PLATINUM ESSENTIALS

Platinum 101 – A primer

Platinum is a commodity with unique characteristics and drivers

Our aim is to provide an intellectual framework, together with research and regular insights into the market that will allow an investor to use market data to make a decision on whether to invest in platinum.

In our first edition of *Platinum Essentials*, we present a detailed primer on platinum, for market participants who may be new to platinum or want a refresher on the fundamentals. Below we address eight fundamental questions on platinum:

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What is platinum?

Platinum is a hard, silvery metal, discovered in 1735, thousands of years after gold. Platinum's discovery was later than gold's given its higher melting point (1,768°C, vs gold at 1,064°C), and the fact that platinum is very rarely found in its pure form in nature.

Platinum metal can be used and stored in the forms below; with different forms of pure metal useful for different types of applications.

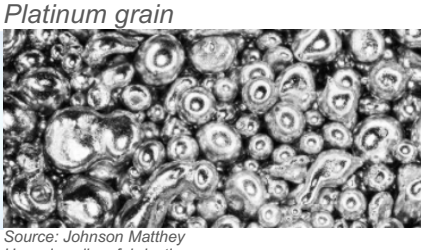
Platinum ingot

Source: Valcambi
Uses: storage and investment

Platinum sponge

Source: Heraeus
Uses: industrial

Platinum grain



Source: Johnson Matthey
Uses: jewellery fabrication

Platinum is rare (only the 72nd most common chemical element in the earth's crust, out of 92 natural elements). Platinum is prized for its catalytic properties; i.e. its ability to speed up a chemical reaction without itself being changed in the process. It is also prized for its physical properties, being ductile (easily drawn into wires), malleable (useful in jewellery making), rigid, dense, and very unreactive. Platinum is also highly recyclable. Due to its attractive properties it has several uses in industrial (autocatalysts, manufacturing, electronics), consumer applications (medical, jewellery), and in investments (bars, coins, other investment products).

WPIC's *Platinum Essentials* is a monthly publication which explores topics affecting platinum as an asset class. This is different to *Platinum Perspectives*, which is a monthly publication which looks at a specific topic affecting supply demand dynamics for platinum and gives our view

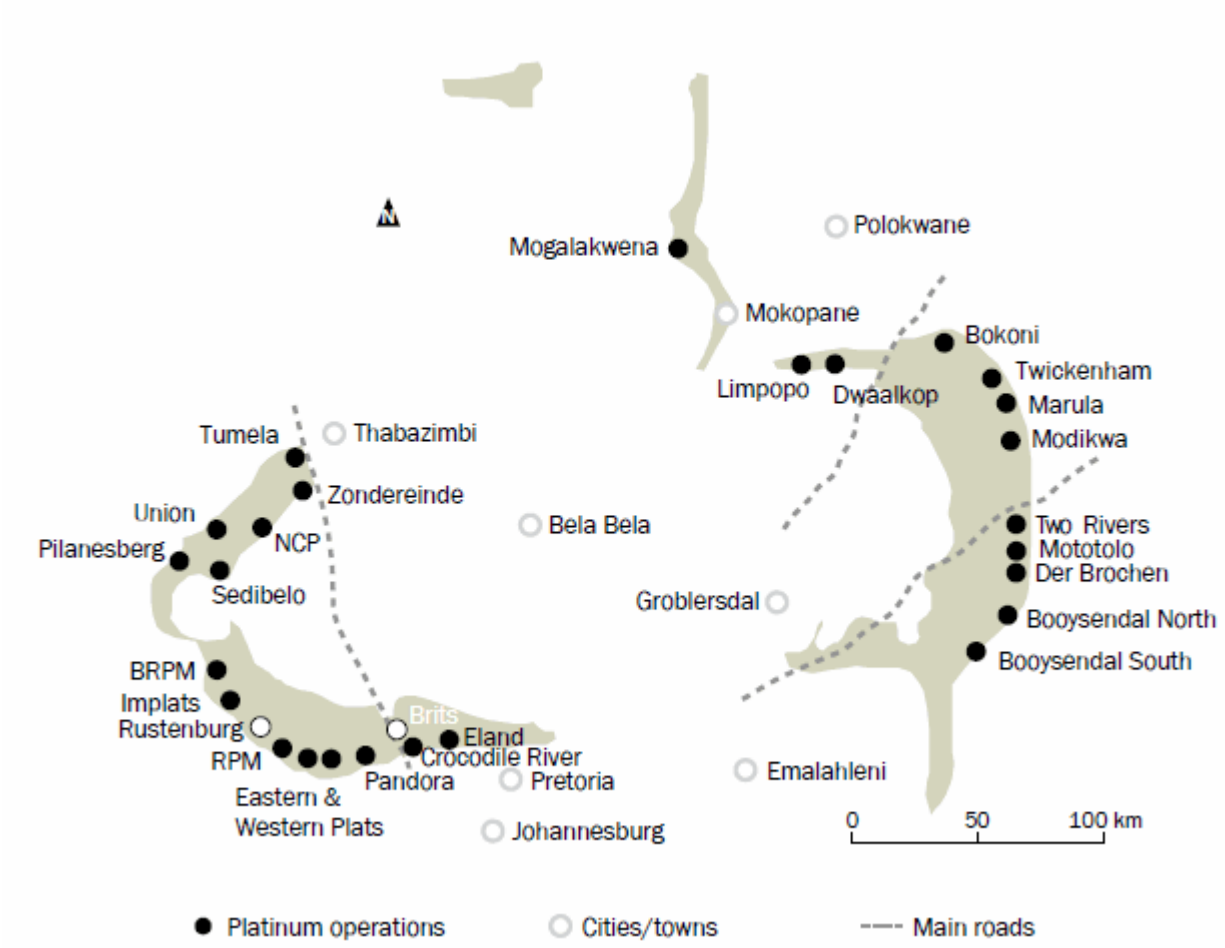
Where and how is platinum "made"?

Where is platinum found?

80% of the world's economically viable platinum-bearing deposits (reserves[1]) are located in the Bushveld Igneous Complex (Bushveld) which is in the northern part of South Africa. The balance is largely in Zimbabwe (the Great Dyke deposit), Russia, and North America. Southern Africa is the only primary source of platinum, with platinum in Russia and North America mined as a by-product of other metals (mainly nickel and palladium, respectively).

Platinum is very rarely found in isolation (i.e. in nodules), and more commonly found alongside other metals; primarily palladium and rhodium (collectively referred to as Platinum Group Metals, or PGMs for this reason); and base metals such as nickel, copper and chrome. Platinum is extracted, processed and purified through a complex series of physical and chemical processes, namely mining, concentrating, smelting and refining.

South Africa's Bushveld Igneous Complex (Bushveld)



Source: Chamber of Mines (South Africa)

The PGM ore (metal-bearing material in the earth's crust) in the Bushveld is found in horizontal layers usually less than one metre thick. The main type of PGM ore bodies the western and eastern parts ("limbs") of the Bushveld are the Merensky and UG2 ore bodies. Merensky historically provided the majority of PGMs, was shallower, higher grade, and higher revenue compared to UG2 ore. However, given increasing depletion of Merensky ore, more UG2 ore is being mined. Platreef ore is found in northern limb of the Bushveld, it is shallower than Merensky and therefore theoretically easier to mine, however has a high palladium contribution and less existing mine infrastructure.

[1] *Terms highlighted in blue are outlined in our glossary on page 24*

The different ore types in the Bushveld all contain slightly different geological characteristics (i.e. depth of deposit, concentration of PGMs) and different ratios of metals (i.e. ratio of platinum to palladium, rhodium, and gold; and concentration of base metals such as chrome, nickel and copper). We outline these differences below.

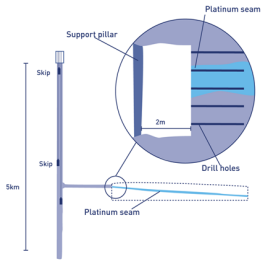
PGM ore types in the Bushveld and characteristics

Ore type	Merensky	UG2	Platreef
Location in the Bushveld	Western limb and Eastern limb	Western limb and Eastern limb	Northern limb
Depth (m)	Up to 1.5km deep	Up to 1.7km deep	Currently mined up to 250m deep
PGM - 4E	Platinum (62%), Palladium (29%), Rhodium (4%), Gold (5%)	Platinum (53%), Palladium (36%), Rhodium (10%), Gold (1%)	Platinum (43%), Palladium (48%), Rhodium (3%), Gold (6%)
Grades (grams 4E PGMs / tonne)	c4-6	c3-5	c2-5
Base metal contribution	high (0.2% nickel, 0.1% copper)	low (0.1% nickel, 0.01% copper)	higher (0.25% nickel, 0.15% copper)
Processing temperature	high	very high	high

Source: Company disclosure, WPIC Research. 4E – total of platinum, palladium, rhodium and gold

Production of PGMs necessitates a complex set of physical and chemical processes. We outline the process that is employed in many South African PGM mines below

Underground platinum mining



Source: Anglo American

Mining

In the western and eastern parts of the Bushveld, PGM ore is traditionally extracted from underground mines (usually between 700 metres and 1,500 metres deep). The mining method entails vertical shafts being drilled into or adjacent to the ore body (a process that takes up to ten years), from which horizontal and / or diagonal paths are drilled to gain access to the ore body. At the ore face, horizontal channels are drilled by human operated machines, making the process quite labour intensive. Explosives are placed into the holes and blasted to liberate the ore. The ore is transported to the surface through a network of underground ore handling machinery.

