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Structure in Gold and Silver Spread Fluctuations

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Abstract
We investigate the price spread between gold and silver trading as a futures contract on COMEX. Although the correlation between gold and silver returns during this period was high we find evidence of time varying long term dependence in the spread, with the positive dependent relationship dominant. This last finding suggests limited opportunity to profit from strategies based on mean reversion of the spread.

Key words: Long term dependence; volatility; gold silver spread; futures
JEL: C22; C32; E31; F30; G15

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Structure in Gold and Silver Spread Fluctuations

1. Introduction

The price dynamics of precious metals, generally, and gold and silver in particular, has long been a matter of popular concern and fascination. Recently, a number of authors have successfully modelled the stochastic nature of precious metal returns (Urich, 2000; Casassus, Collin-Dufresne, 2006) while the new tools of econometrics have demonstrated important insights in the long term price relationships between bivariate combinations of precious metal prices (Escribano and Granger, 1998; Ciner, 2001).

The objective of this study is to report the dynamics of the bivariate relationship between gold and silver prices. First, we investigate the spread, measured as the price difference between gold and silver trading as a futures contract. Rather than apply the cointegration techniques of Escribano and Granger (1998) and Ciner (2001), which aim to identify the presence of a long-term equilibrium, we adapt the classical rescaled adjusted range (RAR) technique of Hurst (1951) using Autoregressive Moving Average (ARMA) filtering (Lo, 1991; Xiao, 2003). This approach accommodates short-term autocorrelated innovations that may be present in the return process, the likely consequence of illiquidity and information effects. The RAR approach also has the benefit of providing an insight into the direction of the equilibrium reverting process since it allows for differentiation between a process that reverts to its long-term mean after an information shock, such as from news announcements (Christie-David et al. 2000), and one that progressively moves away from the long-term mean after each new shock.

Next we provide information on the gold and silver futures data used for the study. Then the results from price analysis using rescaled range analysis are reported. The final section allows for some concluding remarks.

2. Data

Lucey and Tulley (2006) provide a detailed account of studies investigating trading in the international gold and silver markets. We investigate the price of two contracts trading on the New York Mercantile Exchange (NYMEX): the deliverable 100 troy ounce nominal COMEX gold and the deliverable 5,000 troy ounce nominal COMEX silver contracts. In an economic sense these futures contract are fully arbitrageable against gold and silver trading in a variety of other worldwide cash and futures markets. Open-outcry trading commences at 08:20h/08:25h and ends at 13:30h/13:25h (gold/silver). Trading is also available simultaneously (termed side-by-side trading) on the GLOBEX electronic trading system available on the Chicago Mercantile Exchange (CME). Our data comprises 1,746 daily observations of the near month COMEX gold and silver contract at the start of trading from January 1999 to December 2005.

We first estimate the interday returns (ΔP_t) for the price spread (P_t) between gold (G_t) and silver (S_t), where $P_t = G_t - S_t$. Allow $\Delta P_t = \log (P_t) - \log (P_{t-1})$ where the interval $t\text{-}1 \rightarrow t$, is 1-day. Individual asset returns (for gold and silver) are also measured as $\Delta G_t = \log (G_t) - \log (G_{t-1})$ and $\Delta S_t = \log (S_t) - \log (S_{t-1})$ where the interval $t\text{-}1 \rightarrow t$, is 1-day.

Over the sample period the spread varied from a maximum of US$531.89 to a minimum of US$248.63. The spread mean was US$333.22. For the return series the mean was slightly positive in all cases ($\Delta P_{t,}$ $\Delta G_{t,}$ ΔS_t equaling 0.00014, 0.00014 and 0.00013 respectively). Silver was also more volatile over the entire sample period than the spread, or gold, measured by the standard deviation ($\Delta P_{t,}$ $\Delta G_{t,}$ ΔS_t, equaling 0.0044, 0.0044 and 0.0062 respectively) and the coefficient of variation ($\Delta P_{t,}$ $\Delta G_{t,}$ ΔS_t, equaling 3059, 3060 and 4733 respectively). However, this was not the case when the coefficient of variation (CV) was estimated over a 22-day (equal to one calendar month) rolling window (i.e. $CV_n = \mu_n/\sigma_n$, where n =22). The CV_{22} for gold and silver are illustrated in Figures 1a and 1b. It is clear from these figures that silver appears more stable, with less significant peaks and troughs in the CV_{22} of returns than gold. Such differences would likely impact upon the dynamics of the long-term equilibrium between the two metals.

