



EQUITY TAIL RISK HEDGE: GOLD OPTIONS

TAIL RISK HEDGE; SYSTEMIC RISK;
INFLATION-HEDGE

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THESIS

Due to the recent explosion in systemic macroeconomic risks, the equity markets experience high risk-premium, resulting in high carry costs to hedge equity positions. Although hedging with gold exposes the hedger to other idiosyncratic risks, gold's long optionality presents a low-cost, reactive way to hedge global equity exposure. Considering the aforementioned, we believe that the rolling 1 month purchase of a credit-neutral, three-month, out-of-the-money, "1 by 2" call side ratio spread on GLD (a gold ETF) is a low-cost, reactive hedge in the event of systemic market turmoil¹.

KEY DRIVERS

Hedges are essential in times of macroeconomic uncertainty. The outsized impact of sudden paradigm shifts on global financial markets indicates the necessity to hedge equity markets and positively correlated securities with gold. When COVID-19 swept the United States and the world in March 2020, it had a watershed effect on the equity markets and triggered a freefall in share prices. Not only did investors watch their portfolios plummet, but entire industries were also put on hold and unemployment surged which had a cascading effect on the global economy.

Share prices are highly reactive. Prices are volatile to the circumstances of the virus and the developments in our economic recovery and return to "normalcy." Vaccine rollouts, business reopening, and virus cases declining led to a positive recovery in equities, while spikes in cases and the emergence of the Delta variant had negative effects on equities.

COVID-19. The pandemic demonstrated that a spontaneous event could have exorbitant effects on the global macroeconomic condition and significantly influence asset prices across equity markets. Markets have not yet fully recovered from the virus economically and are exposed to several new risks because of the acute measures taken to fuel economic recovery after March 2020. Uncertainty concerning virus recovery status, spending plans passed to stimulate economic recovery, and political polarization have led to high volatility and a stronger correlation between share prices and political/macro-economic uncertainty.

Substantial increases in government spending. Government spending has spiked because of the pandemic. The Coronavirus Aid, Relief, and Economic Security (CARES) Act passed in March, provided \$2.08 trillion in spending to U.S. consumers. This level of extreme amounts of artificial spending to keep the economy afloat, juxtaposed with high unemployment, damaged supply chains, and a decrease in consumer demand arouses fear of mass inflation and economic instability.

The debt ceiling. The massive relief spending is causing the US debt to rise at record-high rates that are unmanageable and may result in the Treasury running out of borrowing power. Congress has an October 18th deadline of paying its bills, and Secretary of the Treasury Janet Yellen said that if Congress does not

¹ A "1 by 2" ratio spread consists of selling an out-of-the-money call option and purchasing two further out of the money call options such that the net credit received is approximately 0. In the optimal case for the next 3 months, the strategy consists of selling a \$172 strike 3 month call and purchasing 2 \$179 strike

Target Carry:
1.24%
(Reflects data on 10/8/21)

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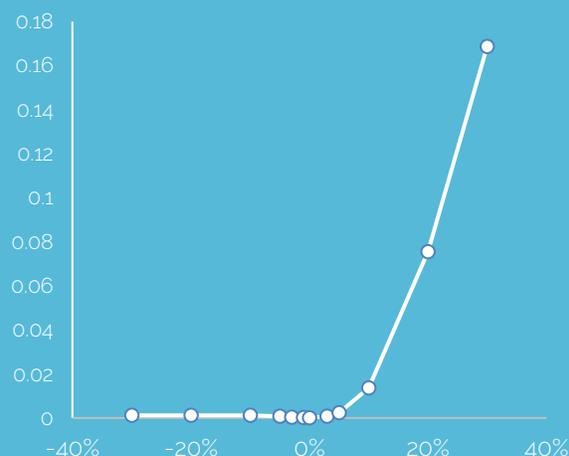
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SUMMARY

Carry Cost (Annual)	1.24%
Sold Strike	\$172
Bought Strike	\$179
Expiration	Dec 31, 2021
Roll-Timeframe	1 month
Underlying Asset	GLD US Equity

1-Day Scenario P&L Chart



raise the debt ceiling, the Treasury will run out of emergency funds to pay U.S. debt holders by that date, which would have "catastrophic economic consequences."

This essentially means that the US will default on its debt or may result in a credit downgrade like the one that occurred in 2011 when low tax revenues due to the great recession and simultaneous increases in expenditures caused several rating agencies to be pessimistic regarding the economic outlook of the US and downgraded the US credit rating from "AAA" to "AA+." The credit downgrade implied an increased risk of default and thus a higher cost to insure US debts against defaults, and a decline in global equity markets followed.

