Cointegration and Causality Between the Platinum Market and the Palladium Market

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Despite the fact that platinum and palladium are two out of four major precious metals and become more and more attractive as investment vehicles, there has been little research on these two markets in terms of their times series characteristics. We examine cointegrating and causal relationships between the platinum market and the palladium market. While we identify no cointegration between these two markets, we find that palladium returns and volatilities Granger-cause platinum returns and volatilities. Our findings are expected to provide critical information to financial market participants in terms of portfolio or asset management.

INTRODUCTION

Generally, gold, silver, platinum, and palladium are regarded as four major precious metals. While platinum and palladium are rarer than gold and silver, they are important metals especially for industrial uses. Platinum is used mainly in automotive, jewelry, and chemical industries. Furthermore, it has been a peerless element of emission control systems in automobiles for quite a long time. On the other hand, palladium is comparable to platinum in terms of its uses. Since, however, palladium is cheaper than platinum, it is gradually replacing platinum. In particular, both platinum and palladium have received attention as alternative investment vehicles along with gold and silver since the financial crisis of 2008 due to anxiety about traditional financial markets.

Financial studies on precious metals have been steadily conducted. Broadly, we can classify them into two different categories. The first category of studies investigates the role of precious metals as a safe haven or hedge. These studies typically pay attention to time-varying safe haven or hedging properties of precious metals by examining how they interact with traditional financial markets or inflation. Jaffe (1989) and Chua et al. (1990) argue that adding gold to the portfolio is important in terms of diversification. Ghosh et al. (2004) and Dempster and Artigas (2010) show that gold serves as an inflation hedge. Hillier et al. (2006) identify low correlations between precious metals and stock index returns and explain precious metals as a hedging tool during turbulent stock market periods. Capie et al. (2005) explain gold as an exchange rate hedge by finding that gold and exchange rates are negatively correlated. While Baur and Lucey (2010) show that gold serves as a hedge under normal market conditions and a safe haven under extreme market conditions, Baur and McDermott (2010) put stress on hedge and safe haven properties of gold in major developed markets. Coudert and Raymond (2010) discover that gold plays a role as a safe haven against stock during stock market downturns. Ciner et al. (2013) find that gold serves as a safe haven against exchange rates. Lucey and Li (2015) show that four major precious metals act as a safe haven during

different time periods. The second category of studies focuses on time series characteristics of precious metals such as seasonality, price spillover, return or volatility movements, price determinants, and long-memory property. These studies include Byers and Peel (2001), Cai et al. (2001), Lucey (2010), Morales and Andreosso (2014), Auer (2015), and Batten et al. (2015). Despite the fact that platinum and palladium are valuable metals for industrial uses and they have more spotlights today as investment vehicles, few studies have analyzed fundamental time series relationships between these two markets.

In this paper, we examine cointegrating and causal relationships between the platinum market and the palladium market. While we find that there exists no cointegration between these two markets, we identify a unidirectional causality from palladium returns to platinum returns. We also find strong evidence that palladium volatilities cause platinum volatilities. This means that information reflected on both risk and return tends to be transmitted from the palladium market to the platinum market. We describe data in Section 2 and explain empirical methods and results in Section 3. In Section 4, we conclude.

DATA

We obtain historical platinum and palladium futures prices from Fusion Media (investing.com). Our data consist of the past 5-year daily prices from 2012 to 2016. While we calculate daily returns to investigate the causal relationship between platinum and palladium returns, we calculate monthly volatilities using daily returns in order to test for the causal relationship between platinum and palladium volatilities. Figure 1 and Figure 2 show platinum and palladium prices respectively over the past 5 years and Table 1 describes summary statistics for platinum and palladium prices.

