alpha)$ is the α quantile of the standardized distribution. The time interval, τ, is the horizon over which we are interested in measuring risk, while μ_p and σ_p are the mean and standard deviation of portfolio returns respectively. When the empirical distribution of returns is normal, the VaR of an asset is simply a constant multiple of the standard deviation of asset returns.

Financial asset returns have been heavily documented as not following a normal distribution, making it likely that two moment VaR will not accurately capture the risk associated with potentially large non-normal returns. In order to understand the downside risk of a portfolio consisting of traditional assets and precious metals, we employ the four-moment *modified VaR*, first documented by Favre and Galeano (2002) in the case of hedge funds. The four-moment modified VaR is derived from the Cornish-Fisher expansion, which adjusts the quantiles of a distribution to account for the higher-order moments of skewness and kurtosis. The Cornish-Fisher expansion approximates the quantile of the distribution as,

$$\begin{aligned}\hat{Z}\left(\alpha,S_p,K_p\right)=&z(\alpha)+\frac{1}{6}\left(z(\alpha)^2-1\right)S_p+\ldots\frac{1}{24}\left(z(\alpha)^3-3z(\alpha)\right)K_p\\&-\frac{1}{36}\left(2z(\alpha)^3-5z(\alpha)\right)S_p^2\end{aligned} \tag{2}$$

where μ_p,σ_p,S_p and K_p are the first four moments of portfolio P, K_p is the excess kurtosis and $z(\alpha)$ is the α quantile of the standard normal distribution. The modified four-moment VaR is then given by

$$MVaR_p\left(1-\alpha,\tau\right)=\mu_p-\sigma_p\hat{Z}\left(\alpha,S_p,K_p\right), \tag{3}$$

[5] Chua, Sick, and Woodward (1990) and Jaffe (1989) indicate increased portfolio returns and corresponding decrease in portfolio risk upon the addition of gold. Hillier et al. (2006) also detail a relative improvement in the reward-to-risk ratio for equity portfolios with a proportional allocation to gold, silver or platinum. Only Emmrich and McGroarty (2013) cite decreasing risk-adjusted returns for a portfolio incorporating gold after 2001.

adjusting the two-moment VaR at interval τ to account for characteristics commonly found in financial time series.

2.2. The effect of skewness and kurtosis on risk reduction

One of the benefits of using modified VaR to assess the risk of a portfolio is the ability to assess the contribution of each distributional moment to overall portfolio risk and to risk reduction. This analysis demonstrates the relative importance of each higher-order moment, and helps identify the sources of aggregate downside risk reduction. To this end, we examine two-, three- and four-moment value-at-risk as detailed by You and Daigler (2010a, 2010b).

Two moment VaR is measured using only mean and variance and is calculated as per Eq. (1). Three moment VaR also incorporates skewness and is calculated using Eq. (3), with the assumption that excess kurtosis has value zero. Finally, four moment VaR is calculated using Eq. (3). Contrasting the relative risk reduction for each of two, three and four moment VaR, we gain insight into the contribution of each to the aggregate risk reduction achievable through diversification into precious metals.

2.3. Relative performance measurement

The initial goal of this paper is to quantify downside risk reduction achieved through diversification into precious metals. Downside risk reduction measures the proportion of equity portfolio VaR that remains after diversifying with precious metals and is given by

$$RR_{VaR} = \frac{MVaR_p\,(1-\alpha)}{MVaR_e\,(1-\alpha)} \tag{4}$$

where $MVaR_p(1-\alpha)$ is the modified VaR of a portfolio containing both equities and precious metals, and $MVaR_e(1-\alpha)$ is the modified VaR of the original equity portfolio. A smaller value of RR_{VaR} suggests greater downside risk diversification benefits, implying that a larger proportion of equity tail risk is eradicated. Risk reduction for two-, three- and four-moment VaR is calculated in an analogous fashion.

Our second aim is to understand the price, or cost, to investors of downside risk reduction, quantified through the impact on risk-adjusted returns. While previous studies considering the investment potential of precious metals have focussed on the reward-to-risk ratio, (for example Hillier et al. (2006)), we consider the Sharpe ratio (SR) and modified Sharpe ratio (MSR), the latter measuring excess return on modified VaR, (Eling & Schuhmacher, 2007; Gregoriou & Gueyie, 2003),

$$\mathrm{SR} = \frac{\mu_p - r_f}{\sigma_p}, \qquad \mathrm{MSR} = \frac{\mu_p - r_f}{MVaR_p}, \tag{5}$$

where μ_p is the expected return, taken as the average unconditional return over the timeframe under study, r_f is the risk-free rate and the denominator in each case is a measure of risk. The relative Sharpe ratio (RSR) and relative modified Sharpe ratio (RMSR) then determine the change in portfolio risk-return characteristics for a portfolio diversified with precious metals and are then calculated as,

$$RSR = \frac{SR_p}{SR_e}, \qquad RMSR = \frac{MSR_p}{MSR_e}. \tag{6}$$

Analogous to the measurement of risk reduction previously described, these measures detail the improvement or deterioration in risk-adjusted returns due to the addition of precious metals to an equity portfolio. A value greater (less) than one suggests an increase (decline) in risk-adjusted returns relative to an equity only portfolio. Thus, if investors pay a price to achieve risk reduction, we expect them to accept a reduction in risk-adjusted returns.

3. Data and summary statistics

The data employed in this study consists of daily prices from 1980 through 2014 for precious metals and equities. All data is sourced from Datastream, a division of Thomson Reuters. Gold and silver bullion spot prices are provided by the London Bullion Market Association (LBMA), while platinum is from the London Platinum Free Market.[6] Gold and silver futures prices are from Commodity Exchange, Inc. (COMEX), while platinum futures prices are from the New York Mercantile Exchange (NYMEX). Futures contracts are nearest to maturity and rolled over to the new contract on the first day of the contract month. Exchange traded funds (ETFs) on precious metals have been introduced in recent years and we look at ETFs where the provider holds the physical underlying metal. In particular, the SPDR gold exchange traded fund (ETF) (2004–2014) and the Ishares Silver Trust ETF (2006–2014) are considered. The risk free rate is taken as the US one-month Treasury Bill rate. Equity prices are represented by the Standard and Poors 500 (S&P 500) total return index from 1980 through 2014. All assets examined are priced in US dollars.