There have been attempts to mechanise some traditional mines on the western Bushveld but these have been unsuccessful, given geological challenges (i.e. the ore reef is too thin for machines to be used economically). Given this, and despite the broader challenges with deep level PGM mining on the eastern and western limbs of the Bushveld, the mining method is unlikely to change materially. These difficulties have also meant that unit cost inflation has historically increased at rates higher than local inflation; i.e. at c10% per year vs c6% local inflation; with the ZAR PGM basket price failing to keep pace with these increases.

In the northern part of the Bushveld, the PGM ore (Platreef) is close enough to the surface for some mining to be open pit; i.e. the ore is accessed directly from the surface rather than through a shaft. Unlike underground mining, drilling and blasting in an open pit mine is mechanised. Trucks and shovels can be used to move large volumes of ore; making open pit mining quicker, cheaper and safer than underground mining.

Concentrating

The mined ore is crushed and milled to liberate the minerals which contain PGMs. Thereafter, the material undergoes a chemical process known as froth flotation. This uses a combination of reagents and the addition of air to create bubbles which the PGM-containing particles attach to. This is done to ensure that the optimal grade and recovery is achieved. In this process, the concentration is increased from 2-6g of 4E (platinum, palladium, rhodium and gold) per tonne of ore, to c300g for 4E per tonne in concentrate.

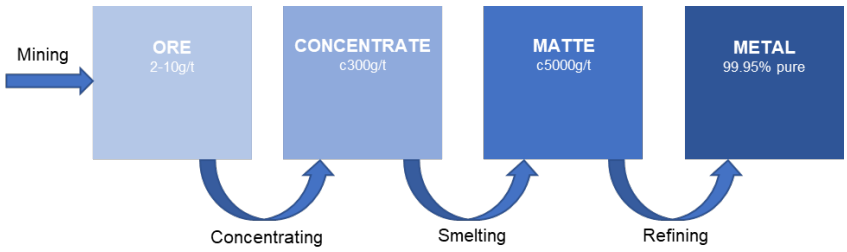
Smelting

The concentrate is then dried and processed through a smelter. The concentrate is heated in a furnace to temperatures which can exceed 1,500°C. Platinum smelting temperatures are high due to the presence of chrome in the ore. Within the furnace, the matte rises to the surface and the waste product discarded (for backfill). During this process, the concentration is increased from 300g 4E / t to 5000g 4E / t.

Refining

The matte is processed through a base metals refinery to extract copper, nickel and other base metals. It is then routed to a precious metals refinery for extraction and purification of the PGMs. Soluble metals such as gold, palladium and platinum are generally the first to be extracted, followed by the soluble metals such as iridium and rhodium. Refined metals have a purity of over 99.95% and are usually in the form of sponge (for industrial applications) or ingot (for storage / investment).

Overview of PGM production



Source: WPIC Research

What drives primary platinum supply?

Mining activity requires significant initial investment to discover and evaluate a deposit, develop the mine and produce the metal. To make this an economically sensible decision, the revenue from the future sale of the metal minus the associated costs of running the mine (operating costs, capital expenditure, taxes, financing costs etc) should lead to a good return on the initial investment (many mining companies use a 15% Internal Rate of Return or IRR as a benchmark). Often, the time from discovery of PGMs in the ground to mine development and eventual production can take over a decade. We outline some of the factors that should impact primary platinum supply (i.e. as conducted by PGM miners) below.

1) **Available reserves / resources** – Platinum is a finite material, and the total amount that can be produced is limited by the amount that is in the ground.
2) **Platinum price** – PGM miners typically generate c60% of revenues from platinum with the balance from by-products. Given the cost base is largely fixed, the operational leverage to platinum prices is very high, with fluctuations in prices broadly flowing directly to earnings and cash flow. This is especially pertinent in a low margin environment, where e.g. a 10% swing in platinum prices could turn many PGM miners from cash and earnings negative to cash and earnings positive.
3) **Palladium and other PGM prices** – PGM miners typically generate 20-30% of revenues from palladium, and the balance (excluding platinum) from rhodium, gold, nickel, copper, chrome and other PGMs (in descending order). Therefore, fluctuations in these commodity prices are also a significant source of operational leverage.
4) **Exchange rates (principally the ZAR)** – In PGM mining, 80-90% of operating costs are in the local currency. Labour (c60% of operating costs); and electricity (c15% of operating costs) are

inextricably linked to the local economy. As 70% of primary platinum supply is in South Africa, the focus is on the ZAR.

There is a perception that the ZAR should have a strong effect on the platinum price (i.e. a weakening ZAR should lead to a falling platinum price). This is expected because i.e. if the ZAR weakens, the PGM miners' costs decrease (in USD terms); so the PGM miners should be incentivised to produce more platinum, weakening the supply demand balance, and therefore the platinum price (in USD) should decrease. This correlation between the dominant producer currency and the commodity price works as a natural hedge in many other commodities; i.e. the Chilean peso and the copper price (given Chile produces c30% of global mined copper) and the Australian dollar and the iron ore price (given Australia produces c50% of the global seaborne iron ore). The opposite effect is also expected; i.e. a weaker commodity price should also lead to a weaker currency of the dominant producer.

The platinum price has indeed shown some sensitivity to the ZAR in the past (although notably less sensitivity to the ZAR's strength than its weakness). However, in recent past, periods of ZAR weakness have not led to increases in platinum production. This is due to:

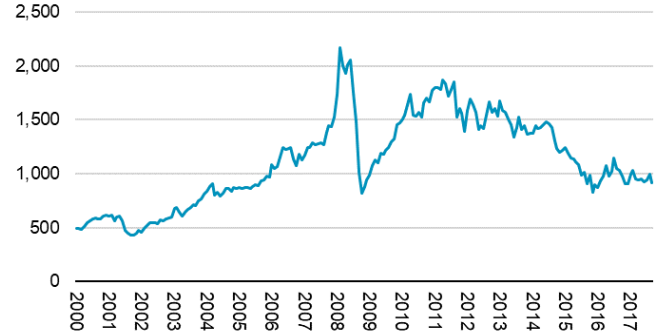
- **Operational constraints** – there are capacity constraints on the amount of ore that can be physically brought out of the ground at any time;
- **Geological constraints** – the concentration of PGMs in a single mine is relatively uniform. Therefore, PGM miners cannot generally reformulate the mine plan to focus on areas of higher metal concentration. This could improve the mine economics by getting more metal from the same volume of ore (and therefore a similar operating cost). This is possible in other metals (e.g. gold high-grading); and is a common approach to material downturn in prices, but difficult for PGM miners.

It could be argued that if movements in the ZAR are sustained, e.g. over a period of several years, this could potentially have an impact on longer term mine production options. However, the physical supply of platinum is much less reactive to the ZAR than platinum price movements would suggest.

PGM ZAR basket price – The real driver of mine economics

Bringing (almost all) the above drivers into a single measure, we have shown below the "average" basket price for PGMs in ZAR terms. This accounts for the fact that PGM mines receive revenue from multiple metals (i.e. a 'basket'), and are highly dependent on the ZAR. The charts below show a material difference between the movements in the PGM ZAR basket price and the platinum USD price, especially over the past five years.

