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Time-varying co-movement of the prices of three metals and oil: Evidence from recursive cointegration

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ABSTRACT

The aim of this paper is to study the continuous and time-varing long-run relationships among three metals' prices, oil price, and the US dollar exchange rate. The recursive cointegration is applied to trace the dynamic linkages. The empirical evidence is follows. First, the results of the recursive trace statistics display one significant and strong conitegration among the gold price and the other variables over much of the period after 1995, and that the European sovereign debt crisis caused a closer linkage from 2010 to 2012. Second, rising gold prices increase silver and copper prices in the long run and are also a long-run leading indicator of silver and copper prices, but their function as a leading signal becomes unstable and weaker after the 2008–2009 global financial crisis. Finally, the long-run relationship between oil and gold prices is an inverse interaction before 2003, but then turns uncertain after 2003, and there is no long-run causality between the two prices.

1. Introduction

Investors, traders, policy-makers, and producers have been heavily interested in the metals markets in recent decades. There are many reasons, other than changes in supply and economic use, to cause price fluctuations in these markets. One reason is more diversified uses of metals in industries, such as jewelry, photography, medical field, and automobiles, which affect price fluctuations in their markets. Another reason is that new financial innovations, for example, futures, options, and ETFs (exchange-traded funds), can change metal prices. Moreover, price fluctuations of metal markets are usually affected by speculative trades, particularly as greater speculative activities in emerging countries have recently brought more risks into these markets.

Among the major metal markets of gold, silver, and copper, increasing gold prices often cause relative adjustments in other metal prices. Gold and silver are extensively applied to produce jewelry and are also traded for investment, with the characteristic of silver being higher commodity-driven than gold, because its monetary function has gradually decreased. Some empirical works show that gold and industrial metals, such as copper, react differently to economic shocks (Erb and Harvey, 2006; Roache and Rossi, 2010; Elder et al., 2012). Do industrial copper prices show a positive or negative interaction with gold? This paper looks to find the answer to this questions.

The relationships among gold, silver, and copper have also been accompanied by a seemingly similar and associated linkage with the oil market. Oil and these metals are priced in US dollars and are included in the commodity portfolios of investors. The relationships between oil and these metals are caused by investors using them for hedging, as well as when investors adjust their investments from dollar-denominated financial assets, such as stocks, to dollar-denominated physical assets, like oil and these metals. Rising oil prices also impact the production costs of these metals. Hence, what is the association between oil and metal prices, especially gold? Moreover, the US dollar exchange rate could co-drive both oil and these metal prices, because they are dollar-denominated. Economic theory successfully demonstrates the linkages of these commodity and exchange rate markets. Higher oil prices cause inflation and exchange rate shocks, and thus investors increase their holdings of metal commodities to hedge the risks of inflation and currency fluctuations. Many studies have investigated the co-movement of oil and different metal commodity prices, including Pindyck and Rotemberg (1990), Wahab et al. (1994), Escribano and Granger (1998), Ciner (2001), Sari et al. (2010), Narayan et al. (2010), Chang et al. (2013), Erb and Harvey (2006), Roache and Rossi (2010), Elder et al. (2012), Bouri et al. (2017), etc.

The abovementioned papers examine the co-movement by way of a static concept; in other words, their empirical works are executed based on the assumption of stability in long run relationships. However, since there is a common phenomenon that structural breaks often exist in

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economic and financial markets, this assumption is not reasonable. In its place, it is more reasonable to consider time-varying and periodic linkages between these commodity markets. Narayan et al. (2010) apply a structural break cointegration test of Gregory and Hansen (1996) to confirm a structural break cointegration between the two markets. Kumar (2017) and Kanjilal and Ghosh (2017) also find evidence of a non-linear relationship between oil and gold prices. Kumar (2017) emphasizes the importance of asymmetric co-movement between the two variable by employing the non-linear ARDL tests. Kanjilal and Ghosh (2017) employs the threshold cointegration to find a non-linear relationship between gold and oil prices.

Allowing for instability or structural breaks between oil and metal prices, Narayan et al. (2010), Kumar (2017), and Kanjilal and Ghosh (2017) estimate their long-run relationships, but they still do not consider the time-varying process of convergence between these markets, which could be slow and continuing. To fill this gap in the literature, our empirical model examines the dynamic linkages of the prices of three metals and oil from a new angle. The aim of this paper is to investigate the recursive cointegration among three metal prices (gold, silver, and copper), oil prices, and the US dollar exchange rate. Comparing with the related literature, we present the contributions of this paper below.

First, different from the relative literature, our goal is to track the dynamic and ongoing price linkages of these three metals and oil in the long run and to show the regime-shifting impacts of critical policy changes, economic shocks, and financial crises on these linkages. We apply a two-step examining process to investigate the effects of the time-varying behavior of these linkages. The first part studies the structural-breaking associations of the variables by using the Gregory and Hansen (1996) tests, which can confirm whether there is a structural-breaking cointegration of these variables, and further finds the structural breakpoint of cointegration. For the second part, we conduct recursive cointegration to examine the continuously dynamic process of the cointegrating vectors and parameters of all variables; the results are able to catch the whole structural-breaking trace of short- and long-run relationships of these variables over the full sample period. Based on the results of recursive analysis, we discuss whether the integration among these markets is closer after some economic shocks or financial crises.

