A DYNAMIC ANALYSIS OF CAUSALITY BETWEEN PRICES ON THE METALS MARKET

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Abstract
The aim of the paper is to analyse causality between the prices of four different metals: gold, silver, platinum and copper. The analysis conducted in this paper is a dynamic one, and the data used consist of monthly prices of futures contracts traded from the period January 2000 – January 2012. The assessment of causality was carried out with the use of rolling regression applied to VAR models, which allowed for the assessment of the stability of relations between metal prices. The results obtained indicate that causality changed in the period analysed. Initially the price of copper was the Granger cause of the prices of the remaining metals, while in the later period the price of platinum became the Granger cause of the prices of the remaining metals. Past prices of gold and silver did not improve the forecasts of prices of other metals.

Keywords: *Granger causality, rolling regression, Toda -Yamamoto tests, metals market*

JEL Classification: C32, G15, O13, Q37
AMS Classification: 91B84, 62M10

1 INTRODUCTION

Gold, platinum and silver are the most popular precious metals. For centuries they have been primarily used to make jewellery, whereas nowadays they also play an important part in various industries, for example, gold is used in electronics, telecommunication and aviation, silver is used in the electronic and electrical industries (mobile phones, computer hardware), and, to a smaller extent, in photography, while platinum is mostly used in the chemical and petrochemical industries as a catalyst and in the motor industry for building catalytic converters, as well as in the electronic and electrical industries. Copper, obtained together with silver, is used in the electronic and electrical industries (wires), as well as the building, machine, and telecommunication industries. In recent years these metals have become an important means of the saurisation, and are now frequently used as an investment through, for instance, the purchase of gold bars or the purchase of Exchange traded funds. Such funds allow for the investment in metals without the need of their actual possessing. (For example, in January 2005 The iShares Gold Trust and in April 2006 The iShares Silver Trust were created).
World gold, silver and copper prices are listed on several stock exchanges, the most important of them being the Commodity Exchange in New York (COMEX) and London Metal Exchange (LME). The largest exchanges of actual trade and trade in futures of platinum are the New York Mercantile Exchange (NYMEX) and London Platinum&Palladium Market.
The vital role of metals on financial markets and in various industries has found its reflection in science. Ciner [2] examined long-term trends between the prices of gold and silver futures contracts traded in the 1990s and concluded that there was no relationship between gold and silver prices. Lucey and Tully [8] confirmed that in the 1990s there was no relationship between gold and silver prices, but found such a relationship in the period 1987-2002. The differences between those two periods may result from the changing nature of the demand patterns for gold versus silver. Sari et al. [10] noticed a strong relationship between gold and silver, while the highly cyclical copper appeared to be nearly independent of the movements in the prices of oil, gold and silver. Hammoudeh and Yuan [6] analysed the relations between oil prices as a determinant, two precious metals (gold and silver) and one base metal (copper) in the USA

based on the daily data from the period January 2, 1990 – May 1, 2006. They concluded that gold and silver had similar volatility persistence globally, but there was no leverage effect in gold and silver prices. Soytas et al. [12], analysing the period between May 2, 2003 and March 1, 2007 found out that the world oil prices had no predictive power of other precious metal prices, the interest rate nor the exchange rate market in Turkey. Sari et al. [11] examined the co-movements and information transmission among the spot prices of four precious metals (gold, silver, platinum, and palladium), the oil price, and the US dollar/euro exchange rate. They found evidence of a weak long-term equilibrium relationship but strong feedback in the short run. Papież and Śmiech [9] conducted research connected with relations between the prices of the most important primary fuels on the European market from October 2001 till May 2011, and their analysis indicated a long-term equilibrium between those prices.
The aim of the paper is to analyse causality between the prices of metals in the period 2000-2011. The analysis is dynamic and based on monthly data. The evaluation of causality will be carried out with the use of rolling regression which allows for the assessment of the stability of the relations between metal prices. The following hypotheses will be verified: causal relations between metal prices are not stable and undergo constant changes; gold, nowadays mostly used as security on the financial markets, is a financial instrument which has no influence on the prices of other metals; the situation on the platinum and copper markets, i.e. metals commonly used in industry, influences the prices of other metals.