If the US continues to spend at immense, uncontrollable rates and Congress cannot agree to raise the debt ceiling before the US defaults, the markets will undergo a similar or potentially much worse decline in markets, as 2021 growth was coupled with high unemployment and high artificial spending.

Gold's role as a hedge in a portfolio. The strategy is rationalized by the current state of the business cycle and fragility of the US economy, which demonstrates a high risk of economic collapse. Gold has a negative beta, meaning that it is negatively correlated with the markets and historically performs well in times of economic distress. Based on the current state of the US economy, an option-based hedge with gold stands as a logical and definite measure of protecting portfolio assets and mitigating downside risk.

COMMODITY OVERVIEW

Commodities are heavily influenced by general economic conditions which cause the overall cyclicity of commodities. Historically, commodities do well in the later stages of the economic cycle, and as interest rates are cut to stimulate economic growth, the strong performance of commodities lasts through the early periods of recession. Such phenomenon provides an important economic justification for gold's late-cycle to early recession performance which is important for this tail risk strategy.

Commodities, unlike equities, are traded under future contracts which allow a buyer/seller to lock in the price of the underlying for delivery in the future. Like equities, these contracts are exchange-traded and quoted daily. Equities, once purchased, have no expiration date. Using future options instead of equity options presents several issues.

Future options add a layer of complexity to modeling as they can expire prior to the expiration of the futures contract itself. Additionally, any model has to track the implied carry cost along with implied optionality on the carry cost (which may be seasonal) rather than just the pricing of the underlying. Future options are also less liquid than their equity counterparts. Due to these limitations, we will use commodity-based ETFs which provide a low-cost way to gain exposure to commodity prices while simultaneously trading equity-based American options. A commodity-based ETF such as GLD holds the commodity physically and thus trades around the spot price for the underlying commodity. Other commodity-based ETFs use a blend of synthetic exposures such as futures, forwards, and swaps to allow their ETF to track the spot price of the underlying.

GOLD AS HEDGE AGAINST INFLATION

Gold's history as a safe-haven asset has justified its use as a hedge against inflation throughout the years. During times of economic recession or turmoil, gold has historically retained its value, serving as a store of value that can't be eroded like fiat money, and is invariant to interest rates. During the hyperinflation experienced by the Weimar Republic in Germany in 1923, gold's value increased 1.8 times faster than the inflation rate and was highly coveted. More recently, from 1976 to 2018, gold futures have been more effective than equity markets at predicting inflation. Gold futures and inflation had a correlation of 0.105, while equities and inflation had a correlation of -0.017.

However, gold's relationship with CPI is poor. From 1971 to 2020, only 16% of the variation in gold prices can be explained by quarterly changes in CPI inflation. In the short run, the price of gold is relatively insensitive to changes in CPI, and gold has a history of mixed returns when it comes to inflationary periods. From 1973 to 1979, gold yielded a 35% return for investors with an average inflation rate of 8.8%. However, from 1980 to 1984, gold yielded a negative 10% return with an average inflation rate of 6.5%, and from 1988-1991, yielded a negative 7.6% return with an average inflation rate of 4.6%. Price volatility limits the effectiveness of gold as an inflation hedge in the short to medium term.

Yet, CPI may not be the best indicator of inflation. For example, the price of gold and the US M2 money supply has been found to have a statistically significant level of cointegration from 1971 to 2020. Inflation, shown by the growth in the M2 money supply, is a fundamental driver for the price of gold. As the supply of cash and cash equivalents grows, investors become more inclined to invest in safe-haven assets that will retain their value through times of economic recession. As the money supply increases, gold not only retains its value but appreciates relatively.

Overall, although gold isn't a perfect hedge for inflation, its significant cointegration with the M2 money supply, and historical track record of appreciating through economic cycles are proof of its merit as an inflation hedge.

GOLD AS A HEDGE AGAINST EQUITY TAIL RISK

Historically, to mitigate significant and negative events, often referred to as 'tail risk', investors would increase their position in gold or alternative assets to protect their portfolio returns. However, it is often too late for investors to buy gold when 'tail risk' has already happened. Some investors also claim that gold would sacrifice their portfolio returns if bought prior to the event. Why does hedging against equity tail risk matter? It is embedded in most of the portfolio optimizers that most of them assume the return from assets follows normal distribution and correlation between assets is relatively constant. Indeed, the asset return in practice follows a skewed distribution, most of the time negatively skewed, creating long fat 'tails' that traditional models do not incorporate.

