Resources Policy 36 (2011) 339–345

Contents lists available at SciVerse ScienceDirect

Resources Policy

journal homepage: www.elsevier.com/locate/resourpol

Testing the international linkage in the platinum-group metal futures markets

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ARTICLE INFO

Article history:
Received 16 December 2010
Received in revised form
10 September 2011
Accepted 10 September 2011
Available online 1 November 2011

JEL classifications:
C32
F36
G14
L61

Keywords:
Causality test
Cointegration
Law of one price
PGM futures market

ABSTRACT

This study tests whether an international market exists in the platinum-group metal (PGM) futures markets. For this purpose, we tested the law of one price (LOP) and the causality between the U.S. and Japanese platinum and palladium futures markets. We also performed the test when structural breaks are considered. Long-run price relationships were found in both platinum and palladium markets but the LOP only sustained in the palladium market. The causality test revealed that it is the U.S. market that leads the price to transmit information between the U.S. and Japanese markets. Structural breaks had large impacts on the test results, suggesting that incorporating breaks is important when investigating the international price linkage in the PGM futures markets.

Introduction

As vehicle emission standards become stringent worldwide, we see an increase in the demand for the platinum group metals (PGMs) from the auto industry. More than half of the platinum and palladium supplied internationally in 2008 was used for the catalytic converters (Johnson Matthey Plc, 2009). Unless technological improvements occur in the catalytic converter production and substitutive materials for platinum and palladium become available, demand for these PGMs will continue to rise in countries that have higher emission standards. If the differences in vehicle emission standards affect the demand structures of regional PGM markets the prices of PGMs may differ by their market locations. Hence, whether an international PGM market exists and how regional PGM markets are linked are becoming important issues for the participants in the PGM markets to obtain valuable price information.

In theory, as stated by the law of one price (LOP), identical goods must have a single price (Lamont and Thaler, 2003) and if the world PGM market follows this law the regional PGM markets should be integrated as one market. Because PGMs are easier to standardize and store compared to other commodities it is likely that the price difference is small among regional PGM markets and that a world market exists for the PGMs. However, if transaction costs and trade barriers are high among the regional markets, these markets will not be integrated. Asplund and Friberg (2001) state that violation of the LOP occurs when demand and costs are different across locations and there are price rigidities and fluctuations in exchange rates. Therefore, if the demand structures are different among the regional PGM markets the LOP condition will be violated and there will not be a world market for this commodity.

Identifying whether the LOP holds for the world PGM market will be valuable not only for the suppliers and consumers of PGMs but also for arbitrageurs and speculators trading the PGMs as financial asset. If the LOP holds among the regional PGM markets it will mean that in the long-run the regional PGM prices become the same and price information of the other markets will be useful even when the markets are far apart or traded at different time zones.

Although there are several studies testing the LOP for different commodities such as wheat (Goodwin, 1992), soybean meal (Yang et al., 2000), fish (Asche et al., 1999, 2004), lumber

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doi:10.1016/j.resourpol.2011.09.003

(Nanang, 2000), natural gas (Walls, 1994), and cars (Goldberg and Verboven, 2005), not many studies have tested this condition for the platinum and palladium markets. Previous studies testing the market linkage among different locations for the precious metal futures markets focus on the price relationship between the spot and futures prices (Chow, 2001) or on the difference in volatility (Xu and Fung, 2005). For study on the information flow between the U.S. and Japanese precious metal futures markets, Xu and Fung (2005) find that it is the U.S. market that plays the leading role in cross-border information transmission. A study testing the price linkage for the U.S. and Japanese gold and silver futures markets (Aruga and Managi, 2011) also reveals that information flow between the futures markets of the two countries are led by the U.S. market. Hence it could be that the information flow for the PGM futures markets of the two countries is also led by the U.S. market.

The objective of this study is to provide some empirical evidence on whether an international market exists for the PGM markets by testing the LOP and the causality of price information flow between the U.S. and Japanese PGM futures markets. For this purpose, we use the platinum and palladium futures markets of the New York Mercantile Exchange (NYMEX) and the Tokyo Commodity Exchange (TOCOM), which are the world's two largest futures markets for PGMs. The LOP test will identify if the U.S. and Japanese PGM futures markets can be integrated as one market. In the causality test we will find the direction of information flow between the PGM futures markets of the two countries. This will allow us to see whether the U.S. and Japanese PGM futures markets are dependent.

