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Quantile behaviour of cointegration between silver and gold prices

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This paper investigates the quantile behaviour of cointegration between silver and gold prices by employing the quantile autoregressive distributed lag (QARDL) model. Our empirical results suggest that the existence of cointegration is mainly due to the tail quantiles outside the interquartile range, revealing quantile-dependent (time-varying) cointegrating coefficients which may result in the absence of cointegration in traditional analysis. The silver price changes are more susceptible to the contemporaneous change of gold than the adjustment from ECM at tail quantiles. In addition, the tail-quantile cointegration also appears to change along with the market states of gold.

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1. Introduction

Economists have shown considerable interest in the movement of commodity prices, with particular attention to investigating whether the prices of silver and gold move in unison, i.e., are cointegrated, because they are the most widely traded in commodity trading centres, priced in U.S. dollars and are considered a safe hedge during the depreciation of the U.S. dollar (see Capie et al., 2005; Tully and Lucey, 2007; Joy, 2011, to name just a few). The existence of a cointegration relationship between the prices of gold and silver is subject to a great of controversy. Escribano and Granger (1998) and Lucey and Tully (2006) document evidence that cointegration exists in the prices of gold and silver (Pierdzioch et al., 2015b), but the strength of this relationship changes over time, and, more seriously, the link may break down. Escribano and Granger (1998) and Baur and Tran (2014) further argue that periods of economic bubbles and financial crises have a major effect on the time-varying cointegration relationship. In this regard, one is tempted to ask whether the prices of silver and gold move together only during bubble-like periods and whether the strength of their cointegration relationship is susceptible to events when the price gets close to its record levels over the last several years. One feasible approach is to use the quantile-based technique as in Reboredo and Uddin (2016). As pointed out by Pierdzioch et al. (2015a, 2016), the quantile-based approach has an outstanding performance in forecasting the gold returns as its ability to account for model

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uncertainty and model instability. Ciner et al. (2013) also show that the dependencies between the gold and other assets change along with the different quantiles. Motivated by these literature, this paper attempts to answer these questions above by employing a novel quantile cointegrating approach developed by Cho et al. (2015).

Compared to the conventional cointegration analysis, this approach outperforms in the following aspects: First, the normality assumption is relaxed for silver and gold prices, resulting in a robust and convincing conclusion. The neglect of non-normality may lead to the failure of rejecting the null hypothesis of non-cointegration, as shown in Pierdzioch et al. (2015b). Second, the cointegration relationship between the prices of gold and silver is explored for the whole distribution rather than the single measure of conditional central tendency. Evidence from the quantile cointegrating approach documents that the conventional cointegration analysis focusing on the mean behaviour may not be sufficiently informative, as presented by Lee and Zeng (2011), Burdekin and Siklos (2012), and Tsong and Lee, 2013. Third, the quantile cointegrating approach, as noted by Xiao (2009), is able to address the troublesome issue of the time-varying cointegrating coefficients–coefficients that characterize the long-run relationship between the prices of gold and silver may vary over time. In other words, the value of quantile cointegrating coefficients reflects shocks to the prices received in each period, while those of the conventional cointegration analysis may result in the absence of cointegration for variables that seem to be cointegrated. Fourth, quantile cointegration analysis, in the application of portfolio management, may lead to more effective hedging methodologies than traditional correlation analysis-based approaches in the long run. Bassett et al. (2004) show that the optimisation problem can be formulated as a quantile regression of cointegrated time series when portfolios are allocated using the conditional value at risk (CVaR) (Rockafellar and Uryasev, 2000).

Our paper, following the aforementioned advantages, contributes to the current literature on the cointegration relationship between the prices of gold and silver along two axes.

First, we analyse the quantile-dependent behaviour of the cointegration relationship between the prices of gold and silver. This provides us a direct way to examine whether the cointegration shows distinct strength when the prices of gold and silver are at different levels. Thus, we have the ability to analyze the long-run relationship in different investment environments, such as bubble-like periods and financial crises, without a dummy variable. Our empirical findings suggest that the prices of gold and silver are cointegrated in tail quantiles but become separated in the middle quantiles, that is, cointegration is evident when silver at a relatively low price level (lower quantiles) or relatively high price level (upper quantiles). This is consistent with the results reported in earlier literature that the cointegration may change over time. One explanation of these empirical findings is the existence of the arbitrage and hedge trade in the gold and silver market when the price of silver is at an abnormal level. In addition, we conclude that the price changes of silver, at any price level, appear to be more strongly driven by the contemporaneous change of the price of gold than by an adjustment of derivation from long-run equilibrium.

Second, we argue and provide evidence that the market states of gold may also affect the detected tail-quantile cointegrations between silver and gold prices, wherein the market states are specified by comparing the current gold price with its historical prices. In particular, the cointegrating coefficients become smaller in the high-price gold market, which indicates a new long-run equilibrium. However, in the case of low-price gold market, a lager cointegrating coefficient can be detected only when silver is also at a relatively low price level (for example, 0.05 quantile). As applied in quantitative finance, the cointegrtion forms the basis of the “pairs trading strategy”, therefore, the investment decisions about the gold and silver should be considered carefully, taking the changes of cointegration into consideration.

The paper is organised as follows: Section 2 provides a brief introduction to the methodological approaches. Section 3 describes the data and discusses estimation results. Section 4 concludes the paper.

2. Methodological issues

To explore the cointegration relationship between the prices of gold and silver across quantiles, a plausible approach is to use the QARDL models. Our study performs the following steps: First, we test the stationarity of variables and determine their orders of integration. Second, Johansen’s linear cointegration test is applied to examine the existence of cointegration. Third, we further investigate the quantile long-run equilibrium relationship between the two variables by using the QARDL model, and then use the Wald test to examine the significance and constancy of cointegrating coefficients over different ranges of quantiles. Finally, we examine whether the cointegration exhibits a different behaviour when extending the basic model specification to specially account for the threshold effect of record prices.

Assume that $\boldsymbol{X}_t = (x_{1,t}, \ldots, x_{k,t})'$ is a $k \times 1$ vector of integrated regressors with one order, but the k variables are not cointegrated among themselves, and then the QARDL model is

$$Y_t = \alpha(\tau) + \sum_{j=1}^{p} \phi_j(\tau) Y_{t-j} + \sum_{j=0}^{q} \boldsymbol{\theta}_j(\tau)' \boldsymbol{X}_{t-j} + U_t(\tau), \quad (1)$$

where $U_t(\tau)$ is defined as $Y_t - Q_{Y_t}(\tau|F_{t-1})$, where $Q_{Y_t}(\tau|F_{t-1})$ is the τth quantile of Y_t conditional on the smallest σ-field F_{t-1} generated by $\{\boldsymbol{X}_t', Y_{t-1}, \boldsymbol{X}_{t-1}', \ldots\}$. Let $\boldsymbol{W}_t = \Delta \boldsymbol{X}_t$, $\gamma(\tau) = \sum_{j=0}^{q} \boldsymbol{\theta}_j(\tau)$

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