Summary statistics for logarithmic returns of spot metals and the S&P 500 are detailed for daily, weekly and monthly data in Table 1. Weekly data is created from daily data by aggregating on the final business day of each week, while monthly data is created from daily by aggregating on the last business day of each month. Across all intervals examined, the S&P 500 has highest returns and lowest standard deviation. Silver is found to have negative returns and the highest standard deviation, although this is heavily influenced by events in 1980.[7] Contrasting the different intervals examined, S&P 500 (silver) has the most negative skewness and highest kurtosis at daily (monthly) intervals. Jarque-Bera statistics reject the null hypothesis that the distribution of returns is normally distributed in each case, supporting the selection of the modified VaR methodology in determining downside risk. The Jarque-Bera statistic decreases from short to long intervals, but the decrease is not sufficient to support the null hypothesis of normality at monthly horizon. The considerable changes found in both skewness and kurtosis from daily to monthly intervals help to motivate our examination of the interval dependence of downside risk reduction.[8]

Measurement of returns at different intervals may suffer from a seasonality effect, whereby characteristics estimated from data aggregated to a particular interval may vary dependent upon when they are aggregated.[9] To overcome this seasonality, we adopt the correction of Corhay (1992). This involves taking T measurements of summary statistics associated with an interval of length T, and calculating a cross-sectional average across these. To calculate a weekly standard deviation, for example, the standard deviation is calculated five times, corresponding to weekly estimated risk for each day of the week and this is averaged to produce a weekly standard deviation. A similar procedure is followed for other statistics and across varying interval lengths. These seasonally adjusted statistics are then used in calculating modified VaR from this point onwards.

[6] Other precious metals such palladium, rhodium and iridium are not considered in this study as data is not available over the same period, preventing active comparison of the risk reduction benefits.

[7] Monthly logarithmic returns for silver are found to be −96.8% during March 1980. Measured using geometric returns, the drop in prices was −62% over the month.

[8] The impact of the so-called intervaling effect on the skewness of asset returns has been previously documented (Lucey et al., 2006; Lau & Wingender, 1989).

[9] This is commonly referred to as the “day of the week” effect, when aggregating from daily data to weekly data.

Table 1
Summary statistics at different intervals (1980–2014). Summary statistics for logarithmic returns of gold, silver, platinum and S&P 500 at different aggregation intervals over the period 1980–2014 are detailed. Weekly returns are derived from daily returns using Friday data, while monthly returns are derived from daily returns using data corresponding to the last business day of the month. Kurtosis corresponds to excess kurtosis. The Jarque-Bera statistic tests the null hypothesis that the returns data comes from a normal distribution.

Asset	Mean	Standard deviation	Skewness	Kurtosis	Minimum	Maximum	Jarque-Bera statistic
(i) Daily returns							
Gold	0.000063	0.012	−0.47	18.39	−0.179	0.122	87,317
Silver	−0.000081	0.023	−0.32	17.32	−0.258	0.230	74,538
Platinum	0.000067	0.017	−0.58	12.24	−0.173	0.139	30,617
S&P 500	0.000334	0.011	−1.16	29.58	−0.228	0.110	261,572
(ii) Weekly returns							
Asset	Mean	Standard deviation	Skewness	Kurtosis	Minimum	Maximum	Jarque-Bera statistic
Gold	0.00044	0.023	−0.37	16.32	−0.270	0.229	13,524
Silver	−0.00039	0.048	−1.31	22.10	−0.535	0.418	28,149
Platinum	0.00032	0.037	−0.64	10.50	−0.332	0.213	43,523
S&P 500	0.00162	0.025	−1.27	19.98	−0.319	0.130	22,418
(iii) Monthly returns							
Asset	Mean	Standard deviation	Skewness	Kurtosis	Minimum	Maximum	Jarque-Bera statistic
Gold	0.00193	0.051	−0.03	6.04	−0.240	0.211	161
Silver	−0.00168	0.098	−2.39	25.49	−0.968	0.254	9185
Platinum	0.00136	0.073	−0.90	9.74	−0.474	0.317	846
S&P 500	0.00702	0.044	−0.94	6.28	−0.245	0.124	250

4. Empirical results

4.1. Downside risk reduction

The ability of precious metals to reduce portfolio downside or tail-risk when combined with the S&P 500 is now studied. To illustrate the risk reduction possibilities, a number of perspectives are considered. First, risk reduction achieved at various intervals and confidence levels for a portfolio consisting of 10% precious metals and 90% equities is examined. Second, we detail the risk reduction achieved for a range of allocation weights. Third, we consider whether results are static over various horizons. Finally, we analyze whether risk reduction benefits are time-varying.

Fig. 1 examines risk reduction at different confidence intervals for a series of investment horizons. In each case, 10% of wealth is allocated to each of gold, silver and platinum and the remainder to the S&P 500. Risk reduction is then measured relative to holding the S&P 500 in isolation. Across all three strategies, we see the level of volatility reduction achieved is little changed across the intervals examined. Taking into account the additional moments of skewness and kurtosis through Eq. (3), we find considerable differences in the level of risk reduction possible at differing intervals.

Across all assets, maximum risk reduction for extreme risks (corresponding to confidence intervals of 99% and 99.9%) is evident at short intervals. At a 1 day interval, 99% VaR of a portfolio with a 10% allocation to gold, silver or platinum is found to be 0.85, 0.77 and 0.85 respectively of a portfolio fully allocated to the S&P 500. The level of reduction achieved is not found to remain constant at longer intervals, especially for silver and platinum. For example, at a 21 day interval (corresponding to one month), the 99% VaR is 0.91, 0.95 and 0.99 for gold, silver and platinum. In fact, for longer intervals, a 10% allocation to platinum is found to be a net contributor to increased downside risk. These results highlight the short-run risk reduction possibilities of precious metals, but point to longer-run pitfalls for platinum and silver.

Next, we consider the impact of differing allocation weights on precious metal portfolio risk reduction. Table 2 details risk reduction achieved for an allocation weighting of between 1% and 30% to precious metals (and corresponding decrease in wealth allocated to the S&P 500) at a 99% confidence level.[10] Only in the case of gold do we witness a monotonic, although non-linear, decrease in risk reduction for larger allocations. For silver and platinum, the impact of larger allocations on risk reduction is distinct at short- and long-run intervals.

Considering silver, increasing the allocation weighting results in a monotonic decrease in downside risk only for the shortest interval studied. Furthermore, beyond an interval of 20 days, little risk reduction benefit is found regardless of the allocation weighting to silver. The diversification benefits of platinum are wholly associated with short intervals. At a one-day interval, the risk reduction provided by platinum is at least equal to that of gold or silver. Beyond a one day interval, however, the risk reduction capacity of platinum is shown to be severely curtailed. Moreover, beyond a 20 day horizon platinum is found to be a net contributor to overall portfolio risk regardless of allocation weighting.

Contrasting the three precious metals, gold is found to have the most consistent downside risk reduction properties. While silver and platinum may contribute to increased portfolio downside risk for certain parameters, gold is found to have strong risk reduction properties for all intervals, weights and confidence intervals examined. These findings complement previous studies examining the safe-haven properties of gold. For example, Baur and Lucey (2010) demonstrate that gold acts as a short-term safe haven for equities during extreme market conditions, while Baur and McDermott (2010) show that gold has significance as a safe haven at daily and weekly intervals, but not for monthly.

Empirical results provide strong support for the ability of precious metals to reduce portfolio downside risk, especially at short intervals, over the period 1980 through 2014. Over the extended period considered the market for precious metals may have altered significantly, and the perception of investors towards precious metals as a safe-haven may have changed. For these reasons, we perform a cohort analysis, considering the downside risk reduction properties

[10] Risk reduction was also considered as a function of expected shortfall, with qualitatively similar results found. Details are not shown for brevity but are available from the authors upon request.