(Insert Figures 1a,1b,1c about here)

To demonstrate the time varying nature of the relationship between gold and silver we also estimate and then plot in Figure 1c, the rolling 22-day correlation between gold and silver returns ($GS\rho_{22}$). Over the entire sample period the correlation is high and positive ($GS\rho_{1746}$ = 0.686, p=0.000). However, estimating $GS\rho_{22}$ the range varies from a maximum of 0.9675 to a minimum of -0.1524. Nonetheless, since a positive correlation is maintained over the sample period trading strategies based on mean reversion of the spread to its average may in fact provide profitable opportunities for market participants. This finding is consistent with widely held views in commodity markets that despite the fundamental differences between the two markets (see Lucey and Tulley, 2006), gold and silver prices tend to move together, thereby offering the possibility for various trading and portfolio strategies. This is considered further when the rescaled range statistic is estimated in the next section.

3. Rescaled Adjusted Range Analysis

The presence of long-term dependence in the spread returns (ΔP_t) between gold and silver may be measured using statistical techniques based on rescaled range analysis (Hurst, 1951) after accommodating short-term autocorrelated innovations in the return process (Lo, 1991; Chow et al. 1995; Xiao, 2003). Collectively this filtering process usually via ARMA models is the basis for RAR. Of specific interest is the residual ψ_t after applying various filters (AR(1) →ARMA (2,1)) to ΔP_t . An ARMA(2,1) model of the form

$$\Delta P_t = \alpha_0 + \beta_1 \Delta P_{t-1} + \beta_2 \Delta P_{t-2} + X_1 \lambda \psi_{t-1} + \psi_t \tag{1}$$

provides the best fit to the data with β_1 = 0.4802 (p=0.06), β_2 = 0.1109 (p =0.000) and X_1 = 0.5780 (p = 0.024). For each ψ_t the classical rescaled adjusted range $(R/\sigma)_n$ is calculated as

$$(R/\sigma)_n = (1/\sigma_n)\left[\max_{1 \le k \le n} \sum_{j=1}^{k} (X_j - \overline{X_n}) - \min_{1 \le k \le n} \sum_{j=1}^{k} (X_j - \overline{X_n})\right] \tag{2}$$

where $\overline{X}_n$ is the sample mean and σ_n is the standard deviation of ψ_t over a particular series n

$$\sigma_n = \left[1/n \sum_{j=1}^{n} (X_j - \overline{X_n})^2 \right]^{0.5} \tag{3}$$

In order to capture the time-varying nature of dependence in ψ_t this study employs a local measure of the Hurst exponent (h). Calculated as

$$h_n = \frac{\log(R/\sigma)_n}{\log n} \tag{4}$$

where n is set to either 22 days or 66 days, which is equivalent to a standard one and three month period. This procedure in effect creates a time-series of exponent values, the change in whose value can be measured over time. The averages of the local Hurst (h) for the entire sample period are summarised in Table 1. The top row in this table records the filtering technique applied to $\psi_{t..}$ These four techniques range from AR(0) – no filtering - to ARMA (2,1) as per Equation 1.

(Insert Table 1 about here)

Recall from Hurst (1951) that under the null hypothesis of no long-term dependence, the value of $h_n = 0.5$. For time-series exhibiting positive long-term dependence, the observed value of the exponent $h_n > 0.5$. Time-series containing negative dependence are alternatively characterised by $h_n < 0.5$. From Table 1, the mean for h_{22} varies from (0.7070 for AR(0) to 0.7170 (ARMA(2,1)). The scores for h_{66} are lower suggesting the series is becoming more random as the sample length n in Equation (4) increases and vary from (0.6487 for AR(0) to 0.6496 (ARMA(2,1)). Note too, that filtering has little effect on the h-statistic. Even, allowing for a 95% confidence interval these local Hurst coefficients are consistent with positive long term dependence. For positively dependent processes another price movement further away from mean (equilibrium) will follow the earlier movement away from equilibrium. That is the spread should tend to get larger, or smaller, depending on whether the previous change in price was positive or negative.

(Insert Figure 2a and 2b about here)

Nonetheless a plot of h_{22} and h_{66} over the entire sample period (shown in Figures 2a and 2b) shows considerable variation in the statistic and rare episodes when the statistic was below 0.5000. In the case of h_{22} the minimum value was 0.3296 and the maximum was 1.0 while for h_{66} the minimum value was 0.4071 and the maximum was 0.9399. Values below 0.5000 are consistent with negative dependence where a price movement towards the equilibrium should follow a movement away from equilibrium.