We will also test the LOP and causalities among the price series when structural breaks are considered because recently several studies suggest that the price linkage can be affected by structural breaks and that price relationships among the price series can become different before and after the break periods (Beyer et al., 2009; Aruga, 2011; Aruga and Managi, 2011). Although many other related studies incorporate structural breaks in the cointegration methods (Hansen and Seo, 2002; Park et al., 2007) we use the general cointegration method for testing the price linkage because we are more interested in identifying effects of structural breaks on the price linkage rather than testing the overall price linkage by including the breaks in the test model. This way of testing the price linkage for periods before and after the breaks allows us to see in detail how the breaks in the series affected the price linkage. If we use special treatments to incorporate the breaks for testing the price linkage in the cointegration model we will not be able to examine the changes in the price linkage before and after the break periods.

There are still relatively a few studies focusing in the effects of structural breaks on the price linkage but Aruga and Managi (2011) have shown that the price linkage between the U.S. and Japanese gold and silver futures markets was influenced by the structural breaks in the price series. It is likely that if such structural breaks do exist in the PGM price series we might find that the price linkage between the U.S. and Japanese PGM markets is also affected from the structural breaks. Testing the effects of breaks on the price linkage is important because we use the 2001–2010 period in our study which includes adverse events such as the global financial crisis of 2008 and it can be that such events have influence on the price linkage for the U.S. and Japanese PGM futures markets.

In the next section, we explain the methods used in this study. In the third section, we illustrate the details of the data. The results of the tests conducted in this study are described in the fourth section. Finally, the last section provides some concluding remarks.

Methods

The LOP and the Johansen cointegration tests

The law of one price is tested using the following equation:

$$\ln P_t^{US} = A + B \ln P_t^{JP} + u_t \tag{1}$$

where P_t^{US} and P_t^{JP} are the prices of the U.S. and Japanese PGMs at time t, A is a constant, B is a coefficient, and u_t is the error term.[1] When transaction costs or transportation costs exist among the U.S. and Japanese markets, A represents these costs. The LOP holds when $B=1$, but the weak version of the LOP also requires $A \neq 0$, while the strong version of the LOP assumes $A=0$ (Asche et al., 1999).[2]

Cointegration is a necessary condition for the LOP to hold between different markets, so the Johansen test (Johansen and Juselius, 1990) is conducted first. When the prices do have a cointegration relationship, the sufficient condition, that $B=1$ holds for Eq. (1), is tested under the Johansen method. Cointegration requires all price series to be integrated of the same order. Therefore, before performing the cointegration tests, all price series are tested for their stationarity. We use the augmented Dickey–Fuller (ADF), Phillips–Perron (PP), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root tests to examine this. The null hypothesis for the ADF and PP tests is that the price series are non-stationarity, while the null for the KPSS test is the stationarity of the series.

It is known that the Johansen method can avoid the problems that occur in the Engle and Ganger method such as the normalization of the test variables and that the normal inference becomes invalid (Asche et al., 2004). Furthermore, the Johansen method can overcome the simultaneity problem such that the test results become different based on the choice of the dependent variable. The Johansen method can avoid this because the Johansen test is carried out in a Vector Auto Regressive (VAR) model.

The VAR model used in the Johansen test has the following form:

$$X_t = \sum_{i=1}^{p} \gamma_i X_{t-i} + \mu + \varepsilon_t \tag{2}$$

where X_t is the $n \times 1$ vector $(x_{1t}, x_{2t}, \ldots, x_{nt})'$ of prices, p is the order of the vector autoregressive process, γ_i is a $n \times n$ matrix of parameters, μ is a constant, and ε_t is a normally distributed n-dimensional white noise process.[3] This can be written in the vector error correction (VEC) form:

$$\Delta X_t = \Pi X_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + \mu + \varepsilon_t \tag{3}$$

where $\Pi = -I + \sum_{i=1}^{p} \Pi_i$, and $\Gamma_i = -\sum_{j=i+1}^{p} \Pi_j$. Whether Eq. (3) shows a cointegration relationship between the U.S. and Japanese PGM futures prices depends on the rank of the Π matrix.[4] The trace and maximum eigenvalue test statistics are used for the cointegration test

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1-\hat{\lambda}_i) \tag{4}$$

[1] The prices of Japanese PGMs are converted into U.S. dollars.

[2] In this study, the weak version of the LOP is tested because there are some arguments that the assumption of the strict version is too strict, which could lead to biased estimation results (Asche et al., 2004).

[3] n is the number of non-stationary variables used in the model.

[4] Other parts of Eq. (3) are stationary because the X variables are integrated of the same order by assumption.