Platinum price (USD / troy ounce)



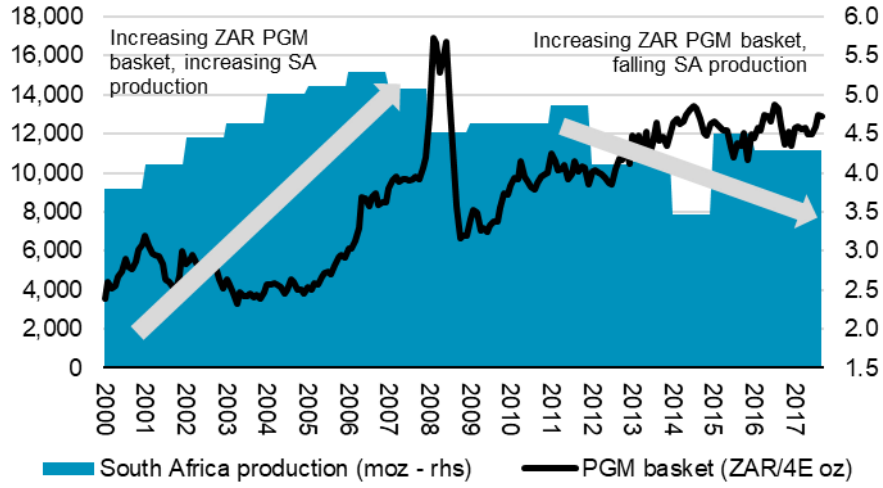
Source: Bloomberg

PGM ZAR basket price (ZAR / 4E troy ounce)

*Source: Bloomberg, WPIC Research. Assumes PGM 4E production volume is 58% platinum, 32% palladium, 8% rhodium and 2% gold, and calculated as 58%*platinum price + 32%*palladium price + 8%*rhodium price + 2%*gold price. Denominator is volume of platinum + palladium + rhodium + gold produced (4E troy ounces). Ignores minority metal contribution.*

We show below that in recent years, despite the modest increase in the ZAR PGM basket, South Africa's production has fallen. Therefore, although a higher ZAR PGM basket price should have incentivised SA PGM miners to increase production, that has not materialised.

South Africa platinum production (million troy ounces, rhs) and ZAR PGM basket (per 4E troy ounce)



Source: Johnson Matthey, SFA (Oxford), Bloomberg, WPIC Research. ZAR PGM basket price calculated in the same way as above. In 2014, many South African PGM mines were impacted by a five-month strike, leading to a material reduction South African platinum production

The PGM ZAR basket price we present above is a simplification of the impact on mine economics as:

- it excludes base metal revenue contributions (which are often deducted from the mine unit cost, in order to make the basket price comparable with the unit cost);
- it excludes revenue contributions of minor PGMs (sometimes also deducted from unit costs, as per the above);
- it ignores the fact that each mine's relative metal volume contribution (i.e. prill split) is slightly different, and could vary over time, especially if there is more UG2 ore mined over time vs Merensky ore (given Merensky ore is shallower and so usually accessed before UG2), and;
- it ignores the fact that many mines sell concentrate (to be processed by a third party) rather than finished metal; and as such only receive c85-90% of what the basket price would otherwise be. This affects 29%[2] of South Africa's platinum production

A robust assessment of mine economics for PGM mining could involve calculating a cash margin curve; consisting of each mine's cash generative position given a basket of metal prices. Nevertheless, the PGM ZAR basket provides a better barometer of mine economics than the platinum USD price, especially post 2011; where the two measures have gone in very different directions.

Regulatory / legal environment – Each country has its own set of complex rules regarding mining. A mine investment is usually a multi-decade undertaking. Fraser Institute's annual survey of mining companies suggests that the policy environment accounts for about 40% of the investment decision making when mining companies decide to explore for potential mining opportunities; with a "stable mining regime" one of the key positives.

In South Africa, mineral resources are owned by the government, but companies have mining rights (effectively licences), obtained from the government which allow them to operate mines. This comes with responsibilities including those regarding safety, environment, labour, procurement, interaction with local communities and equity ownership. The

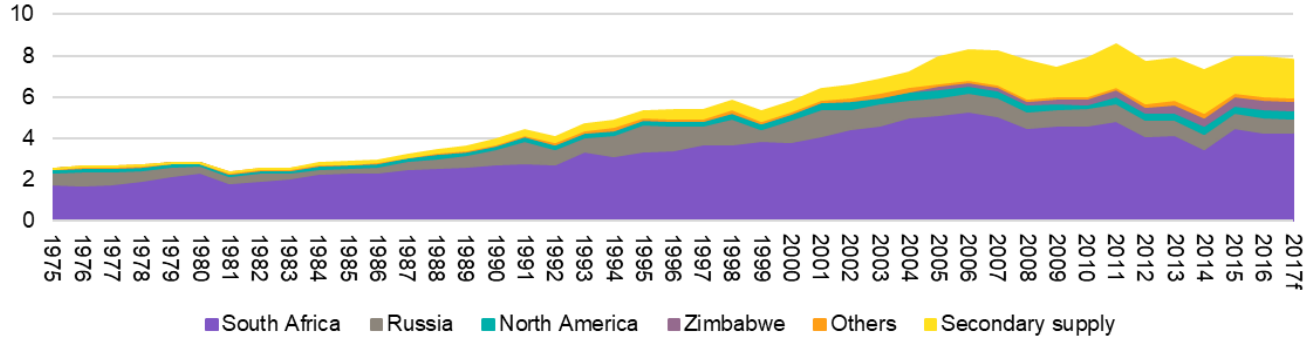
[2] *Based on third party production from Anglo American Platinum and Impala Platinum, divided by total South African refined platinum production, for the 6m to June 2017*

applicable law is the Mineral and Petroleum Resources Development Act, 2002 (MPRDA), and the Mining Charter is an agreement between the government and the companies on how to implement that law.

The Mining Charter was originally agreed in 2004 (after two years of negotiations and consultation). It had several key aims, including a 26% black equity ownership level for mining companies. South Africa's Chamber of Mines (which represents mining companies accounting for 90% of South Africa's mining production), contends that this ownership level had been surpassed by 2014. A 10 year review was due in 2014; after some delays, a revised version of the Mining Charter was announced in 2015, but was referred back to South Africa's courts, as there were concerns on whether the suggested changes were constitutional.

In June 2017, South Africa's mines minister released the latest iteration of the Mining Charter. South Africa's Chamber of Mines have outlined several concerns regarding the latest iteration of Mining Charter and is concerned on the potential for the proposed changes to lead to lower production and further job losses[3]. The most recent version of the Mining Charter is not currently in implementation, and has several legal processes outstanding. The Fraser Institute annual survey, last published in February 2017, places South Africa at 84th of 104 jurisdictions on its Policy Perception Index, and 16th of the 18 African countries included[4] (with a higher numbers suggesting a more supportive policy backdrop).

Total platinum production (million troy ounces)



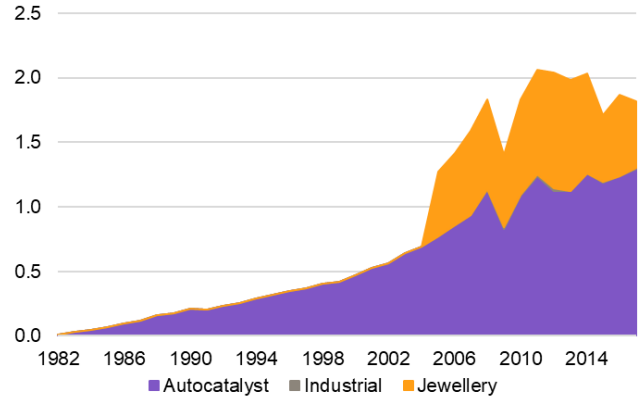
Source: Johnson Matthey, SFA (Oxford)

[3] *See Chamber of Mines' publications for more details e.g. DMR's revised charter and the struggling mining sector*
[4] *See Fraser Institute's Survey of Mining Companies 2016*

“Secondary” (recycled) supply drivers

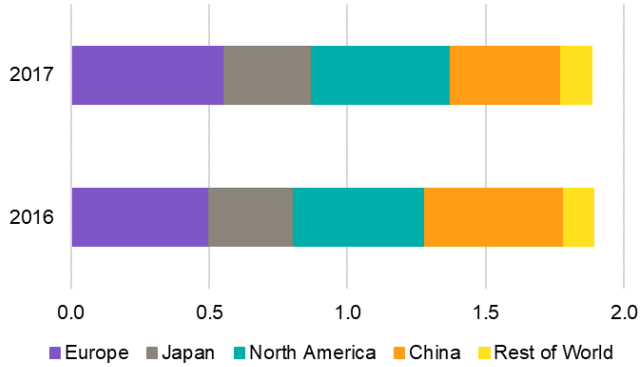
Platinum is highly recyclable; and as industrial and consumer applications for platinum grow over time; products which contain platinum get to their end of life; and the valuable platinum metal is recycled. This source of supply has become more meaningful post 2000. Ultimately the stream of secondary supply is a function of historical platinum consumption, so it is unlikely that these go in opposite directions for a sustained time.

Secondary platinum supply by source (million troy ounces)



Source: Johnson Matthey, SFA (Oxford)

Secondary platinum supply by region (million troy ounces)



Source: Johnson Matthey. Total of secondary supply from automotive and jewellery

What is platinum used for?

Platinum's physical and catalytic properties mean it has a wide range of uses in industrial and consumer applications, and for investment. Currently, automotive represents the highest end use for platinum (37-41%); followed by jewellery (31-38%), other industrial applications (18-21%) and physically backed investments (2-11%).