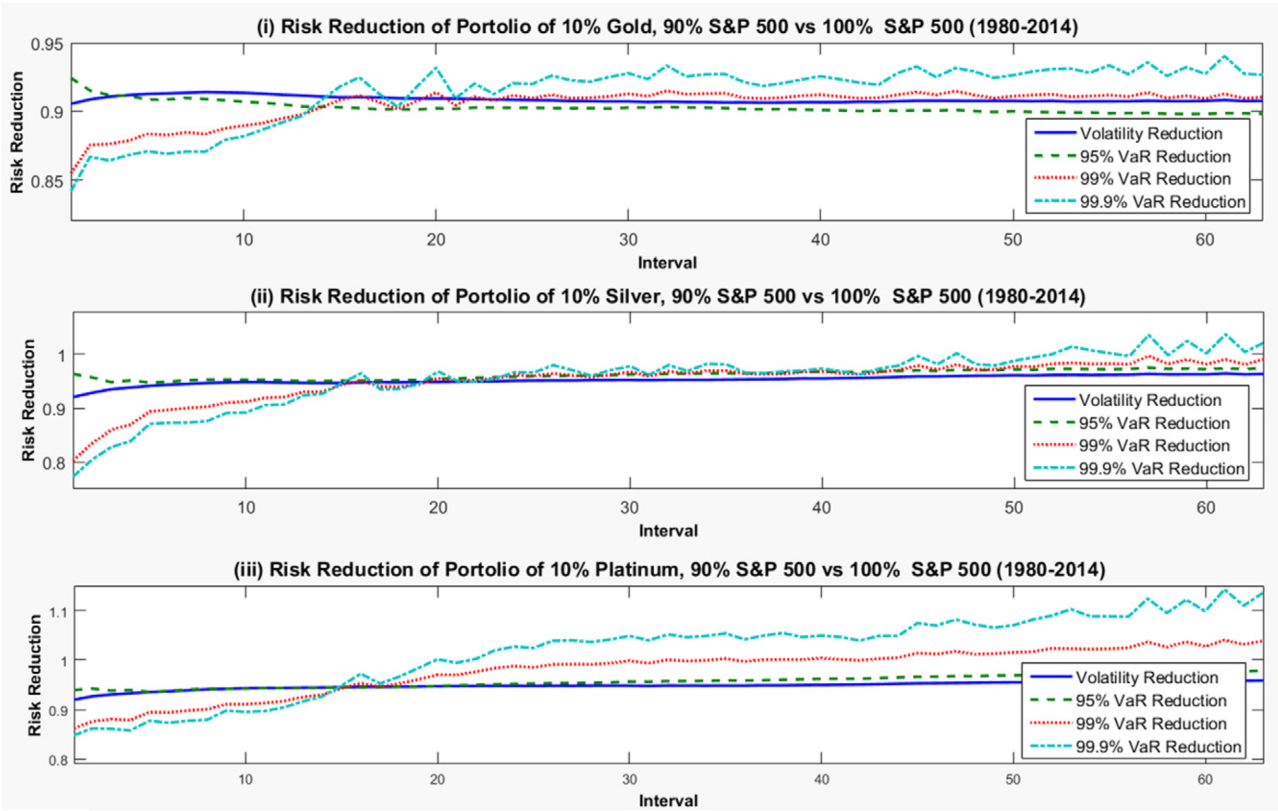

Fig. 1. S&P portfolio downside risk reduction by precious metals (1980–2014). Risk reduction is measured as the Cornish-Fisher four moment VaR quantile of a portfolio with a partial allocation to precious metals relative a portfolio holding the S&P 500 only. For each of gold, silver and platinum, an allocation of 10% to precious metals is assumed, while VaR risk reduction is measured at 95%, 99% and 99.9% confidence intervals across a range of intervals from 1 through 63 days. Volatility reduction is measured as the level of standard deviation of an equity only portfolio which remains after diversifying with precious metals.

of a 10% allocation to precious metals at a 99% confidence interval over the periods 1980 to 1990, 1991 to 2002 and 2003 to 2014.

Table 3, in addition to detailing risk adjusted returns, also outlines the impact on portfolio risk reduction across different time cohorts. This analysis suggests that long interval downside risk reduction properties of precious metals have, in general, deteriorated in recent years. For each precious metal, we observe that the level of VaR risk reduction for intervals longer than 10 days is diminished in the 2003 to 2014 cohort relative to previous. For silver and platinum, portfolio downside risk is found to be increased at long intervals through diversification into precious metals in the recent period. In the case of gold, while downside risk reduction is still evident in recent years at all intervals, the strength of the long interval risk reduction achieved is diminished in comparison to previous cohorts. This may be related to the financialization of commodity markets in recent years, a theory we leave for future analysis.

The dynamic risk reduction capabilities of precious metals are further examined in Fig. 2. To this end, downside risk reduction is calculated each day using a window of 1250 days, at both one day and 20 day intervals for a precious metal allocation of 10% and 20%. Results are found to be largely consistent with those detailed earlier. Precious metals provide greater risk reduction at short intervals, especially for silver and platinum. This is primarily a result of strong short-run risk reduction during times of extreme market stress (for

Table 2
S&P portfolio downside risk reduction by precious metal (1980–2014). Risk reduction is measured as the 99% Cornish-Fisher four moment VaR of a portfolio with a partial allocation to precious metals relative to one holding the S&P 500 only over the period 1980–2014. For each of gold, silver and platinum, a range of allocation weights from 1% to 30% are considered for measurement intervals between 1 and 60 days, with the remainder of the portfolio allocated to the S&P 500.

	Gold - portfolio weight					Silver - portfolio weight					Platinum - portfolio weight				
Interval	1%	5%	10%	20%	30%	1%	5%	10%	20%	30%	1%	5%	10%	20%	30%
1	0.99	0.93	0.85	0.70	0.54	0.98	0.91	0.80	0.59	0.46	0.99	0.93	0.86	0.70	0.55
5	0.99	0.94	0.87	0.77	0.66	0.99	0.95	0.88	0.80	0.80	0.99	0.95	0.89	0.80	0.74
10	0.99	0.95	0.89	0.78	0.68	0.99	0.96	0.91	0.84	0.84	0.99	0.96	0.91	0.84	0.80
15	0.99	0.95	0.90	0.82	0.74	0.99	0.97	0.93	0.92	0.97	0.99	0.97	0.94	0.90	0.90
20	0.99	0.96	0.91	0.84	0.78	0.99	0.97	0.95	0.96	1.04	1.00	0.98	0.97	0.95	0.96
30	0.99	0.96	0.91	0.83	0.77	1.00	0.98	0.97	0.98	1.09	1.00	1.00	1.00	1.01	1.03
40	0.99	0.96	0.91	0.83	0.75	1.00	0.98	0.97	0.97	1.06	1.00	1.00	1.00	1.01	1.03
50	0.99	0.96	0.91	0.82	0.75	1.00	0.99	0.99	1.00	1.11	1.00	1.01	1.02	1.04	1.08
60	0.99	0.95	0.91	0.82	0.73	1.00	0.99	0.99	1.01	1.12	1.00	1.01	1.03	1.07	1.13

Table 3
Relative portfolio performance by cohort (1980–2014). Relative risk adjusted returns, relative returns and relative risk measures are detailed. In each case the relative performance is calculated using performance of a portfolio with a 10% allocation to gold, relative to one that is only invested in the S&P 500. Results are detailed over the entire period and over three cohorts 1980–1990, 1991–2002 and 2003–2014. Risk adjusted returns are measured using the Sharpe ratio (SR) and modified Sharpe ratio (MSR) using 99% VaR, while risk is measured using both volatility (σ) and 99% value-at-risk at different intervals.