FIGURE 1
PLATINUM PRICES

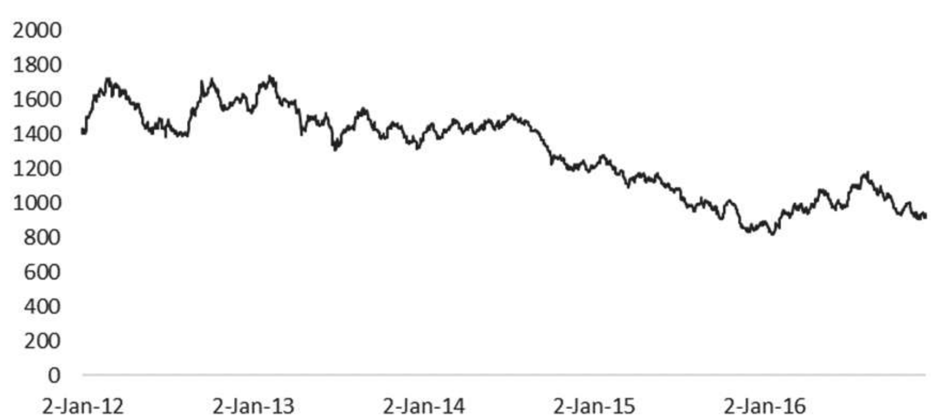

FIGURE 2
PALLADIUM PRICES

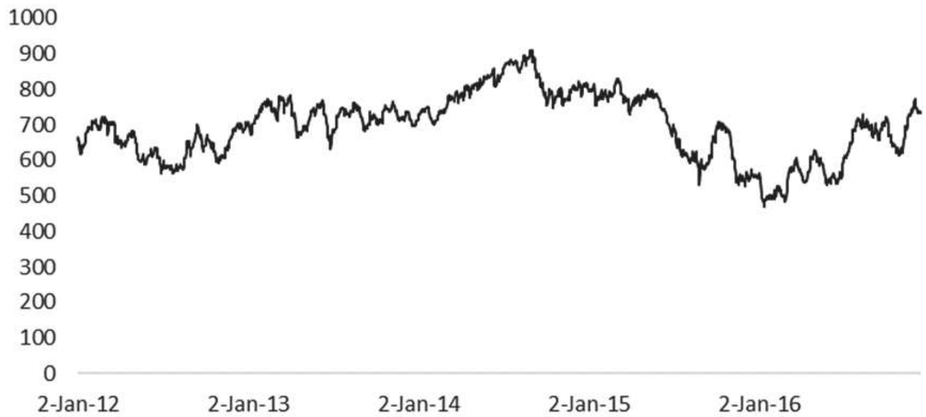

TABLE 1
SUMMARY STATISTICS

	Platinum	Palladium
Average price	1295.96	695.90
Median price	1384.45	703.08
Standard deviation	247.83	91.12
Maximum price	1737.60	909.40
Minimum price	820.00	470.45

METHODS AND EMPIRICAL RESULTS

First of all, we investigate if there exists the cointegrating relationship between platinum and palladium prices. The cointegration explains the long-run equilibrium relationship between two variables. If platinum and palladium prices are cointegrated, it means that they tend to move together over the long run. Since, however, the cointegration test should be conducted with variables that are integrated of order one or I(1), we need to examine if a unit root exists in their prices (levels) and returns (log differences). We use the following regressions with the null hypothesis that ρ is equal to zero.

$$\Delta z_t = b_0 + \rho z_{t-1} + \sum_{i=1}^{n} \beta_i \Delta z_{t-i} + \varepsilon_t \quad (1)$$
$$\Delta z_t = b_0 + \rho z_{t-1} + b_1 t + \sum_{i=1}^{n} \beta_i \Delta z_{t-i} + \varepsilon_t \quad (2)$$

where Equation (1) has no trend and Equation (2) has a trend. If the null hypothesis is not rejected, then a unit root exists in the time series variable, which means that the variable is non-stationary.