Source: WPIC Research

Drivers of auto demand (37-41% of platinum demand)

Fundamentally, demand from automotive is determined by four main drivers detailed below. The same factors drive auto demand for platinum, palladium and rhodium (collectively PGMs); and as such they are discussed together below (except for on powertrain trends). Given automotive is the largest source of end demand, perceptions of automotive trends have a disproportionate effect on the perception of platinum's fundamentals.

1) **Vehicle numbers** – the more vehicles on the road, the more autocatalysts are needed and therefore more PGMs needed. Drivers of vehicle numbers are economic growth, and consumer trends (e.g. the rise of the sharing economy could reduce per capita vehicle ownership in developed markets).
2) **Vehicle sizes** – bigger vehicles have bigger combustion engines and so need higher amounts of PGMs. This relationship is broadly linear; i.e. a 1.5 litre vehicle needs about half as much PGM content as a 3 litre one. So, a consumer trend for larger vehicles would have a positive impact on PGM demand (and vice versa).
3) **Powertrain trends** – different powertrains (e.g. diesel, gasoline hybrid, Battery Electric Vehicle) have significantly different loadings of platinum, palladium and rhodium. Only Battery Electric Vehicles do not contain any PGMs. Given diesel vehicles have the highest platinum loadings of commonly used vehicles, a higher diesel market share would lead to higher platinum demand (and vice versa).

Vehicle powertrain breakdown

	Acronym	Description	PGM content
Diesel conventional		Conventional vehicle with a diesel engine	5 - 10g of total PGM content; high platinum, low palladium
Gasoline conventional		Conventional vehicle with a gasoline engine	2 - 5g of total PGM content; typically in a ratio of 1:8:2 of platinum to palladium to rhodium
Diesel mild hybrid	48V	Conventional diesel car with a small 48 volt battery and electric motor to help with fuel efficiency. Cannot run on battery power alone	Likely to contain similar PGM loadings to a conventional diesel vehicle - same combustion engine size
Gasoline mild hybrid	48V	Conventional gasoline car with a small 48 volt battery and electric motor to help with fuel efficiency. Cannot run on battery power alone	Likely to contain similar PGM loadings to a conventional gasoline vehicle - same combustion engine size
Diesel hybrid	HEV	Contains both a diesel combustion engine and a battery, can run on either battery or combustion engine or both in parallel, but smaller battery than a PHEV, so the battery-only range is shorter	Likely contains similar PGM loadings to a conventional diesel vehicle. Smaller combustion engine, variable technology
Gasoline hybrid	HEV	Contains both a gasoline combustion engine and a battery, can run on either battery or combustion engine or both in parallel, but smaller battery than a PHEV, so the battery-only range is shorter	Likely contains similar PGM loadings to a conventional gasoline vehicle. Smaller combustion engine but runs intermittently (at lower average temperature, so higher PGMs relative to combustion engine size)
Diesel plug-in hybrid	PHEV	Like a HEV (can run on battery, diesel combustion engine or both), can run solely on battery power for at least 10 miles, battery can be plugged in to be recharged	Likely contains similar PGM loadings to a conventional diesel vehicle. Smaller combustion engine, variable technology
Gasoline plug-in hybrid	PHEV	Like a HEV (can run on battery, gasoline combustion engine or both), can run solely on battery power for at least 10 miles, battery can be plugged in to be recharged	Likely contains similar PGM loadings to a conventional gasoline vehicle. Smaller combustion engine but runs intermittently (at lower average temperature, so higher PGMs relative to combustion engine size)
Battery Electric Vehicle	BEV	Contains a battery (minimum 30 minute recharge time) which stores electricity. Always runs on battery power alone	Contains no PGMs
Fuel Cell Electric Vehicle	FCEV	Contains a fuel cell which uses hydrogen to generate electricity which is the only powertrain for the vehicle (5 mins to refuel H_2)	Currently contain 30-80g of platinum per vehicle; DoE target of 12.5g of platinum

Source: WPIC Research

4) **Technological changes** – the most important technological change is driven by emissions legislation, in which countries apply successively more stringent regulation on the CO_2, NO_x and particulates that can be emitted from vehicles. Regulation is currently most stringent in developed countries with developing countries following a similar trend. All else being equal, to achieve lower emissions from a vehicle a higher volume of PGM content is needed. Technological improvements can go some way to offset this; autocatalyst manufacturers have got better at making small incremental reductions to PGM volumes (and maintaining the same emissions performance). Nevertheless, each vehicle has more PGM content today than it would have had a decade ago.

Drivers of jewellery demand (31-38% of platinum demand)

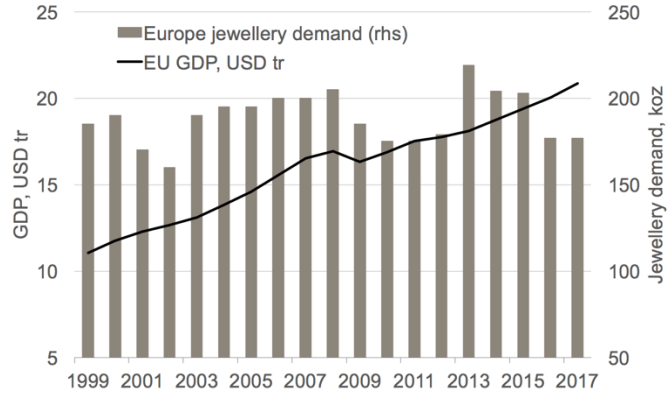
Gold has been used for jewellery for centuries, however use of platinum in jewellery is relatively recent. Given platinum's precious properties are similar to (and in some cases in excess of) gold; it made sense for the platinum jewellery market to be developed. So over 40 years ago, Platinum Guild International (PGI) was set up to develop the jewellery market for platinum, and is now supported by the largest platinum producers. Given PGI's work over the years, platinum jewellery demand has grown from zero to over 3 million troy ounces of demand per year. Since 2001, PGI believes investment of $800m in jewellery demand has generated 35.5 million troy ounces of jewellery demand, worth $7.3bn[5]. For a miner to substantially influence fundamental end demand of a commodity is relatively unusual (and only really has a parallel in diamonds).

[5] *According to miningweekly.com - http://www.miningweekly.com/article/huge-opportunity-to-create-more-demand-for-platinum-pgi-2017-08-23*

PGI continues to develop platinum jewellery markets; especially in emerging economies such as China and India, along with seeking to maintain / increase platinum's share of the jewellery markets in developed markets such as North America and Japan. It also now produces quarterly reports, with updates on platinum jewellery retail demand in key regions[6]. We outline some drivers of platinum jewellery retail demand below:

1) **Economic growth** – can generate an increasing middle class with disposable income. Some of this income can be spent on jewellery and some jewellery spend can be in platinum. However, the relationship is seldom this simple, and is moderated by further factors below.

North America GDP (USDbn, real) vs European platinum jewellery demand (thousand troy ounces, rhs)



Source: Johnson Matthey, IMF. North America = US + Canada

China GDP (USDbn, real) vs China platinum jewellery demand (thousand troy ounces, rhs)

Source: Johnson Matthey, IMF

2) **Social changes** – traditionally, a large proportion of platinum jewellery demand is in the bridal market. A growing population can increase platinum demand on a sustainable basis (i.e. more weddings) over time; additionally, wedding seasons e.g. in China can provide a seasonal uplift in platinum jewellery demand. Conversely, an aging population, or one where the marriage rates are declining for another reason, would lead to a decline in platinum jewellery demand (all else equal).
3) **Consumer trends** – platinum jewellery exists within the luxury market, and therefore is correlated to growth in global luxury. An example of this is the boom in China luxury between 2010 and 2014; which correlated to a significant increase in China jewellery demand. Broader consumption trends can also affect platinum jewellery demand, e.g. an increase in conspicuous consumption should lead to higher platinum jewellery demand. In recent years, there have been concerns that newer generations are more likely to spend disposable income on technology and travel / experiences, which could theoretically reduce the proportion of disposable income that would be spent on platinum jewellery.
4) **Advertising and promotion** – Where there is a growing middle class with disposable income, advertising can be very effective in stimulating platinum jewellery demand helping it to more effectively compete against other potential uses of disposable income. However, advertising in isolation of other supportive economic and social factors is unlikely to increase platinum jewellery demand.
5) **Price of platinum (especially relative to gold)** – jewellery spend is generally value rather than weight driven; i.e. if a groom is shopping for a wedding band; he likely has a specific budgeted amount; rather than e.g. specifically looking for a 5 gram wedding band. There should be a negative correlation between price and demand; so if prices fall and value spent remains constant, the

[6] E.g. Platinum Guild International - Q2 2017 Platinum Jewellery Business Review

demand of volume should increase. Additionally in jewellery, platinum is seen to be a premium product, with retail prices higher than that of gold. This leads to higher margins for jewellery retailers and as such, an additional incentive to offer platinum jewellery products vs gold or other jewellery products.