4. Conclusions

This study investigates the relationship between gold and silver trading as a futures contract on COMEX from January 1999 to December 2005. During this period the correlation between gold and silver returns was positive and high even though the relationship itself was unstable. We apply techniques from fractal geometry after accommodating underlying autoregressive behaviour to investigate the long term dynamics of the spread between these two contracts. Using a local Hurst exponent we find episodes of both positive and negative dependence, though the positive dependent relationship appears to be dominant. This last finding is of importance for spread traders and portfolio managers since trading strategies based upon mean reversion in the spread offer limited profit opportunities.

References

Christie-David, R., Chaudhry, M., Koch, T.W. 2000. Do macroeconomics news releases affect gold and silver prices? Journal of Economics and Business 52 (5), 405-421.

Chow, V., Denning, C, Ferris, S., Noronha, G. 1995. Long-term and short-term price memory in the stock market. Economics Letters, 49(3): 287-293

Ciner, C. 2001. On the long run relationship between gold and silver prices. A note. Global Finance Journal 12 (2), 299-303.

Casassus, J., Collin-Dufresne, P. 2005. Stochastic convenience yield implied from commodity futures and interest rates. Journal of Finance 60 (5), 2283-2331.

Escribano, A., Granger, C.W.J. 1998. Investigating the relationship between gold and silver prices. Journal of Forecasting 17 (2), 81-107.

Hurst, H.E., 1951. Long-term storage capacity of reservoirs. Transactions of the American Society of Civil Engineers 116, 770-799.

Lucey, B., Tully, E. 2006. Seasonality, risk and return in daily COMEX gold and silver data 1982–2002. Applied Financial Economics, 16(4), 319-333.

Urich, T.J. 2000 Modes of fluctuation in metal futures prices. 2000. Journal of Futures Markets 20 (3), pp. 219-241.

Xiao, Z. 2003 Note on bandwidth selection in testing for long range dependence Economics Letters, 78(1): 33-39

Figure 1a: The coefficient of variation of daily silver returns estimated on a 22-day rolling window.

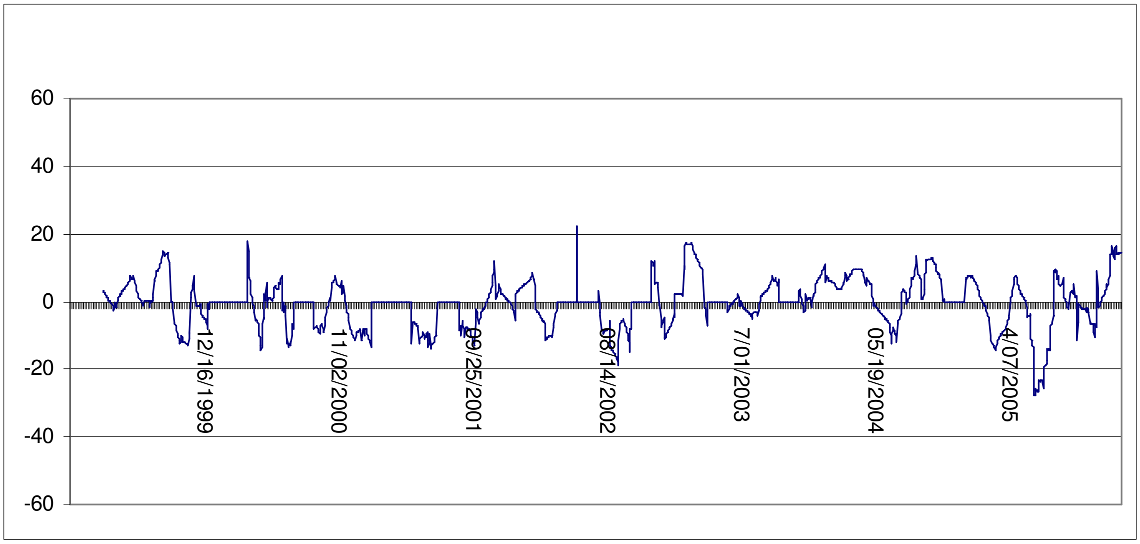

Figure 1b: The coefficient of variation of daily gold returns estimated on a 22-day rolling window.

