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The evolving relationship between gold and silver 1978–2002: evidence from a dynamic cointegration analysis: a note

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This study re-examines the results of Ciner (2001), who claims that the historically stable relationship between gold and silver has broken down in the 1990s. It is shown, using a longer run of data, for both cash and futures, that this finding may be unwarranted. In particular a recursive cointegration model is used to extract the evolution of the relationship over a 25 year period. The findings are that while there are periods when the relationship is weak, overall a stable relationship prevails.

I. Introduction

This study examines the dynamic relationship between gold and silver over the 1978–2002 period. This period covers a very extensive range of economic conditions, political change in major producers and increased sophistication in asset markets generally. It includes, at the start of the period, the attempted cornering of the silver market by the Hunt Brothers. Thus, prima facia one would not expect to necessarily see a stable relationship between gold and silver.

Gold and silver have historically been seen as close substitutes for one another, both being precious metals that can be used to back currency and both having been used as currency. There is significant evidence (see for example Shishko, 1977; Money \textit{et al.}, 1982; Sherman, 1982; Landa and Irwin, 1987; Aggarwal and Sonen, 1988; Johnson and Soenen, 1997; Egan and Peters, 2001; Draper \textit{et al.}, 2002; and Adrangi \textit{et al.}, 2003) that these metals can play a useful role in diversifying risk, as well as being an attractive investment in their own right. Thus, one might expect that the prices share similar dynamics. More recently the focus has switched to collectibles made from these metals: see for instance Kane (1984), Koford and Tschoegl (1998) and Roehner (2001).

However, there are also economic fundamentals that may act to drive the prices of gold and silver apart. While both are used extensively in industrial processes, there are significant differences between these uses. Silver is extremely reflective, a good conductor of electricity and has extensive use in optics and photography. Gold’s industrial uses are fewer, with the majority of demand coming from the jewellery and dental markets as well as being driven by Central Bank reserve demand (official sector gold). Recently, Dooley \textit{et al.} (1995), Christie-David and Mukesh Koch (2000) and Adrangi \textit{et al.} (2003) have examined the relationship between macroeconomic variables and these assets, concluding that

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while they share a similar set of drivers they each also have important unique macroeconomic drivers.

II. Previous Research

Testing for the existence and stability of the gold-silver relationship is not new. Ciner (2001) cites the long held belief that the price ratio should be 1:16 in favour of gold. More recently, studies have used cointegration methods to examine the relationship. Unlike these previous studies the present study examine this relationship both for the cash and the future markets. A finding that there existed such a relationship would be of significance for traders, as it would imply a certain degree of mutual predictability and thus raise the potential for trading profits. However, it would also imply that as the assets shared a common long-term relationship the benefits of including both gold and silver in a portfolio would be considerably reduced.

Portfolio diversification across assets is justified only if there are gains from it. With increasing integration of asset markets, the diversification benefits will tend to decline as the correlations become increasingly positive and strengthen. Significant evidence has accreted for equity and bond markets finding that diversification benefits are non-constant and may be least available when they are most needed. The effect of cointegration is to reduce portfolio benefits as the two assets share a long-term stable relationship. Thus, in assessing the benefits of gold and silver as potential portfolio diversifiers an examination of cointegration is required. There have been an increasing number of papers that have examined this.

The most recent of these include Wahab et al. (1994), Escribano and Granger (1998), Ciner (2001) and most recently Adrangi et al. (2003). Wahab et al. (1994) use cash and futures data, on a daily frequency and find that cointegration does exist, but that there were no profitable arbitrage opportunities between these markets. Examining monthly cash data, Escribano and Granger (1998) find that a cointegrating relationship between gold and silver from 1971 to 1995. They split their dataset at 1990 and find that the relationship was weaker in the latter part of the dataset, indicating that the markets were separating. Ciner (2001) examines daily data on futures on gold and silver from the Tokyo Commodities Exchange, over the 1992–1998 period. He finds that over that period there was no evidence of cointegration. Thus, the indication would appear to be that while there may have been a stable relationship at one time this had disappeared in the 1990s. By contrast, Adrangi et al. (2003) use a multivariate approach, and find that a stable long-run relationship exists not only between these metals but also between them and macroeconomic variables. Thus, the evidence of Ciner (2001) appears anomalous.

All of these studies however can be critiqued on the static nature of their analyses. With the exception of Escribano and Granger (1998) there is no examination of whether or how the relationship changes over time. In particular, there is no examination of the issue of integration over different time periods. This note attempts to fill that gap.

III. Data and Analysis

Data

The data used here are Friday closing prices, from COMEX (now part of the New York Mercantile Exchange) for cash and futures. The dataset runs from start of January 1978 to end-November 2002, giving a total of 1237 data points. The futures data are front month with roll-on-expiration. Four series were examined: Cash Gold, GC; Cash Silver, SC; Gold Future, GF; and Silver Future, SF. Figures 1 and 2 show the evolution of these series. All series have a unit root, as shown by the ADF tests reported in Table 1. This indicates a degree of mean reversion – the data are stable.

In all cases the lag selection was by means of the BIC.

Thus, unit roots being present in the levels one can proceed to an examination of any possible cointegration relationships. The method chosen is that of dynamic cointegration analysis, introduced by Hansen and Johansen (1992). In essence, this involves estimation of the by now well understood Johansen (1988) and Johansen and Juselius (1990) multivariate cointegration approach (hereafter JJ) over various windows. In essence the JJ approach involves the determination of the rank of a matrix of cointegrating vectors.