TABLE 2
UNIT ROOT TEST RESULTS

Panel A – Augmented Dickey-Fuller for Prices		
	Platinum Prices	Palladium Prices
Constant with no trend	-1.13	-1.74
Constant with trend	-2.71	-1.75
Panel B – Phillips-Perron for Prices		
	Platinum Prices	Palladium Prices
Constant with no trend	-0.68	-2.14
Constant with trend	-3.20*	-2.17
Panel C – Augmented Dickey-Fuller for Log Returns		
	Platinum Returns	Palladium Returns
Constant with no trend	-6.16***	-6.23***
Constant with trend	-6.15***	-6.22***
Panel D – Phillips-Perron for Log Returns		
	Platinum Returns	Palladium Returns
Constant with no trend	-33.55***	-34.90***
Constant with trend	-33.55***	-34.89***

Note: To determine the optimal lag length, we adopt the well-known Akaike Information Criterion (AIC) that has been traditionally and widely used.
*, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

In Table 2, while Panel A and Panel C show results for prices and returns respectively based on the Augmented Dickey-Fuller test, Panel B and Panel D show results for prices and returns respectively based on the Phillips-Perron test. We fail to reject the null hypothesis for prices from Panel A and Panel B. The test statistics are not statistically significant even at the 10% significance level except only for the one in Panel B. Thus, platinum and palladium prices (levels) turn out to have unit roots, which means that they are non-stationary. In Panel C and Panel D, we reject the null hypothesis for returns (log differences) because all test statistics are statistically significant at the 1% significance level. This means that platinum and palladium returns do not have unit roots and both of them are stationary. As a result, both platinum and palladium prices are integrated of order one or I(1).

Since platinum and palladium prices are integrated of order one, we can investigate the cointegrating relationship between platinum and palladium prices. First, we employ the traditional cointegration test proposed by Engle and Granger (1987) using the following linear model.

$$y_t - a_0 - \lambda x_t = \varepsilon_t \tag{3}$$

where λ is a cointegrating coefficient and ε_t is an error term. If residuals obtained from Equation (3) are stationary, then platinum and palladium prices are cointegrated, which means that platinum and palladium prices have a long-run equilibrium. Second, we implement the well-known Johansen test with two different types of its test value.

Table 3 shows cointegration test results based on both traditional and Johansen tests. In Panel A, residuals calculated from Equation (3) are not statistically significant at all based on both Augmented Dickey-Fuller and Phillips-Perron tests. These results show that residuals have a unit root and thus, they are not stationary. In other words, the linear combination of platinum and palladium prices is not a stationary process and thus, platinum and palladium prices are not cointegrated.

TABLE 3
COINTEGRATION RESULTS

Panel A – Traditional Cointegration Test			
		Platinum and Palladium	
Residuals		Augmented Dickey-Fuller	Phillips-Perron
Constant with no trend		-0.63	-0.33
Constant with trend		-3.04	-3.11
Panel B – Johansen Cointegration Test			
N	R	Trace	Maximum Eigenvalue
9 lags	0	8.65	7.63
	1	1.02	1.02
10 lags	0	8.95	8.02
	1	0.93	0.93
11 lags	0	9.15	8.32
	1	0.84	0.84

Note: The lag length is determined based on the Akaike Information Criterion (AIC).
*, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

On the other hand, Panel B shows the Johansen test results. R is the number of co-integrating vectors and N is the number of lags included in the co-integration test. To conduct a robustness check, we repeat the Johansen test with two additional lag lengths (one more and one less) as well as the optimal lag length. The null hypothesis for the trace test is that the number of co-integrating vectors is less than or equal to R and the null hypothesis for the maximum eigenvalue test is that the number of co-integrating vectors is equal to R. As shown in Panel B, we fail to reject the null hypotheses because all trace and maximum eigen values are not statistically significant. Thus, Johansen test results also show that platinum and palladium prices are not cointegrated. Since the Johansen test tends to be sensitive to the lag length, we test with several different lag lengths and obtain the same results. Consequently, both cointegration tests show strong evidence that platinum and palladium prices are not cointegrated.