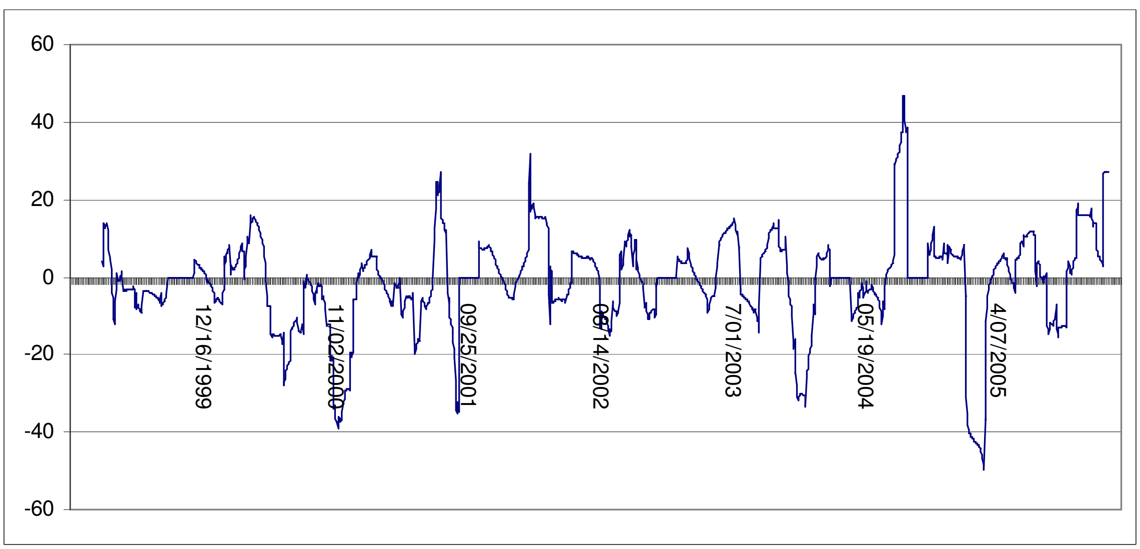

Figure 1c: The correlation between daily gold and silver returns estimated on a 22-day rolling window.

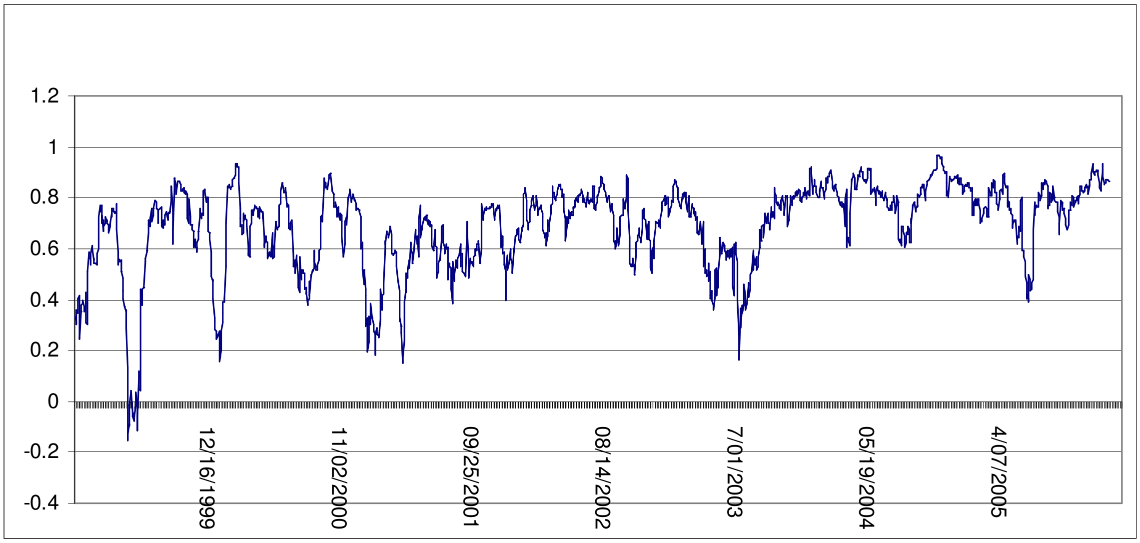

Figure 2a: The local Hurst estimated using an ARMA(2,1) filter on the spread return between daily gold and silver (estimated on a 22-day rolling window).