In the time of economic expansion, investors often invest in risky assets and sometimes construct their portfolios purely based on stock equity in order to gain a higher return. The relatively high

growth during these periods attracted even more investors into the equity market and led to underemphasis on hedging their portfolio risk. Commodities like gold and platinum often experience downward pressure because of their limited return. This repeated process further accumulates risk in the market, which eventually left investors unprotected during an extreme negative event — e.g., the 2007-2009 financial crisis.

Gold stands out as a perfect asset for portfolio risk management not only for protection in extreme circumstances but also for not dragging down a portfolio's Sharpe ratio. The World Gold Council investment research had found that between January 1987 and July 2010, gold correlation with S&P 500 is -0.07, when S&P 500 returns down by two standard deviations, the correlation rose to -0.17, which indicated gold as an effective asset to hedge against the equity tail risk. In addition to the correlation, it also found out that during tail risk events like the LTCM crisis, Black Monday et al., portfolios that included gold outperform those that did not include gold 75% of the time. With allocations to gold between 2.5% - 9.0%, the portfolio could reduce weekly volatility by 1% to 2.5%.

Overall, gold has been proved by the historical data to play an important role in investors' portfolios and serves as an essential method for hedging and reducing tail risk.

GARAM-STATIC HEDGE

To determine the optimal option strategy, two related models are employed. First, the GARAM (General Auto-Regressive Asset Model) is employed and used to fit the static option hedging model. The model uses historical gold prices from 1979 to 2021 as the input and will output the risk premium of the gold options chain.

Why do the GARAM model? The intuition behind this model is the observation from the market that a rapid increase or decrease in price is usually followed by high volatility for a period of time, which implies that there exists an autocorrelation pattern in the return magnitude (slow-dying kurtosis effect). In addition, each asset will indeed observe a different autocorrelation pattern because of its unique characteristic. Thus, we will specifically analyze gold prices by observing and simulating their autocorrelation pattern.

In this model, the return magnitude and return sign separately are simulated separately using their respective auto-correlation functions. Using Cholesky decomposition, we generate a price magnitude that has the same autocorrelation curve as the historical return magnitude/sign. The return magnitude and sign are then combined to determine the returns and generate pricing paths. Using this framework in a Monte Carlo type fashion, 100,000 future price paths are generated for the next 120-days.

We then move from the GARAM model to the Static Hedge model and use the predicted price path as the input. The Static Hedge model helps us to find an optimal strategy for dynamic hedging and comes up with an option price that is derived from the expected attempted replication cost plus the risk premium. By fitting the predicted price path into the model, we find the risk premium for each gold options chain. Eventually, by analyzing the option's risk premium, we develop our optimal trading strategy of gold option for portfolio hedging.

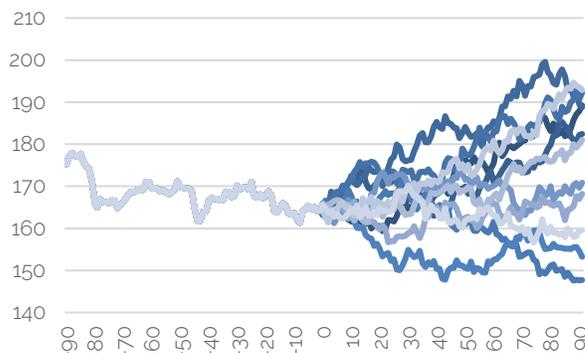


Figure 1 shows 10 sample paths of gold generated by the model for the next 90 days. The previous 90 days are shown for reference.

MODEL RESULTS

Applying the GARAM, static hedge as described above provided a curve for the expected sellers' risk-premium for the one-month, two-month, and three-month gold option chains. Based on the curve and magnitude of the risk premium, the three-month option chain yields the most promising results compared to the one and two months. Further, it is optimal to sell the option which corresponds to the maximal risk-premium (104.5% moneyness option). Intuitively, it is clear that the optimal strategy will reduce carry by taking advantage of the positive risk premium while purchasing reactive lower-cost options. This situation is optimal for a ratio spread. When determining the optimal option to purchase, the following two issues are in counterbalance. First, the farther out of the money the options are, the higher the risk premium spread is however, the bought options may not be reactive enough to generate returns over the sold option. On the flip side, if an option is purchased too close to the sold option, then it results in debit and has higher time decay. Analysis of 30-day market simulations for a portfolio of these options shows that when the credit received from the sold options has parity with the debits from the bought options, these two issues are optimized.