6) **Availability of platinum jewellery products** – the platinum jewellery market is small, (platinum jewellery demand was c4% of gold jewellery demand in Q2 2017). This means that in many locations platinum jewellery is not available, which restricts platinum jewellery demand.

A caveat on the value chain – above we have discussed drivers of platinum jewellery retail (i.e. consumer) demand, which should ultimately determine the amount of platinum used in jewellery applications.

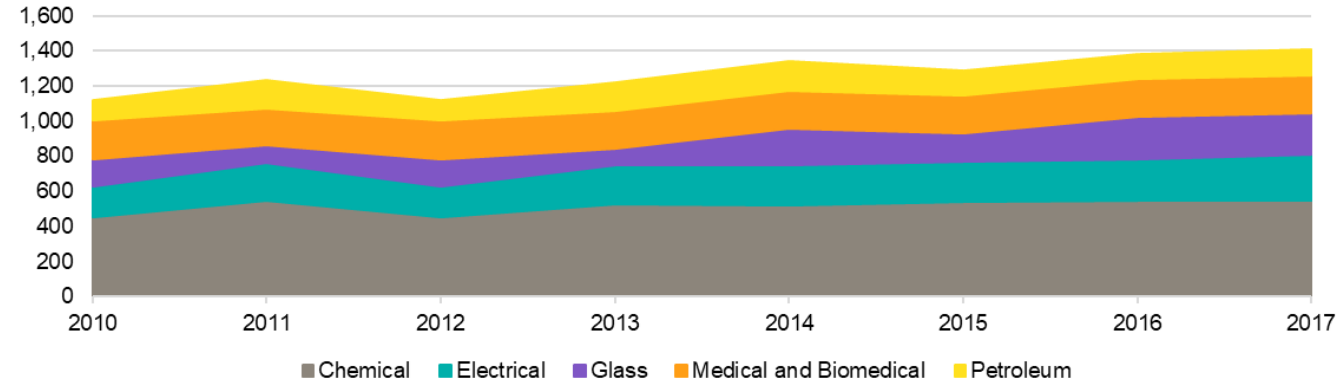
However, the jewellery value chain is complex. Inventory builds and releases at different points in the value chain can result in platinum jewellery manufacturer demand as represented in a platinum supply / demand table differing materially from platinum retail jewellery demand (though this effect should be temporary). For example, in 2016, China platinum jewellery manufacturer demand was -20% y/y, due to a reduction in inventory through the manufacturing chain. However, China platinum jewellery retail demand fell more modestly. Therefore, although in the long-term manufacturer demand should be broadly equal to retail demand, on a year by year basis there can be changes in platinum inventory that can obscure trends at the retail level.

Drivers of industrial demand (18-21% of platinum demand)

Given its unique physical properties, platinum has a broad variety of applications in the industrial sector (ex autos). Generally, there is a positive relationship between platinum industrial demand and global GDP. However, unlike other sources of demand, most industrial demand is represented on a net basis (i.e. the gross demand less the supply from recycled metal). Together with other factors, this makes industrial demand somewhat "lumpy"; as shown in WPIC's Platinum Quarterly reports. However, we believe that even as some applications in each subsector becomes less widely used; platinum's physical properties make it likely that others will be found, leading to robust industrial usage over time.

Industrial demand is broken into five areas, and we give an example of platinum's use in each sub sector below:

Platinum industrial (ex auto) demand over time (thousand troy ounces, gross)



Source: Johnson Matthey

Chemical – Platinum has been used in production of nitric acid for over a century. A crucial step in nitric acid production is the oxidation of ammonia gas which requires a platinum rhodium gauze. Nitric acid is needed for production of nitrogen fertilisers, which is an important source of plant nutrients.

Electrical – Platinum is used in hard disk drives (HDD); in a cobalt, chromium and platinum alloy which is the storage layer in a HDD stack.

Glass – glass is made from melting its raw materials at temperatures up to 1,700°C. Platinum alloys are used in the fabrication of vessels that hold the molten glass because of platinum's high melting point and resistance to corrosiveness. LCD glass (used in watches, laptops) is one of the most intensive uses of platinum within glass, given its requirements for thin, high quality glass with zero defects.

Medical and Biomedical – In some chemical forms, platinum can inhibit the production of living cells. The discovery of this property has led to the development of platinum-based drugs to treat a wide range of cancers. These platinum-based antineoplastic drugs are used to treat almost 50% of cancer patients. Examples include including cisplatin (shown to cure testicular cancer), nedaplatin (newer drug developed to address issues of toxicity and cancer resistance in earlier versions), and satraplatin (currently pending FDA approval).

Petroleum – In oil refining, platinum is used in reforming and isomerisation, which provides the higher octane components needed for the production of gasoline fuel. The platinum is coated onto an alumina substrate in the form of small beads. Over time, technical developments have led to a reduction in the platinum required per unit; but this has been offset by the rise in demand for gasoline products; leaving the annual demand for platinum from petroleum fairly stable.

Fuel cells - Fuel cells have been converting hydrogen into electricity and water for over 100 years. A fuel cell uses the reaction of oxygen and hydrogen to generate electricity (with drinkable water as a by-product). Many fuel cell applications contain platinum.

The most advanced cell technology uses highly compressed hydrogen gas as fuel. Hydrogen gas can be generated from renewable sources; e.g. from water through electrolysis, which is completely carbon-free or biomass (organic matter used as a fuel, almost carbon free). Hydrogen gas can be also be made from non-renewable sources such as natural gas, coal or oil. Fuel cell performance depends on a range of factors, from a sufficient supply of hydrogen and the purity of the hydrogen supplied through to the pressure of the gas, the temperature of the cells, the thickness of the platinum electrodes and the permeability of the isolating foil for the protons.

Fuel cell applications are divided in portable, mobile and stationary with different power ranges supported by different types of fuel cell (shown below).

Different types of fuel cells

Name	Acronym	Common uses	Industries	Operating temperature (ºC)	Electrical efficiency (%)	Contains platinum?
Proton Exchange Membrane Fuel Cell	PEMFC	Portable, mobile	Road transport, Consumer	<120	up to 55%	Yes
Alkaline Fuel Cells	AFC	Stationary, mobile	Stationary power generation, space travel	<100	up to 65%	Yes
Phosphoric Acid Fuel Cell	PAFC	Stationary	Stationary power generation (100-400kW)	120-150	40%	Yes
Molten Carbonate Fuel Cell	MCFC	Stationary	Stationary power generation	600-700	up to 55%	Yes
Solid Oxide Fuel Cell	SOFC	Stationary	Stationary power generation	500-1,000	up to 60%	No

Source: WPIC Research

Although many fuel cell applications are already in use; the application with the most potentially transformative effect on platinum demand is Fuel Cell Electric Vehicles (FCEVs) in passenger vehicles. The technology for FCEVs has existed for decades but has been slow to be adopted commercially for several reasons; technology needed to be proven; cost of

building a completely new electric vehicle platform was high and other challenges for an electric car (regenerative braking; running air conditioning on electricity rather than fuel) were not yet solved.

Currently two types of commercially viable vehicles are zero emission at use; Battery Electric Vehicles (BEVs) and FCEVs. Many assume that, given the (relative) popularity of BEVs; there will be no place for FCEVs within the electrification trend. However, it is likely that achieving a zero carbon economy necessitates exploiting all appropriate technology; and on a practical level, if one assumes the challenges for BEV are overcome (range anxiety, infrastructure build) it is likely that FCEVs can also overcome its challenges (hydrogen infrastructure, more commercial options), and could achieve at least a modest market share. There are FCEVs currently available for sale in some markets, including the Toyota Mirai and the Hyundai ix35.

One of the considerations for the impact of FCEVs is the platinum loadings that they may bear. The technology requires a significant amount of platinum (autocatalyst manufacturer Johnson Matthey suggests current loadings are 30-80g per vehicle), this is expected to fall over time. The U.S. Department of Energy has set a platinum loading target of 12.5g[7], which is still materially higher than the platinum contained in a conventional internal combustion engine vehicle (3-10g for diesel). Given the high platinum loading, a modest market share of FCEVs would garner significant platinum demand.

Automotive executives rate FCEVs as a breakthrough for electric mobility (vs BEVs where large scale adoption is expected to be moderate due to infrastructure constraints) and FCEVs are also considered by automotive executives to be attractive due to the strong attachment to existing infrastructure and traditional vehicle applications[8].