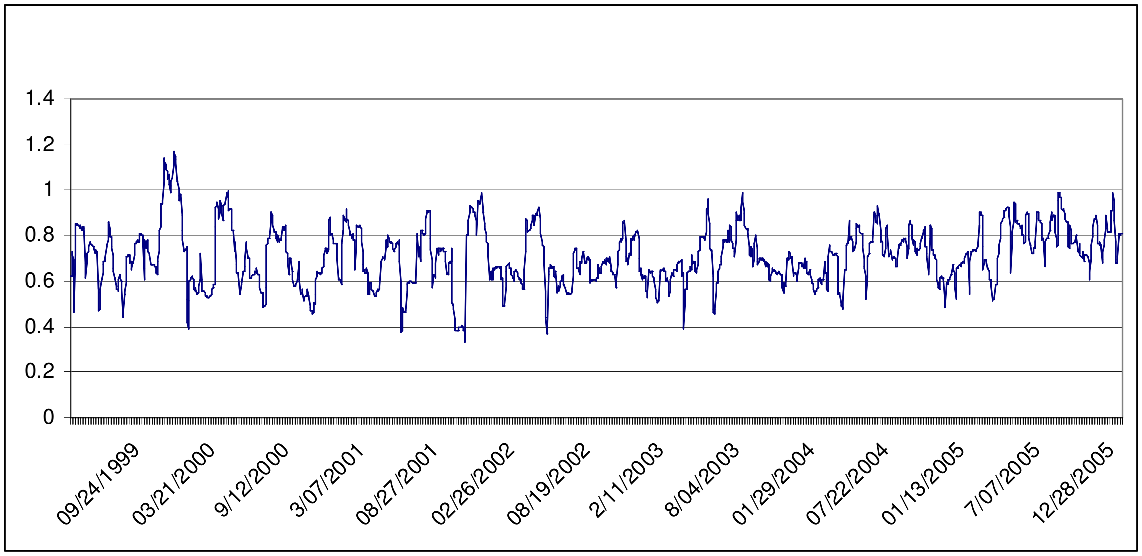

Figure 2b: The local Hurst estimated using an ARMA(2,1) filter on the spread return between daily gold and silver (estimated on a 66-day rolling window).

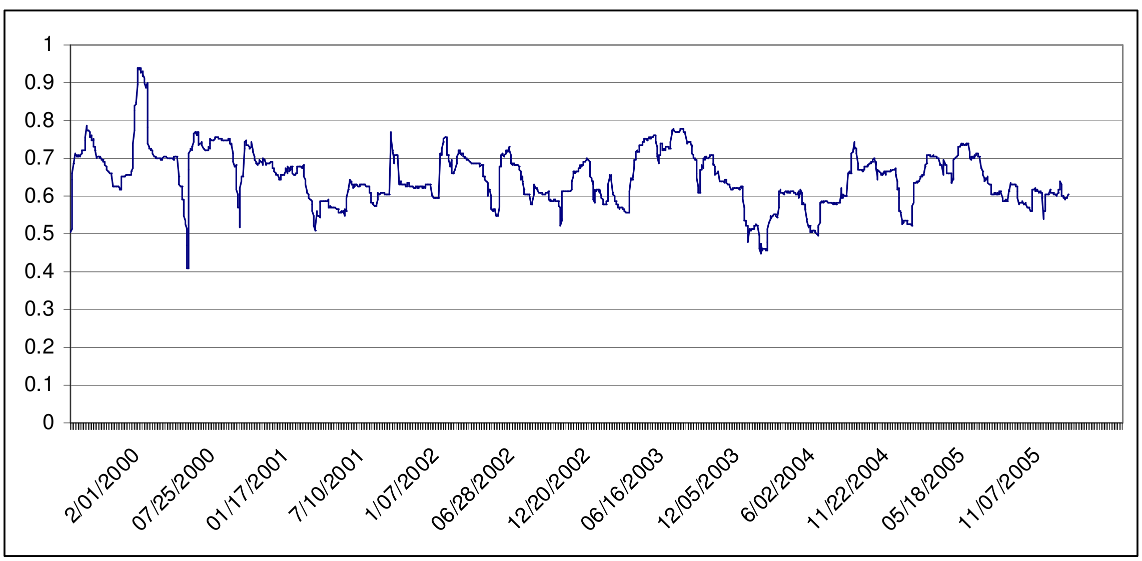

Table 1: Local Hurst exponents estimated using 22 and 66-day rolling windows

Overall Sample	22-Day Windows (1 month)				66-day Windows (3 months)			
	AR(0)	AR(1)	AR(2)	ARMA (2.1)	AR(0)	AR(1)	AR(2)	ARMA (2.1)
mean	0.7071	0.7370	0.7189	0.7170	0.6487	0.6667	0.6577	0.6496
Standard deviation	0.1314	0.1328	0.1312	0.1283	0.0737	0.0741	0.0740	0.0725
95% Confidence interval	0.7007-0.7133	0.7239-0.7366	0.7123-0.7521	0.7046-0.7168	0.6451-6523	0.6631-6703	0.6541-6613	0.6460-6532