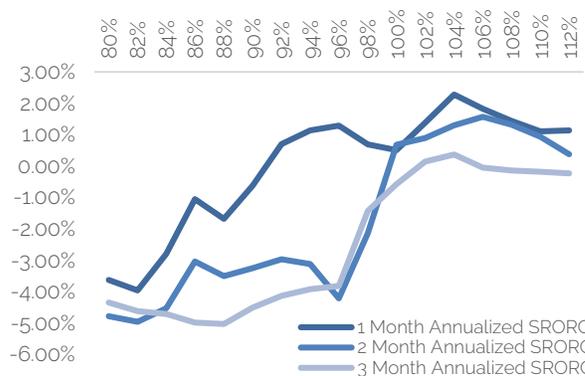


Figure 2 shows the seller's return on risk capital (SRORC) for different option moneyness for 1, 2, and 3 months. Moneyness was interpolated when chains did not have a one-to-one correspondence.

MODEL VALIDATION

The majority of academic literature for simulation of future assets

makes assumptions about the normality of the underlying distribution of returns that do not match the real-world paradigm. The GARAM model, however, relies on the observed distribution of returns in asset simulation and uses the empirical auto-covariance to exhibit the non-decaying kurtosis endogenous within the market pricing. Additionally, the GARAM model deployed conditional simulation, so contemporary conditions are projected into the paths of the simulation. Combinedly, these factors allow the GARAM model to produce realistic simulations of future asset pricing that is required to accurately price options. Derived from empirical data, the GARAM model results in a stochastic description of return that has realistically slow dying kurtosis over time which does not conform to the independence assumption of central limit theorem under many existing asset models.

The static hedge part of the model does not assume any risk-neutral tautology and is based purely on the realistic assumption that market participants wish to minimize wealth volatility without sacrificing generality. The static hedge lacks, however, the more realistic use of interval hedging which occurs in most trading settings. Yet ultimately, the use of the output is to determine the relative risk-premium of various options, this limitation does not hamper the ability of the static hedging framework to produce reliable real-world results other than constraining our ability to make statements regarding the actual risk-premium of the strategy.

The difference between realized and implied volatility contributes to the pricing of options. As implied volatility is almost always greater than realized volatility; therefore, options sellers benefit from prices reflecting greater expected volatility. Gold, however, is an exceptional case. The implied volatility and historical volatility data from October 2011 till October 2021 demonstrated an interesting parity in terms of varying investment horizons for gold. The 10-day and 30-day historical volatility were greater, on average than implied volatility while the 50-day and 100-day historical volatility was less, on average than implied volatility. Therefore, when trading in the 10 to 30-day investment window, gold options are rich, and sellers have the edge, yet in the 50 to 100-day investment window, buyers have the edge. This should be considered when finding the optimal static hedging strategy. As seen in the model output, the output of the risk-premium approximately matches this observed effect.

RISK FACTORS

Inflation may subside. With the introduction of vaccines, the shutdowns resulting from the COVID-19 pandemic are beginning to subside, as workers are being called back into the office and manufacturers are ramping up production. The growth rate of inflation is also showing signs of slowing down. The CPI only grew 0.3% from July to August 2021, coming in under expectations. In addition, the lower rate is a sign of inflation slowing down, as, during the previous 5 months, CPI grew by an average of 0.68%. As supply constraints begin to ease as time passes, inflation may continue to slow down and lower closer to pre-pandemic levels placing downward pressure on gold prices.

The short-term effectiveness of gold as an inflation hedge.

Historically, gold has a strong track record of retaining its value over long periods of time, through multiple economic cycles. However, in the short to medium term, the price volatility of gold has given mixed returns in inflationary periods. In addition, the price of gold has been shown to be relatively insensitive to quarterly changes in CPI, limiting its use as an inflation hedge. Therefore, its use as a hedge in short investment windows may prove to be more volatile than we expect.

Market liquidity. By trading gold options, we open ourselves up to an increased level of risk in terms of market liquidity. Gold is one of the more liquid precious metals, but even still, market liquidity of gold options with an underlying asset of gold holdings is a serious risk. Gold ETF options have a much lower volume traded than more popular investment choices such as other equities or debt-backed securities. In addition, it faces a time horizon risk. As the options get closer to their strike dates, illiquidity problems are exacerbated by urgency.

CONCLUSION

As evidenced by the current macroeconomic uncertainties and sudden paradigm shift experienced during the pandemic, it is necessary to hedge against such unpredictable scenarios to protect holdings in the equity market. In the foreseeable future, systemic risks are expected to ensure volatility will remain high. Using the quantitative techniques of GARAM/GARCH and static hedging, which has shown to be highly applicable to the real world, to determine the optimal hedge ratio and predict the realistic paths of gold to assist in determining that the rolling 1 month credit-neutral, three-month, out of the money, "1 by 2" call side ratio spread is optimal. Thus, with a negative beta to equity markets and overall, as an effective hedge against inflation, the gold options strategy described above would prove a sufficient, low-carry strategy to protect against downside risk.