Source: WPIC Research, Johnson Matthey, Johnstone et al (2014), "Understanding and Improving Platinum Anticancer Drugs – Phenanthriplatin". Anticancer research. 34

FCEV market share, platinum loading, and potential platinum demand

		Platinum loading (g/car)				
Platinum demand (moz)		7.5	12.5	17.5	22.5	27.5
FCEV market share	1.5%	0.63	0.76	0.89	1.01	1.14
	3.0%	1.27	1.52	1.77	2.03	2.28
	4.5%	1.90	2.28	2.66	3.04	3.42
	6.0%	2.53	3.04	3.55	4.05	4.56
	7.5%	3.17	3.80	4.43	5.06	5.70

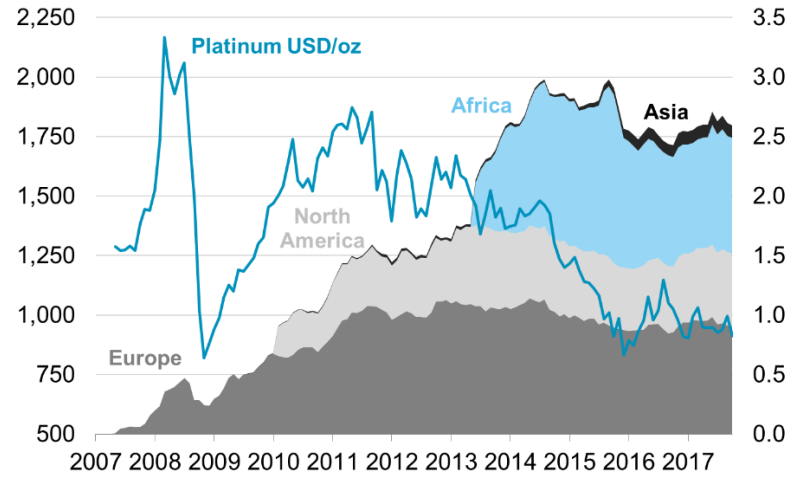
Source: Bloomberg, WPIC Research. Assumes 105m global passenger vehicles

Drivers of investment demand (2-11% of investment demand)

Investment demand included in WPIC's published supply demand analysis includes net purchases or sales of platinum bars and coins, and of Exchange Traded Products (ETPs) which are physically backed with platinum. Investors trade platinum for varying reasons; some for the perception of platinum's fundamentals, some for perception of macro fundamentals and a large proportion of trading activity is automated, with algorithmic trading making up 54% of precious metal trading according to the CFTC[9].

[7] *US Department of Energy - https://energy.gov/eere/fuelcells/doe-technical-targets-polymer-electrolyte-membrane-fuel-cell-components*
[8] *KPMG's Global Automotive Executive Survey 2017*
[9] *Financial Times – From ranchers to fund managers, 'algos' cause a stir – 10th October 2017*

ETP holdings (million troy ounces, rhs) and price (USD / troy ounce)



Source: Bloomberg, WPIC Research

Platinum ETFs were created in 2007, and generally the volume of platinum invested has increased (despite a broadly downward trending platinum price).

Should investment demand be included in supply/demand analysis?

Given a commodity is a physical entity, what is represented as a "surplus" or "deficit" in a supply demand table is actually changes in inventory, whether that inventory is owned by producers, consumers or financial speculators (investors). Whilst investment demand (e.g. inventory held by speculators) has historically been included in supply demand forecasts, the view on this has changed over the past couple of years, and different financial analysts and consultancies now take varying approaches on whether to include investment demand on supply demand analysis. We outline reasons for and against including investment demand in supply demand analysis below.

Yes – Investment represents physical demand on investment, and is a potential source of supply if the investor decides to sell the metal. In this regard, it is similar to other sources of platinum demand; i.e. auto demand comes back as recycled supply once the vehicle reaches its end of life, platinum jewellery can be recycled (e.g. when the platinum price is high), with the value used toward purchase of the next piece etc.

An increase in investment demand directly affects the physical market. As an example, if there is an increase in demand for safe haven assets, there could be an increase in investment demand for platinum, which would lead to an increasing volume of platinum being bought in the market and put into a vault (in the case of a physically backed ETP). This would tighten the physical market and make it more difficult for industrial consumers to obtain metal. WPIC's approach is to include investment demand in supply demand analysis for these reasons.

No – Investors could be seen as the buyers of last resort, given neither producers nor consumers will want to hold increasing volumes of metal in an environment where the price is falling. Under this viewpoint, an increasing demand from investors does not necessarily indicate a robust underlying market, and is a potential future source of metal if the physical market tightens.

Half and Half? – A third method involves including retail investment demand but excluding institutional investment demand. The logic of this seems to be that institutional investment demand is backed by LPPM good delivery bars (ingots); if the financial instrument is sold, the underlying bar can, for example, be bought by an automaker, and converted into sponge for industrial use. If a retail investor sells a coin; the higher premium charged

on the coin makes it more likely that it will be bought by another coin investor, and less likely that it will be sold to an industrial consumer, melted down, and converted into sponge for industrial use. Indeed, where the platinum coin is legal tender, it can be illegal to melt it down. Under this rationale, institutional investment demand is excluded from demand as it represents a greater risk to the physical market in the future.

Is platinum a precious or an industrial metal?

As outlined above, platinum has characteristics similar to precious metals and many industrial varied end uses too. In our view, platinum has traded in three distinct patterns over the past 15 years:

1) **A precious metal with an industrial premium** – correlation with gold, lower correlation with copper, increasing premium to gold (2002 – 2005)
2) **An industrial metal with a precious floor** – correlation with gold, higher correlation with copper, premium to gold, and responsiveness to risk appetite (2005 – 2013)
3) **A precious metal with an industrial discount** – higher correlation to gold, high and increasing discount to gold, falling correlation with copper (2013 – date)

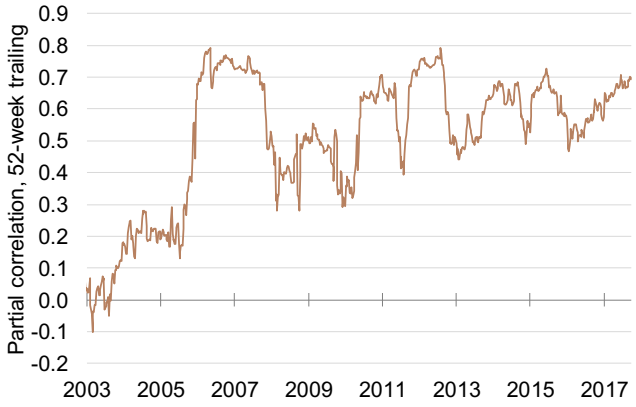
Correlation in returns between platinum and copper / gold (ex USD effect), platinum premium / discount to gold [10]

		Correlation with copper (ex USD)	Correlation with gold (ex USD)	Premium / discount to gold (USD/oz)
2002-2005	Precious metal with an industrial premium	0.27	0.21	362
2005-2013	Industrial metal with a precious floor	0.37	0.55	323
2013 to date	Precious metal with an industrial discount	0.23	0.61	-125

Source: Bloomberg, WPIC Research. Based on weekly returns

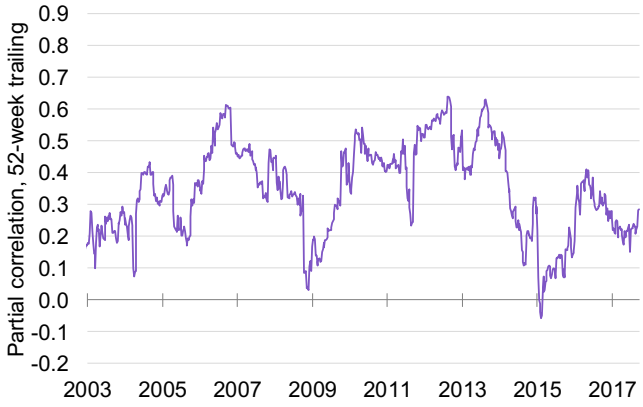
As shown below, platinum has a significant and variable correlation, with both gold (most actively traded precious metal) and with copper (most actively traded industrial metal). Since 2002, the correlation in platinum returns with gold (0.51, ex USD effect) was higher than that of copper (0.35, ex USD effect) but both correlations were statistically significant (within a 0.1% probability).

Platinum correlation with gold (ex USD effect)



Source: Bloomberg, WPIC Research

Platinum correlation with copper (ex USD effect)



Source: Bloomberg, WPIC Research

Given the historical performance and the fundamental drivers of platinum, we believe it is likely that platinum will continue to trade with both precious and industrial characteristics.

[10] *Commodity correlations are shown excluding the USD effect; given the relative strength of the USD affects all commodity pricing and we wish to strip out this impact*

How can I invest in platinum?

Financial exposure to platinum can be obtained through physical platinum, physically backed financial assets, financial assets that are linked to platinum's price movements, and assets that are affected by platinum's price movements (amongst other drivers).

Below we outline some platinum investments, with an indication of the cost of acquiring a position. The total return for an investor is also impacted by the total cost of ownership and disposal, which may include tax implications, which are not detailed below. An example is platinum coins which have a higher premium than some other options; but are not liable for capital gains tax in the UK. We refer investors to the disclaimer on page 26.