	Gold					Silver					Platinum				
(i) 1980–2014															
Interval	SR	MSR	Returns	σ	VaR	SR	MSR	Returns	σ	VaR	SR	MSR	Returns	σ	VaR
1	0.91	0.97	0.83	0.91	0.85	0.77	0.88	0.70	0.92	0.80	0.98	1.05	0.90	0.92	0.86
5	0.90	0.94	0.82	0.91	0.87	0.74	0.80	0.70	0.94	0.88	0.96	1.01	0.90	0.94	0.89
10	0.89	0.92	0.82	0.91	0.89	0.73	0.76	0.69	0.95	0.91	0.96	0.99	0.90	0.94	0.91
30	0.88	0.88	0.81	0.91	0.91	0.71	0.71	0.68	0.96	0.97	0.95	0.90	0.90	0.95	1.00
60	0.89	0.89	0.81	0.91	0.91	0.72	0.71	0.70	0.97	0.99	0.94	0.88	0.90	0.96	1.03
(ii) 1980–1990	Gold					Silver					Platinum				
Interval	SR	MSR	Returns	σ	VaR	SR	MSR	Returns	σ	VaR	SR	MSR	Returns	σ	VaR
1	0.52	0.58	0.47	0.92	0.82	−0.02	−0.02	−0.01	0.94	0.76	0.52	0.60	0.48	0.93	0.81
5	0.50	0.53	0.46	0.93	0.87	−0.01	−0.01	−0.01	0.97	0.88	0.50	0.54	0.48	0.96	0.89
10	0.42	0.44	0.40	0.94	0.88	−0.14	−0.15	−0.13	0.98	0.91	0.43	0.47	0.43	0.97	0.90
30	0.23	0.23	0.24	0.94	0.91	−0.44	−0.45	−0.40	1.00	0.99	0.25	0.25	0.27	0.98	0.97
60	0.31	0.33	0.31	0.94	0.90	−0.29	−0.30	−0.27	1.02	0.98	0.29	0.30	0.30	0.98	0.97
(iii) 1991–2002	Gold					Silver					Platinum				
Interval	SR	MSR	Returns	σ	VaR	SR	MSR	Returns	σ	VaR	SR	MSR	Returns	σ	VaR
1	0.76	0.76	0.69	0.90	0.91	0.84	0.85	0.76	0.91	0.90	0.92	0.92	0.83	0.91	0.91
5	0.79	0.78	0.71	0.90	0.90	0.85	0.86	0.77	0.91	0.90	0.93	0.95	0.85	0.91	0.89
10	0.81	0.82	0.73	0.90	0.89	0.86	0.88	0.79	0.91	0.90	0.94	0.96	0.86	0.91	0.89
30	0.83	0.81	0.74	0.89	0.91	0.88	0.87	0.80	0.91	0.92	0.94	0.94	0.86	0.92	0.92
60	0.82	0.82	0.73	0.89	0.90	0.88	0.89	0.80	0.91	0.91	0.94	0.92	0.86	0.92	0.94
(iv) 2003–2014	Gold					Silver					Platinum				
Interval	SR	MSR	Returns	σ	VaR	SR	MSR	Returns	σ	VaR	SR	MSR	Returns	σ	VaR
1	1.19	1.21	1.07	0.90	0.89	1.17	1.26	1.08	0.92	0.85	1.08	1.06	0.99	0.92	0.94
5	1.19	1.24	1.09	0.92	0.88	1.14	1.22	1.10	0.96	0.90	1.06	1.12	1.00	0.94	0.90
10	1.20	1.21	1.10	0.91	0.90	1.14	1.17	1.10	0.96	0.94	1.05	1.07	1.00	0.95	0.94
30	1.17	1.15	1.06	0.91	0.93	1.12	1.11	1.07	0.96	0.97	1.02	0.95	0.98	0.96	1.03
60	1.16	1.14	1.05	0.91	0.93	1.09	1.04	1.06	0.98	1.02	0.98	0.92	0.97	0.98	1.06

example, black Monday, October 19*th*, 1987 and the announcement of Lehman Brothers bankruptcy on September 15*th*, 2008). Risk reduction is evident at short intervals across most periods, with the exception of a brief period up to 1987. At a 20 day interval, the level of risk reduction is less consistent and is observed to result in a relative increase in risk at many points in time for silver and platinum. An increased allocation to precious metals is seen to result in further risk reduction benefits at most points in time, but with the cost of increased volatility in the proportion of risk reduced.

4.2. Risk-adjusted returns

The analysis presented has demonstrated that an allocation to precious metals has the potential to reduce downside risk for an equity portfolio. Building on this, we next evaluate the significance for portfolio performance more generally by investigating the price of downside risk reduction. To this end, the impact on risk-adjusted returns of adding precious metals to a portfolio is considered in two ways. First, the relative Sharpe ratio is considered, measured as the Sharpe ratio for a portfolio with an allocation to precious metals divided by the Sharpe ratio for a portfolio fully invested in the S&P 500. The relative modified Sharpe ratio is calculated analogously, but incorporates downside risk as the measure of risk. These relative metrics demonstrate the improvement or deterioration in risk-adjusted returns through a portfolio allocation to precious metals. Results, provided in Table 3, are detailed over the entire period 1980–2014 and in specific cohorts.