According to the cointegration theory, it doesn't mean that two variables that are not cointegrated have no causal relationship. On the contrary, two different models are used to test for the causal relationship depending on the presence of cointegration. If two variables are cointegrated, their causal relationship should be investigated with the vector error correction model (VECM) that has an error correction term. In the VECM, short-run deviations from their long-run equilibrium are dynamically adjusted through the error correction term. If, however, two variables are not cointegrated, their causal relationship (Granger causality) is usually examined with the vector autoregressive (VAR) model as follows.

$$\Delta p_t = a + \sum_{i=1}^{n} b_i \Delta p_{t-i} + \sum_{i=1}^{n} c_i \Delta q_{t-i} + \varepsilon_t \quad (4)$$
$$\Delta q_t = a + \sum_{i=1}^{n} b_i \Delta q_{t-i} + \sum_{i=1}^{n} c_i \Delta p_{t-i} + \varepsilon_t \quad (5)$$

where Δp_t and Δq_t are platinum and palladium returns respectively. In Equation (4) and Equation (5), the F-test is employed with the restricted equation that makes c_i equal zero. Then, we calculate the F-value with respect to the null hypothesis that c_i is equal to zero.
In Table 4, while we fail to reject the first null hypothesis even at the 10% significance level, we reject the second null hypothesis at the 5% significance level. This means that palladium returns Granger-cause platinum returns whereas platinum returns do not Granger-cause palladium returns.

TABLE 4
CAUSALITY TEST – PLATINUM AND PALLADIUM RETURNS

Null Hypothesis	F-value
1. Platinum returns do not Granger-cause palladium returns.	1.09
2. Palladium returns do not Granger-cause platinum returns.	2.10^{**}

Note: The lag length is determined based on the AIC.
*, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

In other words, there exists the unidirectional causality from palladium returns to platinum returns. Thus, the dynamic information that affects return movements appears to flow from the palladium market to the platinum market. Since there have been few studies on the relationship between the platinum market and the palladium market, our findings are expected to provide a critical insight to financial market investors who actively manage their portfolios or assets.

Next, we investigate how volatilities from these two markets interact with each other. We calculate annualized volatilities every month using platinum and palladium returns and the following traditional method.

$$\sigma_i = \sqrt{\frac{252}{m-1} \sum_{j=1}^{m} (r_{ij} - \bar{r})^2} \quad (6)$$

where σ_i is the i^{th} month volatility and r_{ij} and $\bar{r}$ are j^{th} day return and average daily return respectively. Using Equation (4) and Equation (5), we conduct the Granger causality test for platinum and palladium volatilities.

In Table 5, the second null hypothesis is statistically significant at the 1% significance level. Thus, it is certain that palladium volatilities Granger-cause platinum volatilities. Although we also reject the first null hypothesis at the 10% significance level, it appears to be a relatively weak evidence. As a result, it seems that there exists the unidirectional causality from palladium volatilities to platinum volatilities rather than the bidirectional causality between their volatilities. This implies that the risk variations of the palladium market tend to be passed to those of the platinum market. Since risk analysis is critical in terms of portfolio or asset management, the causal relationship on the risk transmission between the platinum market and the palladium market is expected to provide an important information to financial market investors.

TABLE 5
CAUSALITY TEST – PLATINUM AND PALLADIUM VOLATILITIES

Null Hypothesis	F-value
1. Platinum volatilities do not Granger-cause palladium volatilities.	1.97*
2. Palladium volatilities do not Granger-cause platinum volatilities.	4.32***

Note: The lag length is determined based on the AIC.
*, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

CONCLUSION

Platinum and palladium are important metals as substitutes for industrial uses. In particular, despite the fact that they have received more attention as investment vehicles since the financial meltdown of 2008, few studies on the relationship between these two markets have been conducted. The purpose of our study is to investigate cointegrating and causal relationships between the platinum market and the palladium market.

First, we conduct the cointegration test based on the Johansen test as well as traditional cointegration test and identify no cointegrating relationship between these two markets. This means that platinum and palladium markets have no long-run equilibrium. Second, using the VAR model, we find that palladium returns Granger-cause platinum returns, which means that information that influences return movements tends to flow from the palladium market to the platinum market. Third, using the same VAR model, we also discover strong evidence that palladium volatilities Granger-cause platinum volatilities. This implies that the risk variations of the palladium market are transmitted to those of the platinum market.

Conclusively speaking, our results show that information on both risk and return tends to be transmitted from the palladium market to the platinum market. Our study provides critical information to financial market participants in terms of portfolio or asset management.

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