A range of platinum investments

Description	Region[1]	Name	Ticker	Management fee (bps)	Assets under Management (USDm)[2]
Physically backed					
Exchange Traded Products - ETPs[3]	Asia	Japan Physical Platinum ETF	1541 JP	50	92.6
	Europe	ETFS Physical Platinum	PHPT LN	49	330.6
		ZKB Platinum ETF	ZPLA SW	51	256.7
		Julius Baer Precious Metals	JBPLUX SW	34	93.4
		UBS ETF CH-Platinum USD	PTCHA SW	35	65.2
		db Physical Pt Euro Hedged	XAD3 GR	45	33.8
		db Physical Pt ETC	XPLA LN	45	25.2
		iShares Physical Platinum ETC	IPLT LN	40	15.3
		ETFS Physical PM Basket	PHPM LN	44	10.9
		Source Physical Platinum P-ETC	SPPT LN	39	7.9
	North America	ETFS Physical Platinum Shares	PPLT US	60	513.4
		Sprott Physical Pt & Pd	SPPP US	117	34.1
		ETFS Physical PM Basket	GLTR US	60	19.0
	South Africa	New Gold Platinum ETF	NGPLT SJ	40	768.7
		Africa Platinum ETF	ETFPLT SJ	30	136.6
Allocated ownership of bars	United Kingdom	BullionVault		Fees c~1%[4]	9.1
Physical					
Description	**Country**	**Name of Product**		**Premium**	**Sales tax**
Bars[5]	United States	Valcambi 1oz		6%	State dependent[6]
		Credit Suisse 10oz		3%	
	United Kingdom	Valcambi 1oz		6%	20%[7]
		Royal Mint 100g		4%	
		Royal Mint 1kg		3%	
	Singapore	Valcambi 1oz		4%	0%
		Valcambi 100g		4%	
		Valcambi 1kg		1%	
Coins[8]	United States	Platinum Maple Leaf (Canada)		9%	State dependent[6]
		Platinum American Eagle (US)		15%	
		2018 Platinum Kangaroo (Australia)		8%	
	United Kingdom	Platinum Queen's Beast (UK)		4%	20%[7]
		Platinum Maple Leaf (Canada)		9%	
	Singapore	Platinum American Eagle (US)		14%	0%
		2016 Platinum Maple Leaf (Canada)		9%	
		Philharmonic Platinum (Austria)		9%	
		Platypus Platinum (Australia)		10%	
Assets affected by platinum price					
Description	**Region**	**Entity**	**Ticker**	**Market Cap (USDm)[9]**	**Platinum % revenue (2016)[10]**
Equities	South Africa	Anglo American Platinum Ltd	AMS SJ	7,379	57%
		Impala Platinum Holdings Ltd	IMP SJ	1,895	60%
		Northam Platinum Ltd	NHM SJ	1,141	54%
		Royal Bafokeng Platinum Ltd	RBP SJ	439	64%
		Sibanye Gold Ltd	SGL SJ	2,772	12%
	United Kingdom / South Africa	Lonmin PLC	LMI LN	365	64%

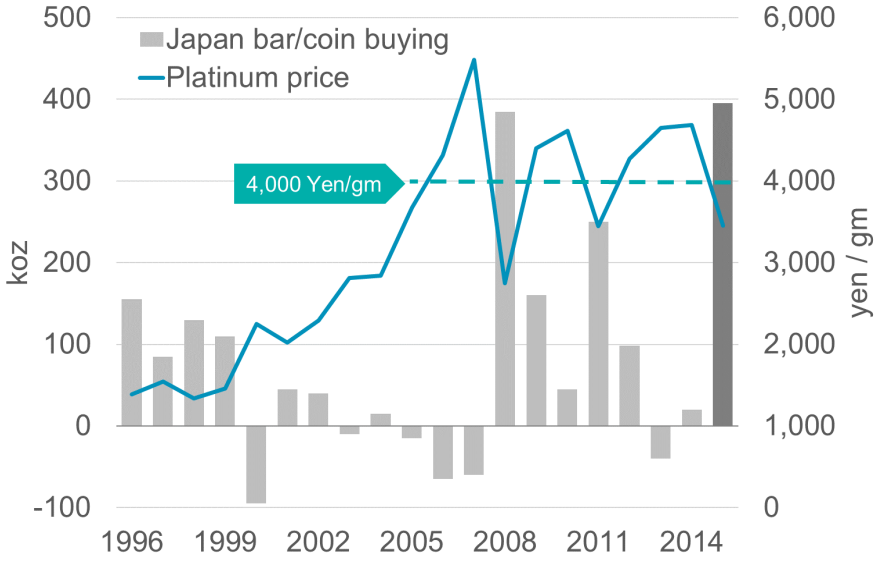
Source: Bloomberg, WPIC Research, BullionVault, goldsilvercentral.com, apmex.com, royalmintbullion.com, jmbullion.com. 1. Deontes the region the financial product is listed in, rather than where investors are domiciled. 2. AuM as at 26th October 2017. 3. ETPs included which have holdings over 5koz of platinum. 4. Bullion Vault Fees include 0.5% comission and 0.48% storage and insurance fees. 5. Bars are minted only, with premiums calculated based on price of a bar (on a per oz basis) vs spot platinum price at 25th October 2017. 6. US sales taxes on platinum bars / coins dependent on the state they are sold from; many states apply 0 tax. 7. VAT only becomes payable on physical delivery, with bars and coins held in the Royal Mint's vault VAT-free. 8. Coins shown are 1oz 2017 editions except where noted. Premiums are calculated based on purchase of a single coin vs spot platinum price at 25th October 2017. 9. As at 26th October 2017. 10. Based on reported revenues for financial year 2016.

Physical investments

Physical platinum investments exist across a spectrum from bullion products to collectible products, with the latter garnering higher premiums. Bars and coins are examples of physical investments. The positives are that the investor gains direct price exposure and has physical possession of the asset. The negatives are platinum coins and bars are often liable for sales taxes (unlike gold coins) although in some cases these can be avoided; i.e. retail investors that keep their coins / bars in Royal Mail's vault avoid VAT in the UK. Coins and bars also often and garner storage and insurance fees. Platinum coins and small bars are harder to produce than gold and silver, given platinum's hardness relative to gold and an established infrastructure that is optimised for gold and silver, not platinum. This means that the premium (e.g. price paid in excess of the value of the metal) is likely to be higher than that paid e.g. on gold coins and small bars. The premium can be significantly reduced on purchase of multiple coins.

The secondary market for platinum bars and coins can be somewhat illiquid in many regions. Nevertheless, where there is an established market, the demand for platinum bars and coins is robust, with Japanese investment demand responsive to dips in the domestic platinum price.

Japan platinum bar and coin demand (thousand troy ounces) vs platinum price (yen per gram)



Source: Bloomberg, Johnson Matthey, Metals Focus, WPIC Research

Physically backed investments

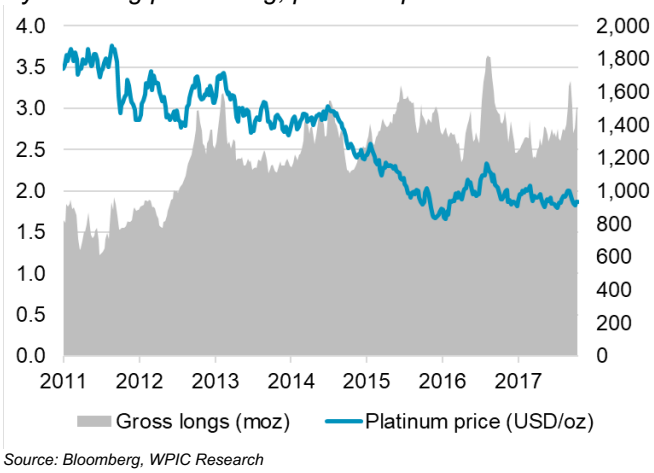
Platinum Exchange Traded Products / Funds (ETPs / ETFs) are a financial asset backed by physical platinum; i.e. a new share in a platinum ETF requires the market maker to go into the OTC market and buy platinum to be delivered into a vault (unlike many gold ETFs). The positives are direct price exposure, and easy re-sale (given its exchange traded nature). There is also no insurance, storage costs and sales tax on ETFs, although there is a management fee (0.5%-0.7%). However, financial ownership of the ETF does not confer the right to take possession of the physical platinum.

There are services that offer allocated ownership of physical platinum. Typically, allocated ownership in platinum has meant physical delivery and possession which has meant higher premiums, commissions, insurance costs and taxes for the investor. Investors can also now take allocated ownership of platinum, vaulted on behalf of the investor without taking physical delivery, avoiding associated costs. An example is BullionVault which offers allocated platinum for 0.5% trading commission plus 0.48% storage / insurance fees per annum. The owner can also take physical delivery, subject to additional fees and taxes.