First, we consider the impact on risk-adjusted returns of a 10% allocation to precious metals. In the case of gold over the period 1980–2014, such an allocation would have resulted in a reduction in the Sharpe ratio of between 9% and 12%, with only small variation across the intervals examined. At the shortest interval examined, an investor would have achieved a 15% reduction in downside risk, but relinquished 9% of risk-adjusted returns. In contrast, at the longest 60 day horizon examined, an investor would have surrendered 11% of risk-adjusted returns, reducing downside risk by 9%. For a risk averse investor only interested in downside risk-adjusted returns or modified Sharpe ratio, the results are somewhat more varied. At a 1 day interval, an investor holding 10% gold would reduce downside risk by 15% but give up only 3% of risk-adjusted returns. At long intervals, however, an investor loses 11% of downside risk-adjusted returns for a 9% improvement in downside risk, identical to the findings for the Sharpe ratio. Finally, little variation in mean returns is found by interval, suggesting that most of the divergence in results for differing intervals is a consequence of changes in risk. The results detailed provide further support for the use of gold as a short interval hedge against downside risk, but cast a shadow on the long term benefits. Our findings contrast previous empirical results detailing a reduction in risk and increased risk-adjusted returns through combining

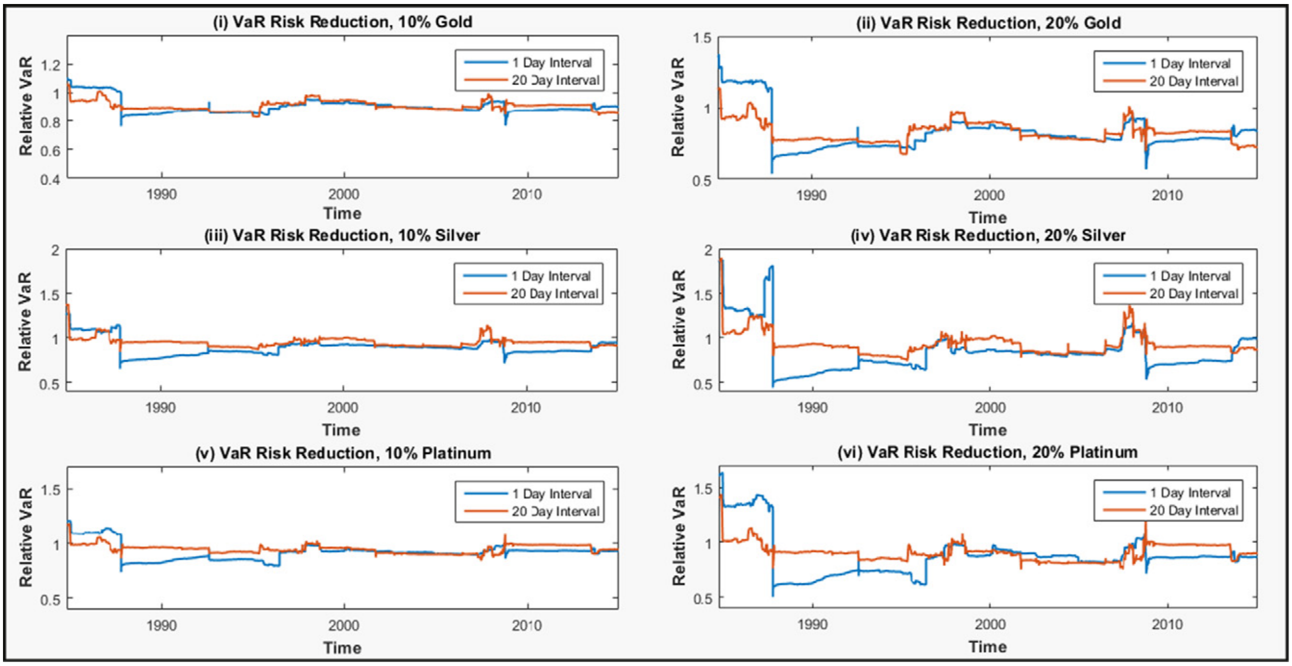

Fig. 2. Dynamic S&P portfolio downside risk reduction by precious metals (1980–2014). Dynamic risk reduction properties are measured using a moving window of 1250 days between 1980 and 2014. Risk reduction is measured as the 99% Cornish-Fisher four moment VaR of a portfolio with a partial allocation to precious metals relative to a portfolio holding the S&P 500 only. For each of gold, silver and platinum, an allocation of 10% and 20% to precious metals is examined for intervals of 1 and 20 days.

precious metals with equities (Hillier et al., 2006). The contrasting implications presented here are a consequence of a differing time period and, crucially, accounting for the risk-free rate in calculating risk-adjusted returns.

Next, risk-adjusted returns for silver and platinum over the period 1980–2014 are considered. Results are generally consistent with those found for gold. Moving from short to long intervals, the relative Sharpe and modified Sharpe ratios are found to decrease, signaling decreasing risk-adjusted returns, while the ability to remove downside risk deteriorates. For silver the results are emphatic; at a one day interval an investor can remove up to 20% of downside risk and surrenders 23% of the equity only Sharpe ratio and 12% of modified Sharpe ratio. At the longest interval considered, an investor can only reduce 1% of downside risk but gives up an even greater proportion of risk-adjusted returns. For platinum, at a one-day interval the impact on risk-adjusted returns is negligible or even slightly positive, while an investor can reduce downside risk to 86% of an equity-only portfolio. As highlighted above, however, the risk reduction properties of platinum are eliminated at long intervals, while investors still pay a price in terms of a reduction in risk-adjusted returns.

The consistency of results across different cohorts, 1980–1990, 1991–2002 and 2003–2014, for each precious metal are also detailed in Table 3. During the first cohort, results are consistent with those over the entire period. The relative risk-adjusted returns are found to decrease for longer intervals, suggesting that an investor would have to pay a price to hedge downside risk. Furthermore, the possibility for downside risk reduction diminishes at long intervals. While the 2003–2014 cohort indicates an increase in risk-adjusted returns across all intervals, it is important to note that this occurred during a period of below average equity market performance, while commodity markets had relatively strong performance. Finally, during the 1991–2002 cohort, a small increase in risk-adjusted returns is witnessed from short to long intervals, in contrast to other cohorts. The price of hedging downside risk using precious metals during this period is steep; for gold a 9% reduction in downside risk results in a 24% reduction in both measures of risk-adjusted returns at a one-day interval.

Finally, we determine the price of downside risk reduction for a range of precious metal allocation weights, focussing on the Sharpe ratio. In Fig. 3, the relative modified Sharpe ratio and relative VaR at a 99% confidence are shown for weights of between 1% and 30% precious metals, with the remaining capital allocated to the S&P 500. Considering gold first, we find that relative VaR decreases to 0.54 times that of a fully equity invested portfolio at a one day interval as the allocation is increased to a 30% weight. The cost to the investor is a reduction of 11% in risk-adjusted returns. Moving from short to long horizons, the level of risk reduction achievable is aversely affected, while the relative risk-adjusted returns decrease, consistent with previous findings. For a 30% allocation to gold, an investor with a 30 day horizon reduces portfolio risk to 0.785 times that of an equity only portfolio, but surrenders 47% of risk adjusted returns to do so. This again confirms that, while gold has some diversification benefits, these are largely associated with short rather than long intervals.

When silver is included in the portfolio, risk reduction is also greatest at short horizons. In fact, at longer horizons silver is found to increase portfolio risk for most allocation weights. Similar findings are witnessed for platinum, with substantial risk reduction only achievable at short intervals. Moreover, in the case of silver, relative risk-adjusted returns deteriorate to negligible levels for larger allocations. In contrast, platinum seems to provide some benefits at the shortest intervals examined. In summary, our findings suggest that gold is the most consistent of the precious metals in reducing downside risk at all intervals. This, however, does come at a cost in terms of reduced risk-adjusted returns for investors worried about tail-risk. While previous literature suggests that investors require a risk premium to hold downside risk, (Bali et al., 2009; Ang et al., 2006), our findings provide evidence that downside risk averse investors are willing to pay a premium to negate such risks through holding precious metals.