Second, the empirical model of this paper specifically includes copper, an important industrial metal, to study the relationship between precious and industrial metals. Unexpected economic growth might decrease gold and silver prices for portfolio rebalancing, while at the same time bringing about higher industrial metal prices due to greater industrial demand. On the other hand, the investment demand for oil and other commodities has greatly increased, because of the development of electronic trading of oil and ETFs in the commodity markets after 2006, and has caused the role of copper, aside from being a pure raw material, to take on a variety of investment options and portfolio diversification strategies. What are the relationships of the precious and industrial metals' prices under this background? Do industrial copper metal prices show a positive or negative linkage with gold prices after the trading role of copper changed? With limited literature analysis on these linkage, this paper thus tries to find the answers to these questions, which will be valuable and useful for investors and policy-makers.

The remainder of the paper is as follows. Section 2 presents the relative literature. Section 3 offers methodology. Section 4 gives the empirical results. Section 5 concludes.

2. Literature review

Many papers in the literature have investigated the efficiency hypothesis of commodity markets, with some empirical studies focusing on this issue for industrial metal markets and precious metal markets (Neal, 1989; Beckers, 1984; Wang et al., 2011, etc.). Many relative studies of metal markets look at the volatility-spillover of metal markets, focusing on modeling volatility properties of precious metals, because forecasting volatility is a key factor of asset valuations, hedging, and risk management (McKenzie et al., 2001; Tully and Lucey, 2007; Hammoudeh and Yuan, 2008; Hammoudeh et al., 2010, 2011; Batten et al., 2010, etc.).

Some other studies in literature focus on the linkages between metal prices and macroeconomic variables. Many studies have indicated that commodity prices, including metal prices, may be a leading sign of current economic variables since these prices will automatically adjust, being based on continuous auction markets with efficient information (Garner, 1989; Marquis and Cunningham, 1990; Sephton, 1991; Awokuse and Yang, 2003; Hamori, 2007). More recent empirical works support that commodity prices are good indicator variables for macroeconomic variables (De Gregorio et al., 2007; Herrera and Pesavento, 2009; Verheyen, 2010, etc.). Moreover, many papers focus on the linkages between metal prices and inflation or global liquidities (Worthington and Pahlavani, 2007; Belke et al., 2013, etc.).

One important line of empirical works examines the degree of long-run co-movements between oil and metal prices. Phillips and Ouliaris (1990) are the pioneers on the work of excess co-movement in precious metal prices, and their empirical results show that the excess co-movements of seven major commodities prices are unrelated. Excess co-movement is caused by herding behavior, and while many further studies examine the co-movement of different commodities, most of them focus on the gold and silver markets. The empirical results of Basu and Clouse (1993) confirm significant correlations between the gold spot market price and other market variables, such as equities, bonds, and currencies. Some research studies use cointegration techniques to examine the relationship between metal prices and macroeconomic variables. Wahab et al. (1994) apply the cointegration test and confirm that cointegration exists between gold and silver in both the cash and future markets. Conversely, some other papers display different evidence, such as the results of Escribano and Granger (1998) who find that gold and silver markets are separate after 1990. Ciner (2001) also confirms that the long-run relationship between gold and silver markets is not integrated in the 1990s, because the two markets have different economic usages.

Another important line of empirical works has discussed the impact of oil prices on metal prices. Sari et al. (2010) study the linkages among the prices of four precious metals, oil, and the US dollar exchange rate, and their empirical results support a weak relationship for these variables in the long run, but strong feedbacks in the short run. They also find that there is a temporary and significant impact from an exchange rate shock to precious metal prices. From the viewpoint of price discovery finding out the common effective information between crude oil and gold markets, Zhang and Wei (2010) demonstrate the existence of a cointegrating relationship between the two markets, and that the oil price has a larger contribution according to the common effective price. They also employ the non-linear Granger causality of Baek and Brock (1992) and Hiemstra and Jones (1994), but the results reject non-linear causality and instead confirm linearly unidirectional causality from oil price to gold price. Jain and Ghosh (2013) also support the existence of a cointegration among oil price, precious metal prices, and the Indian Rupee–US Dollar exchange rate. Conversely, the empirical results of Chang et al. (2013) find that the oil price, gold price, and exchange rate are significantly independent of each other.

Expect for the above literature in light of the precious metals, some other research studies have studied the relationship between precious and industrial metals. Erb and Harvey (2006) indicate that economic shocks could cause different reactions among precious and industrial metal prices, because unexpected economic growth might decrease gold and silver prices for rebalancing portfolio actions, while at the same time bringing about increasing industrial metal prices due to higher industrial demand. Roache and Rossi (2010) show a similar result in which an unanticipated economic expansion causes a falling effect on