Methodology

To illustrate, for a given lag length $l$, and assuming no deterministic components, one can write a
Fig. 1. Gold and silver cash series

Fig. 2. Gold and silver futures series 1978-2002

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The second approach is a rolling one, where the data are divided into a number of non-overlapping samples (periods of 52 weeks in this study) and the JJ approach then applied. Again this allows an interpretation of how the dynamics of the system evolve over time. A further advantage is that with the output being the two \( \lambda_{\text{max}} \) and \( \lambda_{\text{trace}} \) statistics as well as the number of cointegrating vectors, this renders it possible to graphically represent the evolution. Such approaches have been used in Barari and Sengupta (2002) and Aggrawal et al. (2003) to demonstrate increased integration in equity markets. There is some debate over which of these approaches provides a better estimate of the true situation, with Pascual (2003) suggesting that in relatively small samples the rolling estimates are to be preferred. However, in the dataset here the number of data points is large by comparison with the studies he examines.

One issue that is important in examination of cointegrated systems is which statistic, \( \lambda_{\text{max}} \) or \( \lambda_{\text{trace}} \) to use. These have differing interpretations, and can give conflicting results. \( \lambda_{\text{max}} \) tests for \( r \) cointegrating vectors against the specific alternative of \( r + 1 \) while \( \lambda_{\text{trace}} \) tests that the number of vectors is less than \( r \). Enders (1995) suggests that in general \( \lambda_{\text{max}} \) is preferred when testing specific hypotheses. However, with two series there can be only at most one vector, so the \( \lambda_{\text{trace}} \) is presented.

### IV. Results

The \( \lambda_{\text{trace}} \) statistic cointegrating vector is shown on a global basis in Fig. 3 while Fig. 4 shows it on a local basis. All statistics are rescaled to be shown as ratios to the critical values of 15.19 (95%) and 13.31 (90%).

In all cases it is seen that the ratio of the global statistics is well in excess of 1, indicating that over the 1978–2002 period one can reject the null of no cointegration. A stable, long run relationship existed between gold and silver returns over the period examined, in both cash and futures markets.

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2 In all cases the JJ approach is estimated on a VAR in levels. One issue that arises then is the appropriate lag structure of the VAR. In this case, using a variety of approaches including the BIC and the AIC, as well as the General-to-simple approach, a lag of 2 (2 weeks) was suggested.
**Fig. 3. Global plots**

*Note:* This chart shows the ratio of the calculated statistic to the 90% and 95% critical values. The statistic is calculated on a recursive basis, starting January 1978 and initially ending January 1988. Thereafter the statistic is recalculated by adding ten observations each period successively.

**Fig. 4. Local plots**

*Note:* This chart shows the ratio of the calculated statistic to the 90% and 95% critical values. The statistic is calculated on a rolling basis, where each observation is calculated over 52 non-overlapping observations.
The ratio, and hence the probability of rejection, increases as time progresses, but even at the start, examining from the 1978–1998 period one can still reject. This rejection is not dependent on the choice of confidence interval. This result is in contrast to Ciner (2001), but reconfirms in a dynamic setting the findings of Wahab et al. (1994) and Escribano and Granger (1998). Thus, one can conclude that the stable relationship between gold and silver found to prevail historically appears to have continued to the present day.

However, when one examines the local plots, formed by analysing non-overlapping 52 week datasets, a different picture emerges. In general the data indicate that one cannot reject the null of no cointegration. A number of periods emerge however when such rejection is possible. First of these is the 1979–early 1982 period, corresponding to the cornering of the silver market by the Hunt brothers, with a corresponding knock-on effect from silver to gold. Second, the 1983–1984 periods emerges as one of stable relationships, as does the 1999–2001 periods. Explanations for these may involve the explosion in interest rates in the 1980s which corresponded to a rising market in these precious metals. In the 1999–2001 period the Washington Central Bank gold agreement catapulted the price of gold. Other factors in this time period include the beginning of the bear market in equities and terrorist activities in the USA.

It is interesting to note that Ciner (2001) examined (albeit on the Tokyo market) a period from January 1992 to December 1998. From local plots one can see that this was a period when, with rare exceptions, one observes non-rejection of the null of no cointegration. Thus his finding of non-cointegration is mirrored over this period. In the overall context however this period is unexceptional – at some time periods one will find cointegration, at others not. This may indicate that the results of Ciner (2001) are driven by the period under analysis.

Figure 5 shows a rolling 52-week correlation coefficients for both the cash and futures series. There is no case where the correlation coefficients are negative. Over the total period the correlation coefficients are 0.64 and 0.62 for cash and futures: the figures for average quarterly, semi annual and annual rolling correlations are 0.58/0.67, 0.59/0.67 and 0.58/0.67 respectively.

V. Conclusions

Overall the findings indicate that in the long run the stable relationship historically observed between
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gold and silver has been maintained. This relationship is, in general, strong and convincing. However, there are significant periods when it is weakened or broken. The use of dynamic cointegration methods allows for greater disaggregating of the temporal relationship. The evidence indicates that the long term for the relationship appears to lie in a horizon greater than one year. For portfolio managers and investors the overall message is that while gold and silver, in general, offer little advantages when together in a portfolio due to their close relationship; this relationship is neither stable nor constant however and thus there may be potential at certain times to include both. In particular, as many funds, etc. are rebalanced annually, if not more frequently, and as can be seen that in most one year samples there is not a stable relationship, the case for the inclusion of both gold and silver in portfolios may still be defensible.

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