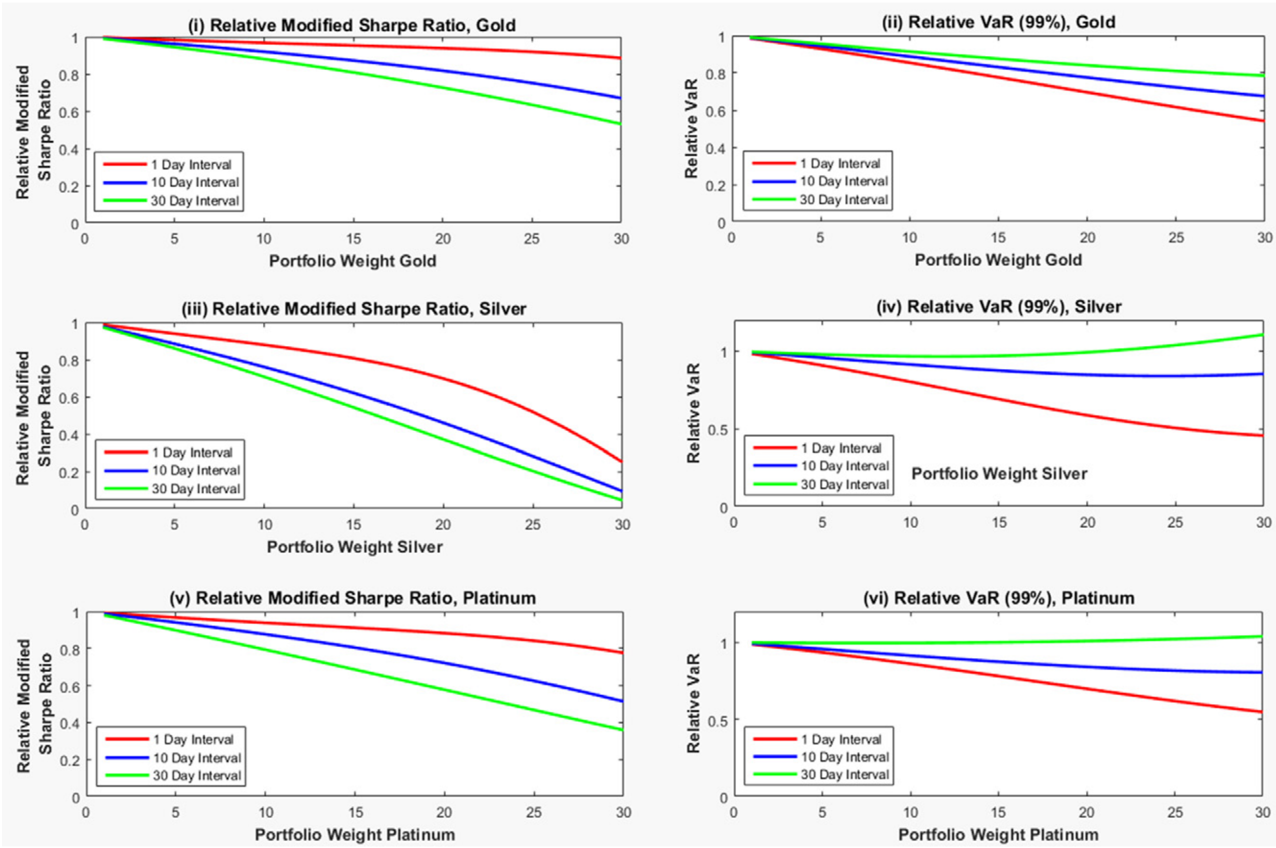

Fig. 3. Relative portfolio performance by precious metals allocation weight (1980–2014). Relative portfolio performance is detailed for a range of precious metal allocation weights over the period 1980–2014. Relative modified risk adjusted returns and relative risk reduction are measured as the 99% Cornish-Fisher four moment VaR of a portfolio with a partial allocation to precious metals relative to a portfolio holding the S&P 500 only. For each of gold, silver and platinum, an allocation of 10% to precious metals is assumed, while VaR risk reduction at a 99% confidence interval for return intervals of 1, 10 and 30 days.

4.3. Marginal risk reduction contributions from distributional moments

An extensive literature documents the preferences of investors over higher-order moments of returns such as skewness and kurtosis. Previous research has documented the importance of higher moment characteristics such as skewness in forming an optimal allocation of wealth to assets including gold, (for example, Lucey et al. (2006)). However, our focus differs somewhat from previous literature, as we consider how an allocation to precious metals may influence the moments of a portfolio's distribution and their associated contribution to extreme downside or tail-risk. To this end, the risk reduction capacity of precious metals is considered for two-, three- and four-moment VaR. This analysis is analogous to previous research contrasting the level of downside risk measured by two-moment and four-moment VaR and tradeoffs between the different moments (You & Daigler, 2010a).

In Table 4, we detail the level of risk reduction achieved through diversification into precious metals as outlined in Section 2.2. In each case, we consider a 10% allocation to precious metals and a 99% VaR confidence interval. To illustrate our findings, we outline the example of gold at a one-day interval. As detailed above, the four-moment VaR reduction of a portfolio with a 10% allocation to gold is 0.85 of one fully invested in equities. Considering two-moment VaR reduction, we note that short horizon risk reduction capacity is curtailed, relative to that estimated using four-moment VaR. Accounting for the third moment of skewness results in little alteration, suggesting that skewness does not contribute substantially to risk reduction. This is in sharp contrast with findings for four-moment VaR, suggesting that kurtosis is a strong contributor to downside risk reduction with gold at the shortest horizons considered, but does not augment risk reduction at long intervals. Finally, the distinct contributions of moments is eliminated at long intervals, where similar risk reduction is evident for two-, three- and four-moment VaR.

For silver and platinum results are generally similar for short intervals. Greatest risk reduction benefits are measured at short horizons using four moment VaR. Moreover, while similar risk reduction is evident for 2- and 3-moment VaR, accounting for kurtosis implies greater risk reduction benefits while little sign of a contribution from skewness is found. At long horizons, we find evidence that kurtosis properties of gold and skewness contribute to a diminution of reduction benefits. In the case of platinum, adding this to a portfolio results in a increase in portfolio downside risk for intervals greater than 40 days.

These results are supportive of our earlier findings, which indicated that gold has the most consistent equity portfolio risk reduction properties amongst precious metals. While similar risk reduction characteristics are associated with skewness and kurtosis for all metals examined, only gold provides consistent 2-moment VaR reduction at all intervals. The finding that kurtosis is a major contributor to downside risk reduction is novel. These short-horizon findings suggest that benefits from kurtosis are a consequence of low co-kurtosis between precious metals and equities at short horizons. This would seem to be a result of non-coincident tail risks, in keeping with the safe haven properties of precious metals.