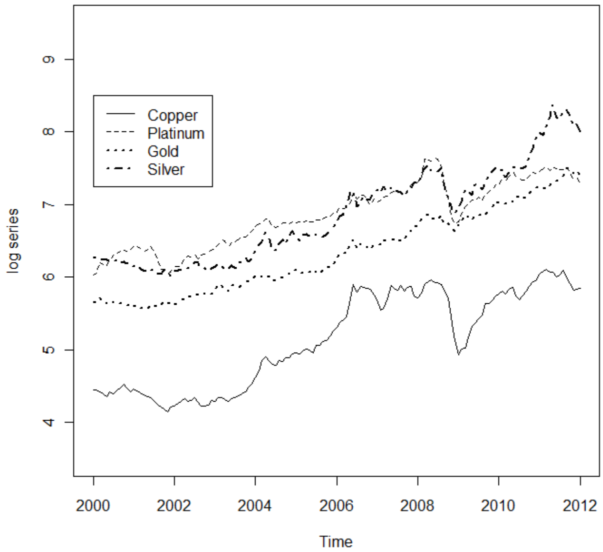
2 METHODOLOGY

In order to test causality in unrestricted VAR models we conducted Toda and Yamamoto [13] and Dolado and Lutkepohl [4] procedures, which involved a modified Wald test and did not require pretesting for cointegration properties of the system. The idea of the preposition is to artificially augment the true lag length (say, p determined by information criterion) of a VAR model by maximal order of integration of the processes (d). The next step requires the estimation of VAR with ($p+d$) order, ignoring the coefficients of the last d lagged vector, and testing the restrictions on the first k coefficient matrices by a standard Wald test.
Granger [5] pointed out that the most important problem facing researches today is the structural instability. A common technique to assess the constants of model parameters and the stability of variable relations is to compute parameter estimates over a rolling window containing a fixed sample size [1]. The number of observations must by fixed to compromise between two conflicts: the degree of freedom of estimation results requires a large sample size, while the potential structural change of model requires a small sample size. The analysis and recommendations can be found in Zapata and Rambaldi [14]. We applied the fixed window rolling regression to the level VAR model. This means that we ran a series of regressions with a fixed sample size (a fixed window size). Every time the number of lags in VAR models was determined by AIC. Then, the parameters of VAR(p+d) models were estimated, and, finally, the modified Wald statistics was used to test the Granger causality.

3 EMPIRICAL RESULTS

The data used in this study consisted of monthly prices of gold, platinum, silver and copper futures contracts traded on the COMEX and the NYMEX. The analysis of causalities were conducted using the monthly time series data from the period January 1, 2000 – January 1, 2012, which yielded 145 observations. The data were taken from the stooq.pl basis. Taking into consideration the increase of variance over time, price series were logarithmed, and the results are presented in Figure 1.

Figure 1 Logarithms of prices of copper, platinum, gold and silver in the period January 2000 – January 2012.



The prices of all metals increased in the period analysed, which indicated that drifts or deterministic trends should be taken into consideration within unit root tests. Using the augmented Dickey–Fuller (ADF) method [3] and KPSS test for stationarity [7], it was verified that all metal prices were first-difference stationary I(1) (Table 1). The number of lags in the test was established using AIC criterion.

Table 1 ADF and KPSS tests of unit roots in monthly data (January 2000 – January 2012)

Variables	ADF tests in level data		ADF tests in first-differenced data		KPSS tests in level data		KPSS tests in first-differenced data	
	C	C +T	C	C +T	C	C +T	C	C +T
LCopper	-1.08 (1)	-2.488 (1)	-7.564 (0)	-7.537 (0)	6.263 (1)	0.584 (1)	0.103 (1)	0.103 (1)
LGold	1.64 (2)	-2.837 (0)	-9.684 (1)	-10.07 (1)	7.134 (1)	0.972 (1)	0.283 (1)	0.030 (1)
LPlatinum	-1.61 (1)	-3.384 (1)	-7.864 (0)	-7.852 (0)	6.466 (1)	0.341 (1)	0.068 (1)	0.038 (1)
LSilver	0.49 (0)	-3.124 (4)	-8.988 (1)	-9.126(1)	6.622 (1)	0.566(1)	0.189 (1)	0.046 (1)

Notes: C- constant; C+T - Constant and trend. The 95% critical values are −2.86 for ADF with constant and -3.41 for ADF with a constant and trend. The asymptotic critical values for 5% is 0.463 and for 1% is 0.739 for KPSS with constant and for 5% is 0.146 and for 1% is 0.216 for KPSS with a constant and trend.

Conducting the analysis within the rolling regression requires obtaining the window size. In the analysis we used monthly observations from a 5-year period, which means that each window consisted of 60 observations (we followed the recommendations of [14]). The number of lags in VAR models is presented in Figure 2. The horizontal axis indicates a starting point of window (of analysis). The first value represents the number of lags for the model estimated for the period from January 2000 to January 2005. The last one represents the number of lags in VAR estimated for the window January 2007 – January 2012. The most frequent fixed number of lags in the model was 3 or 4.

