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Some facts on the platinum-group elements☆

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ABSTRACT

The platinum-group elements (PGE) include platinum, palladium, rhodium, ruthenium, iridium, and osmium. In this article, we concentrate on the dependency structure and economic determinants of PGE, silver, and gold prices. We find that the strongest relationship is between silver and gold returns at a weekly frequency (July 1992–July 2016), which display tail dependence in bearish and bullish markets. By contrast, palladium and platinum display tail dependence with silver only under bearish markets. When focusing on real prices, at an annual horizon (1930–2014) the first principal component of PGE and silver prices is positively and strongly correlated with PGE/silver world production and US PGE/silver apparent consumption. At a monthly frequency (July 1992–July 2016) in turn, the first principal components of gold, silver, and PGE are positively and strongly associated with US industrial production, South Africa manufacturing production, and the US M1 and M2 monetary aggregates; and, to a lesser extent, inversely correlated with consumer sentiment and a trade-weighted US dollar index. To our knowledge, this is the first comprehensive study on PGE dependency with respect to other precious metals, such as silver and gold, and on PGE-price drivers.

1. Introduction

The platinum-group elements (PGE) include platinum, palladium, rhodium, ruthenium, iridium, and osmium. PGE are among the rarest metals on earth: nowadays, the average grade of PGE in ores mined range from 5 to 15 ppm (ppm). These metals share similar physical and chemical properties and are found together in nature. In particular, high melting points, corrosion resistance, and catalytic qualities make PGE key to many industrial applications. Platinum was described as a new metal in 1750, followed by iridium and osmium in 1803, palladium and rhodium in 1804, and ruthenium in 1807 (Zientek & Loferski, 2014).

In spite that PGE are usually associated with jewelry and investment commodities, their major applications are industrial. Specifically, the leading use of PGE is in catalytic converters: in 2013 the auto-catalyst demand for platinum reached 37% of its total gross demand, whereas 72% and 79% of palladium and rhodium's corresponding total gross demands (Johnson Matthey, http://www.platinum.matthey.com).[1] The chemical industry in turn uses platinum or platinum-rhodium alloys to manufacture raw material for fertilizers, explosives, and nitric acid. In the petrochemical industry, platinum-supported catalysts are utilized to refine crude oil and to produce high-octane gasoline. Meanwhile, in the electronics industry, PGE components enhance storage capacities in computer hard disk drives and are commonly utilized in electronic devices, multilayer ceramic capacitors, and hybridized integrated circuits.[2]

Other uses of PGE include the making of fiberglass and liquid-crystal and flat-panel displays, medical implants, such as pacemakers, and cancer-fighting drugs. Moreover, because of their white coloration, strength, and tarnish resistance, platinum alloys are most suitable for jewelry. In addition, platinum, palladium, and rhodium are used for investment in the form of coins and bars, and as stocks, mutual funds, or exchange-traded funds (Zientek and Loferski op. cit).[3] For instance, in 2013 jewelry and investment represented sizeable shares of the total gross demand for platinum—33% and 9%, respectively, and, to a lesser extent, for palladium—4% and 1% of total gross demand, respectively (Johnson Matthey).

Most PGE produced nowadays come from mineral deposits in Siberia and in southern Africa discovered around 1920. Development of these deposits, however, was not significant until the 1960s, when industrial demand for PGE took off. According to information provided by Johnson Matthey, in 2013 the main producers of platinum were South Africa (72%), Russia (14%), Zimbabwe (7%), and North America (6%). The same countries concentrated the 96% of the palladium production—Russia (40%), South Africa (37%), North America (15%), and Zimbabwe (5%), and the 99% of the rhodium production in

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[1] Net demand is defined by Johnson Matthey as gross demand minus recycling.

[2] In the particular cases of iridium and ruthenium, the demand for chemical, electrical, and electrochemical applications represented 58% and 92% of total gross demand, respectively, in 2013 (Johnson Matthey).

[3] Exchange-traded funds (EFTs) for platinum and palladium were introduced in the United States and Europe in 2007 and 2010, respectively (Loferski, 2013).

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2013—South Africa (80%), Russia (12%), Zimbabwe (5%), and North America (3%).

A secondary supply of platinum, palladium, and rhodium comes from the recycling of jewelry, electronic equipment, and catalytic converters from vehicles. According to Johnson Matthey, in 2013 recycling accounted for about 27% of the total platinum and palladium supply and about 28% of the total rhodium supply.

Recent academic articles on PGE are Aruga and Managi (2011), Gleich, Achzet, Mayer, and Rathgeber (2013), and Krogscheepers and Gossel (2015).[4] In particular, Aruga and Managi (2011) tested the law of one price (LOP) and causality between the U.S. and Japanese platinum and palladium futures markets. Their findings showed the existence of long-run price relationships for both metals, that the LOP only held in the palladium market, and the US futures market led the Japanese one.

Gleich et al. (2013) in turn studied the driving factors of nominal prices of 42 chemical elements, including three white metals: platinum, rhodium, and silver. They found that key driving factors of the prices of platinum and rhodium were secondary and mining production, respectively. In the case of silver, the key determinant of nominal price was found to be the concentration of producer countries, measured as the Herfindahl-Hirschman index (HHI).

Krogscheepers and Gossel (2015) concentrated on the main drivers of PGE production in South Africa in the period of 1980–2011. The authors found that in the long run, production is most significantly impacted by net international demand of platinum and palladium, domestic electricity tariffs, and salary shocks.