Table 4
Higher moment contributions to downside risk reduction (1980–2014). The impact of each individual distributional moment on parametric 99% VaR risk reduction is calculated by incrementally incorporating higher order moments. 2-Moment VaR accounts for mean and standard deviation, 3-moment VaR also incorporates skewness, while 4-moment VaR further considers the impact of kurtosis on downside risk reduction. Risk reduction is measured as the 99% Cornish-Fisher four moment VaR of a portfolio with a partial allocation to precious metals relative to one holding the S&P 500 only. In each case, a 10% allocation to precious metals is assumed.

	Gold risk reduction			Silver risk reduction			Platinum risk reduction		
Interval	2 moment VaR	3 moment VaR	4 moment VaR	2 moment VaR	3 moment VaR	4 moment VaR	2 moment VaR	3 moment VaR	4 moment VaR
1	0.91	0.91	0.85	0.92	0.93	0.80	0.92	0.92	0.86
5	0.91	0.91	0.87	0.95	0.95	0.88	0.94	0.94	0.88
10	0.92	0.93	0.89	0.96	0.97	0.91	0.95	0.96	0.91
15	0.91	0.92	0.90	0.96	0.96	0.93	0.95	0.96	0.93
20	0.91	0.92	0.91	0.96	0.97	0.95	0.96	0.96	0.96
30	0.91	0.92	0.91	0.97	0.97	0.97	0.96	0.95	1.00
40	0.92	0.92	0.91	0.98	0.97	0.97	0.96	0.95	1.00
50	0.92	0.92	0.91	0.99	0.99	0.99	0.97	0.96	1.02
60	0.92	0.92	0.91	0.99	0.99	0.99	0.97	0.96	1.02

4.4. Risk reduction using precious metals ETF and futures

Holding physical metals as an investment asset is cumbersome in contrast to more traditional assets such as equities. For instance, precious metals have associated costs of storage and security, not found with paper assets. These are among the reasons that investors may decide not to turn to exchange traded funds or futures contracts. An additional benefit of futures contracts may result when markets are in backwardation, where an investor with a long position may earn a positive return from rolling from a higher priced nearby contract to a lower priced distant contract. Recent evidence also suggests that price formation in gold is heavily linked to futures markets (Hauptfleisch, Putnins, & Lucey, 2016). In recent years, investors have adopted both futures and ETFs as a means to gain exposure to precious metals. Whether or not the risk reduction properties of ETFs and futures on precious metals are consistent with those of physical metals is largely an unexplored research question.

Table 5 details relative portfolio performance for a 10% allocation to gold and silver ETFs. Physical gold and silver performance over the same period are also shown for comparison. Considering gold first, similar risk reduction performance is evident for ETFs and physical gold at all horizons over the period 2004–2014. Risk-adjusted returns, for a portfolio holding 10% physical gold or ETF, are shown to improve relative to an equity-only portfolio. Relative risk-adjusted returns for an allocation to spot gold are found to be slightly better than those found for the ETF.

Comparing the downside risk reduction benefits of the iShares Silver Trust ETF with physical silver over the period 2006 through 2014, contrasting fortunes are evident. At short intervals of one day, the downside risk of a portfolio with an allocation to the silver ETF is 0.93 of a portfolio fully invested in equities. In contrast, for physical silver the analogous downside risk reduction is 0.86. At long intervals, similar risk reduction benefits are evident for both investments. Considering risk-adjusted returns, substantially better

Table 5
Relative portfolio performance - exchange traded funds. Relative risk adjusted returns, relative returns and relative risk measures are detailed for gold and silver ETFs over the period 2004–2014 (Gold) and 2006–2014 (Silver). In each case the relative performance is calculated using performance of a portfolio with a 10% allocation to precious metals, relative to one that is only invested in the S&P 500. Risk adjusted returns are measured using the Sharpe ratio (SR) and modified Sharpe ratio (MSR) using 99% VaR, while risk is measured using both volatility (σ) and 99% value-at-risk at different intervals. Performance is considered for measurement intervals of between 1 and 60 days.

	Gold ETF (2004–2014)					Silver ETF (2006–2014)				
Interval	SR	MSR	Returns	σ	VaR	SR	MSR	Returns	σ	VaR
1	1.24	1.27	1.13	0.91	0.89	0.98	1.00	0.93	0.95	0.93
5	1.25	1.29	1.15	0.92	0.89	0.96	1.01	0.93	0.97	0.92
10	1.26	1.27	1.15	0.92	0.91	0.95	0.97	0.92	0.98	0.96
15	1.26	1.24	1.14	0.91	0.92	0.96	0.97	0.93	0.97	0.96
20	1.25	1.25	1.14	0.91	0.91	0.96	0.98	0.93	0.96	0.95
30	1.25	1.22	1.13	0.90	0.93	0.97	0.96	0.93	0.96	0.97
40	1.25	1.22	1.12	0.90	0.92	0.98	0.96	0.94	0.96	0.99
50	1.24	1.21	1.12	0.90	0.93	0.98	0.94	0.95	0.97	1.01
60	1.24	1.21	1.12	0.90	0.93	0.98	0.93	0.95	0.97	1.02
	Gold spot (2004–2014)					Silver spot (2006–2014)				
Interval	SR	MSR	Returns	σ	VaR	SR	MSR	Returns	σ	VaR
1	1.26	1.29	1.14	0.90	0.88	1.06	1.13	0.97	0.92	0.86
5	1.26	1.31	1.16	0.92	0.89	1.00	1.06	0.96	0.96	0.91
10	1.27	1.28	1.16	0.92	0.91	0.98	1.00	0.95	0.97	0.95
15	1.27	1.25	1.16	0.91	0.92	0.99	0.99	0.95	0.96	0.96
20	1.27	1.26	1.15	0.91	0.92	0.99	1.00	0.95	0.96	0.95
30	1.26	1.23	1.14	0.90	0.93	0.99	0.97	0.94	0.96	0.97
40	1.26	1.24	1.13	0.90	0.92	1.00	0.97	0.96	0.96	0.99
50	1.26	1.22	1.13	0.90	0.93	1.00	0.95	0.96	0.97	1.01
60	1.25	1.22	1.13	0.90	0.93	0.99	0.94	0.96	0.97	1.02

Table 6
Relative portfolio performance for futures and GSCI total return index (1980–2014). Relative risk adjusted returns, relative returns and relative risk measures are detailed. In each case the relative performance is calculated using performance of a portfolio with a 10% allocation to gold, relative to one that is only invested in the S&P 500. Results are detailed for physical metals, futures contracts and the respective GSCI total return index. All results are over the period 1980–2014, with the exception of the GSCI platinum index which is over the period 1984–2014. Risk adjusted returns are measured using the Sharpe ratio (SR) and modified Sharpe ratio (MSR) using 99% VaR, while risk is measured using both volatility (σ) and 99% value-at-risk at different intervals.