Figure 2 Number of lags in VAR models for the consecutive windows of the analysis

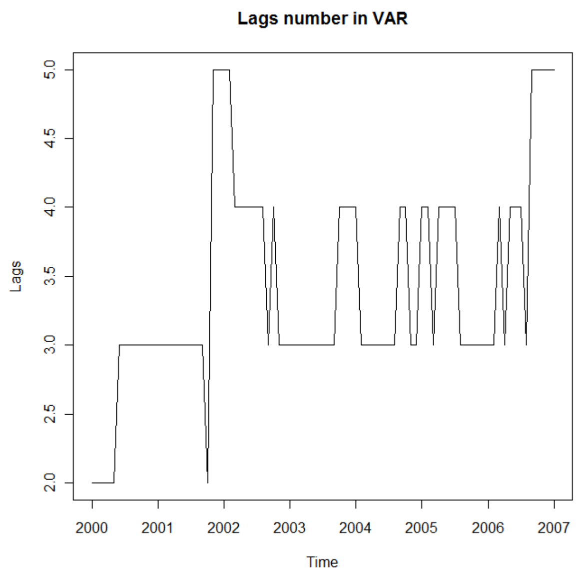
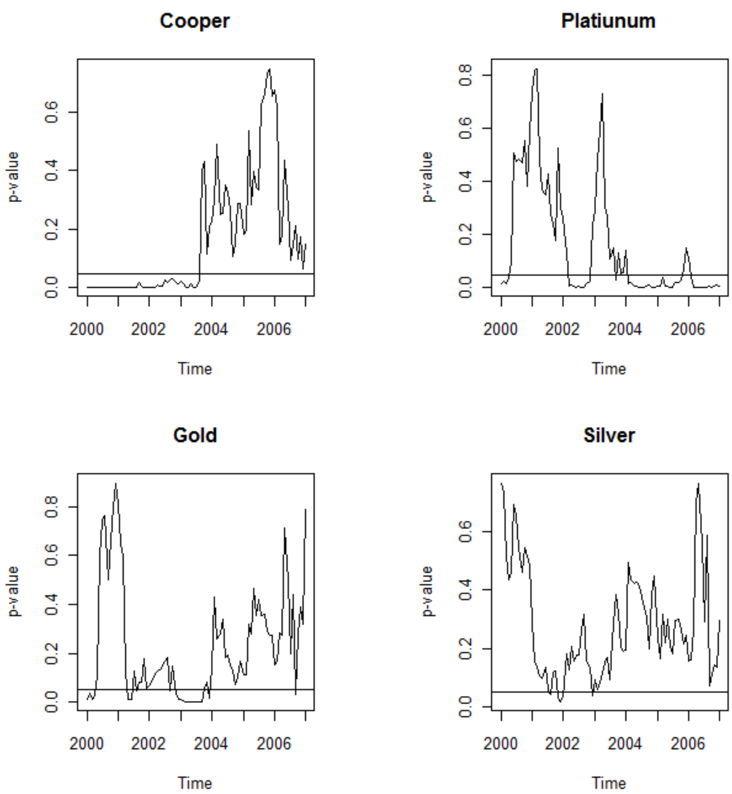


Figure 3 presents p-value for Granger causality tests. The horizontal line in the chart indicates the significance level of 5%. The values of p-value below this line mean that in a given window the price of the analysed metal is the Granger cause for the vector of the remaining metal prices. The values of p-value above this line mean that with such a significance level there are no justifications for rejecting the hypothesis of the lack of causality between prices of a given metal and the vector of the remaining prices. The results presented in Figure 3 indicate that causal relations between the elements of the system were not stable in time.

The results of the analysis indicate that the price of copper was the Granger cause of the prices of other metals from the beginning of the period analysed till the end of 2008. In the later period past information regarding the price of copper did not improve the forecasts of others metals prices. A different situation could be observed in case of the platinum prices. In the initial period (with the exception of several first windows) p-value significantly exceeded the 5% significance level, which means that in this period the platinum price was not the Granger cause of other metals prices. In the models obtained from 2004 onward the price of platinum was the Granger cause of prices of the remaining metals. Thus, the forecast of the prices of copper, gold and silver were improved by the values of the platinum price. In the majority of periods analysed, past gold prices did not improve forecasts of the remaining metals with the exception of the windows beginning in 2003 (the period analysed 2003 - 2008). The results of the Granger causality test showed that in the period 2000-2011 the price of silver was not the Granger cause of the prices of other metals.

Figure 3 The value of p-value of Wald test. Null hypothesis states the lack of Granger causality.



4. CONCLUSION

The analysis conduced indicated significant structural changes on the international metals markets. The role of particular variables in the analysed system changed with time. The results obtained justified using a dynamic approach, such as rolling regression.

The results of causality tests revealed that metals playing an important role in the industry (i.e. platinum and copper) are more useful in forecasting than other metals. During the initial period, copper carried a forecasting force, and later this function was taken over by platinum. Silver and gold were not the Granger causes of other metals within the model used. It is worth noticing that the results obtained are characteristic for monthly metal prices, and the more frequent data may display different characteristics.

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