In this article, we analyzed the dependency structure of PGE, silver, and gold returns and the determinants of price principal components. To that end, we look at three price data sets: the first one at an annual frequency (1930–2014), the second one at a weekly frequency (July 1992–July 2016), and the third one at a monthly frequency (July 1992–July 2016). Specifically, the first data set is comprised of annual real prices of white metals: iridium, palladium, platinum, ruthenium, rhodium and silver. The second data set in turn is made of weekly nominal prices of palladium, platinum, silver, and gold. Iridium and rhodium were discarded because of infrequent observations at a weekly basis. The third data set is comprised of monthly prices of iridium, ruthenium, rhodium, platinum, palladium, silver, and gold.

The reason for considering alternative time frequencies is that it allows us to study return dependency as well as price determinants in more depth. For instance, when analyzing annual prices, one can correlate them with demand and supply-related variables, such as annual metal consumption and production. In contrast, when considering monthly data, it is possible to link price dynamics to industrial production, consumer sentiment and monetary aggregates (see, for instance, Batten, Ciner, and Lucey (2010)'s analysis on the macroeconomic determinants of the volatility of four precious metals: gold, palladium, platinum, and silver). Weekly information in turn enables us to analyze return dependency by non-linear methods on the basis of a larger data set.

Altogether, on the basis of weekly data, the empirical results show that the strongest relationship is between silver and gold, which display tail dependence in bearish and bullish markets (i.e., left- and right-tail dependence, respectively). By contrast, palladium and platinum only display tail dependence with silver under bearish markets.

When focusing on principal components analysis, the estimation results show that an annual horizon (1930–2014) the first principal component of PGE and silver prices is positively correlated with world PGE/silver production and US PGE/silver apparent consumption. At a monthly frequency (July 1992–July 2016) in turn, the first principal components of gold, PGE, and silver are positively associated with US

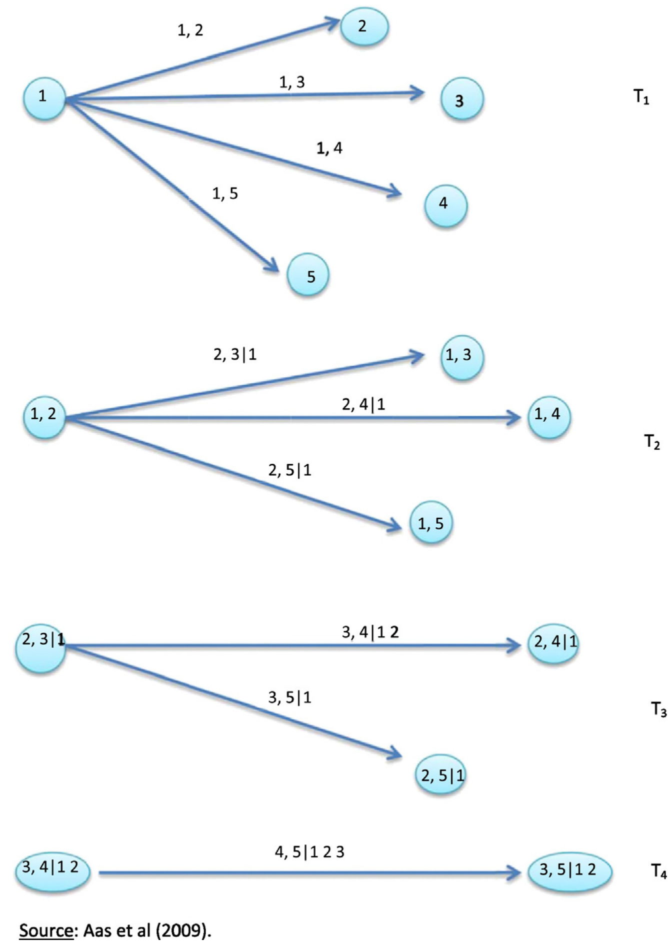

Fig. 1. Canonical–Vine for 5 random variables, 4 trees and 10 edges. Source: Aas et al. (2009).

industrial production, South Africa manufacturing production, and US M1 and M2 monetary aggregates[5]; and, to a lesser extent, inversely correlated with consumer sentiment and a trade-weighted US dollar index (i.e., a measure of the value of the US dollar relative to other world currencies.)

In addition to the above analysis, we provide an overview of the supply and/or demand of PGE and silver in recent years. To our knowledge, this is the first comprehensive study on PGE dependency with respect to other precious metals, such as silver and gold, and on PGE price drivers.

This article is organized as follows. Section 2 summarizes some methodological tools utilized in the copula literature and principal components analysis. Section 3 describes the real and nominal price data of PGE, silver, and gold. In addition, this section provides figures on supply and/or demand figures of PGE and silver. Section 4 focuses on the dependency structure of the metals under consideration and on their price determinants. Section 5 closes by presenting the main findings of this study.

2. Methodology

This study utilizes two statistical techniques to test association among real/nominal returns and prices: C-Vine copulas and principal components. In what follows we provide a brief overview of these two methods. For further details, the reader is referred to the bibliographic references here provided.

[4] For a technical approach on PGE recovering from mineral ores (e.g., gravity, flotation, and flow-sheet), see Xiao and Laplante (2004).

[5] In the United States, the standardized monetary aggregates are labeled M0 (physical paper and coin), M1 (all of M0 plus travelers checks and demand deposits), and M2 (all of M1, money market shares and savings deposits) Source. http://www.investopedia.com/terms/m/monetary-aggregates.asp.

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