(i) Physical metals	Gold					Silver					Platinum				
Interval	SR	MSR	Returns	σ	VaR	SR	MSR	Returns	σ	VaR	SR	MSR	Returns	σ	VaR
1	0.91	0.97	0.83	0.91	0.85	0.77	0.88	0.70	0.92	0.80	0.98	1.05	0.90	0.92	0.86
5	0.90	0.94	0.82	0.91	0.87	0.74	0.80	0.70	0.94	0.88	0.96	1.01	0.90	0.94	0.89
10	0.89	0.92	0.82	0.91	0.89	0.73	0.76	0.69	0.95	0.91	0.96	0.99	0.90	0.94	0.91
30	0.88	0.88	0.81	0.91	0.91	0.71	0.71	0.68	0.96	0.97	0.95	0.90	0.90	0.95	1.00
60	0.89	0.89	0.81	0.91	0.91	0.72	0.71	0.70	0.97	0.99	0.94	0.88	0.90	0.96	1.03
(ii) Futures contracts	Gold					Silver					Platinum				
Interval	SR	MSR	Returns	σ	VaR	SR	MSR	Returns	σ	VaR	SR	MSR	Returns	σ	VaR
1	0.95	1.00	0.87	0.91	0.87	0.88	0.98	0.81	0.93	0.83	0.99	1.05	0.92	0.92	0.87
5	0.94	0.98	0.86	0.92	0.88	0.86	0.90	0.82	0.95	0.91	0.97	1.03	0.92	0.94	0.89
10	0.94	0.97	0.86	0.92	0.89	0.85	0.88	0.82	0.96	0.93	0.97	1.01	0.92	0.95	0.91
30	0.94	0.94	0.86	0.91	0.92	0.85	0.83	0.81	0.96	0.98	0.96	0.92	0.91	0.95	1.00
60	0.95	0.94	0.86	0.91	0.92	0.84	0.83	0.81	0.97	0.99	0.95	0.89	0.91	0.96	1.03
(iii) GSCI precious metals indices	Gold					Silver					Platinum (1984–2014)				
Interval	SR	MSR	Returns	σ	VaR	SR	MSR	Returns	σ	VaR	SR	MSR	Returns	σ	VaR
1	0.95	1.00	0.86	0.91	0.87	0.88	0.97	0.81	0.93	0.83	1.02	1.06	0.94	0.91	0.89
5	0.94	0.98	0.86	0.91	0.88	0.86	0.90	0.81	0.95	0.90	1.01	1.05	0.94	0.93	0.90
10	0.94	0.96	0.86	0.92	0.89	0.85	0.88	0.81	0.95	0.92	1.01	1.03	0.94	0.93	0.91
30	0.94	0.93	0.86	0.91	0.92	0.84	0.83	0.80	0.96	0.97	1.00	0.94	0.94	0.94	1.00
60	0.94	0.94	0.86	0.91	0.92	0.83	0.82	0.81	0.97	0.99	0.98	0.91	0.93	0.95	1.03

performance is found for physical silver, in particular at short intervals. For example, adding 10% physical silver to an equity portfolio is found to increase the Sharpe ratio by 6%. In contrast, adding an analogous quantity of the silver ETF is found to reduce the Sharpe ratio by 2%. A possible rationale for the differential behavior is provided by the relationship between silver spot and ETF, which are found to have a correlation of only 0.335 over the period examined. An explanation for this finding is left for future research.

Next, we consider the risk reduction properties of futures contracts in two ways. First, we consider rolling front month futures, where the futures contract is rolled into the new contract once trading begins. Second, we examine risk reduction benefits from the Goldman Sachs Commodity Indices (GSCI) relating to gold, silver and platinum. All data, with the exception of the GSCI platinum index, is available over the same period 1980–2014. In each case, the level of risk reduction is slightly weakened compared to that found for physical metals at all horizons, but differences in the price of hedging emerge.

Results are detailed in Table 6. Results for futures and GSCI indices are largely in agreement, which is expected as the latter measures the returns from investing in fully collateralized nearby commodity futures. While the level of variance reduction possible using futures and GSCI is similar to physical metals, an investor can achieve one to 2% further downside risk reduction by investing in physical metals. In contrast, futures investors experience a less pronounced decrease in returns than those investing in physical metals. This, in turn, carries over to risk adjusted returns. An investor using futures or GSCI indices does not have to bear the same reduction in risk adjusted returns as one investing in physical metals. These findings suggest that while investors in futures contracts do not achieve quite the same level of risk reduction, the cost of risk reduction is reduced relative to physical investors for the same proportional allocation. The difference in risk adjusted returns is attributed to benefits from futures market backwardation, where gains may be had from rolling from nearby to distant contracts.

5. Conclusion

Recent literature has indicated the capacity of gold to act as a safe haven during times of financial turmoil. In this study we build on previous research, by investigating the capacity of gold, silver and platinum to mitigate extreme portfolio downside risk. We further investigate the cost or benefit of such risk reduction, by considering the impact on risk-adjusted returns. As the focus of the study is on rare events, we adopt a methodology appropriate to capturing infrequent but dangerous tail events. The Cornish-Fisher modified VaR adjusts the quantile of a distribution to account for higher-order moments of skewness and kurtosis.

Empirical results are supportive of previous studies expounding the safe haven properties of gold. In particular, we conclude that gold provides strong downside risk reduction for equity investors across a range of short and medium horizons. In contrast, the equity risk reduction properties of silver and platinum, while strong at the shortest intervals considered, are abated at long intervals. For the longest horizons considered, both silver and platinum may be associated with increased downside risk for large allocations.

We determine the contribution of various moments to downside risk reduction by examining modified VaR accounting, in turn, for two, three and four distributional moments. Evaluating the level of VaR reduction for each moment in turn, we find marginal risk reduction contributions from precious metals variance at all intervals studied. In contrast, the kurtosis properties of precious metals are found to reduce portfolio risk at short intervals but become a net contributor to risk at long intervals. A related issue, not examined here, is the role of predictability in returns in optimizing downside risk reduction (See Urquhart (2016), Urquhart, Batten, Lucey, McGroarty, and Peate (2015) and Charles, Darné, and Kim (2015) for evidence of predictability in precious metals markets).

The price, in terms of risk-adjusted returns, of adding precious metals to a portfolio is also examined. Over the entire period, 1980–2014, the Sharpe ratio and modified Sharpe ratio of a portfolio containing precious metals is shown to be reduced relative to an equity only portfolio. This finding suggests that investors are willing to sacrifice returns in order to reduce the potential for large tail losses. These findings are in contrast to earlier studies considering the performance benefits of investing in gold, and show the importance of accounting for the risk-free rate in assessing safe-haven assets.

An additional contribution of the paper is the analysis of alternative precious metal investment vehicles. The downside risk reduction properties of ETFs and futures relating to precious metals are examined. Precious metal futures, in particular, are found to provide an interesting and viable alternative to physical metals.

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