Investments directly linked to the platinum price

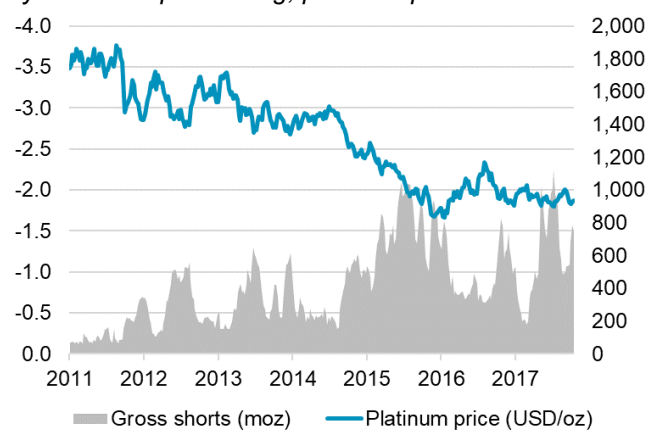
A view on platinum can also be expressed by buying a futures position. Platinum futures are standardised, exchange traded contracts, in which the buyer agrees to take delivery from the seller, a specific quantity of platinum. Although the contract is theoretically for settlement of physical metal; in practice a very small amount of futures result in delivery of the underlying metal; instead traders are more likely to offset their futures contracts before they mature. Platinum futures listed on the CME cover a period of 15 months, beginning with the current month, the next two calendar months and moving into the quarterly cycle of January, April, July and October.

Nymex long positioning, platinum price



Source: Bloomberg, WPIC Research

Nymex short positioning, platinum price



Source: Bloomberg, WPIC Research

Futures have some peculiarities vs other ways of investing. Firstly, only a fraction of the value of the investment is required when buying or selling, known as the initial margin. This fraction can be as low as 5%, which entails a leverage of 20x the initial stake. Secondly, futures have a finite maturity, so to hold on to a position past the maturity of the contract, an investor needs to roll into the next available contract (sell the old one and buy the new one). As the futures curve for platinum is usually upward sloping (prices are higher in further into the future), this implies rolling from a cheaper contract into a more expensive one to maintain the same exposure. Over time, this 'rolling' incurs a cost known as a 'negative roll yield'. For many commodities, it is mostly positive. But for platinum, as for other precious metals, the negative roll yield can exert a considerable drag on returns.

Investments significantly affected by the platinum price

An example is equities of PGM miners, where c60% of revenues are generated from platinum. However, there are other significant drivers of PGM equities, including the price of other elements of the PGM ZAR basket price (i.e. palladium, gold, nickel price, and ZAR strength); operational performance; social, regulatory environment, and global risk appetite.

WPIC aims to increase investment in platinum

World Platinum Investment Council (WPIC) was established by six leading South African PGM miners in 2014 to increase investment ownership in platinum. This is done through provision of actionable research and insights, e.g. the Platinum Quarterly and monthly Platinum Perspectives and Platinum Essentials. We also analyse the platinum investment value chain by investor, product, channel and geography and work with partners to enhance market efficiency and increase the range of cost-effective products available to investors of all types. Examples of new products brought to market are BullionVault (10koz since March 2017 launch), and provision of platinum coin products through the UK's Royal Mint.

What data is important for investing in platinum?

There are several indicators that are relevant for platinum; we outline a (non-exhaustive) list below.

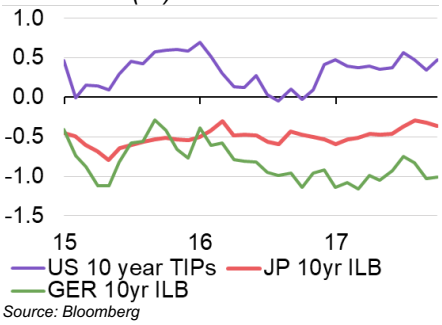
- **Macroeconomic backdrop** – The global macro backdrop will affect pricing for all assets. Specifically changes to US real rates and the trade weighted USD index and the gold price are important
- **PGM fundamentals** – Common wisdom suggests that the price of a commodity should reflect its supply demand fundamentals
- **Commodity backdrop** – There is a significant correlation between price performance of all commodities, including platinum

Macroeconomic backdrop

Gold price (USD/oz)

Source: Bloomberg

Real rates (%)

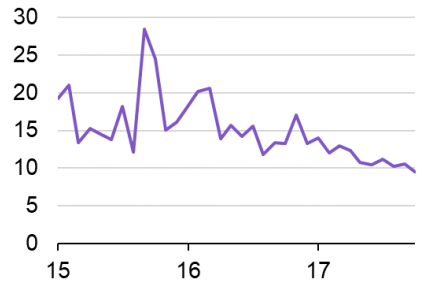


Source: Bloomberg

DXY Index

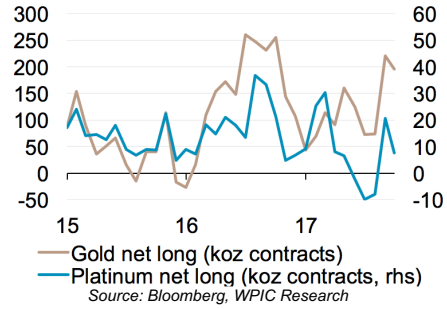
Source: Bloomberg

VIX Index



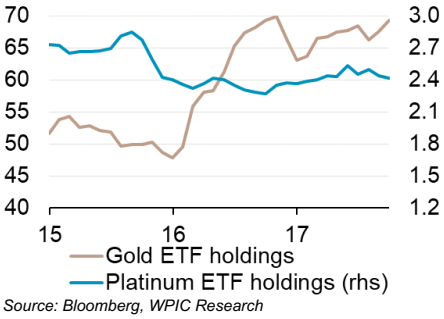
Source: Bloomberg

Gold, platinum futures positioning



Source: Bloomberg, WPIC Research

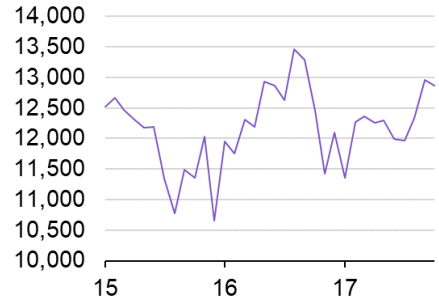
Gold, platinum ETF holdings (moz)



Source: Bloomberg, WPIC Research

PGM fundamentals

PGM basket (ZAR/oz)

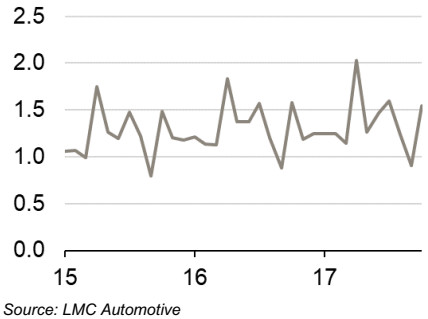


Source: Bloomberg, WPIC Research

ZAR (vs USD)

Source: Bloomberg

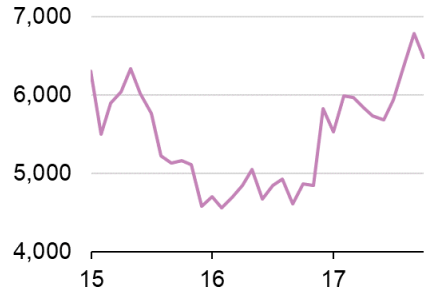
European auto sales (k)



Source: LMC Automotive

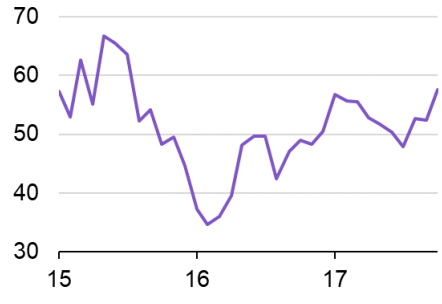
Commodity backdrop

Copper price (USD/t)



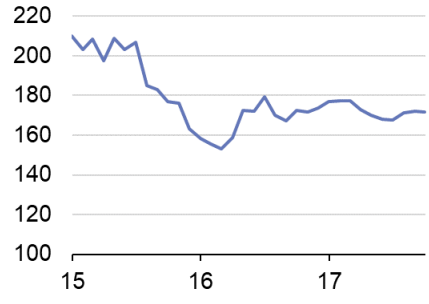
Source: Bloomberg

Oil price (Brent, USD/bbl)



Source: Bloomberg

BBG commodity index



Source: Bloomberg

What are the ESG considerations for investing in platinum?

Mining in South Africa has a socially and politically contentious history, given many mining activities were started far in advance of South Africa 1994 independence. Local labour was cheap, safety and housing standards were low; and the economic benefit from mining was explicitly only for the previously politically dominant demographic.

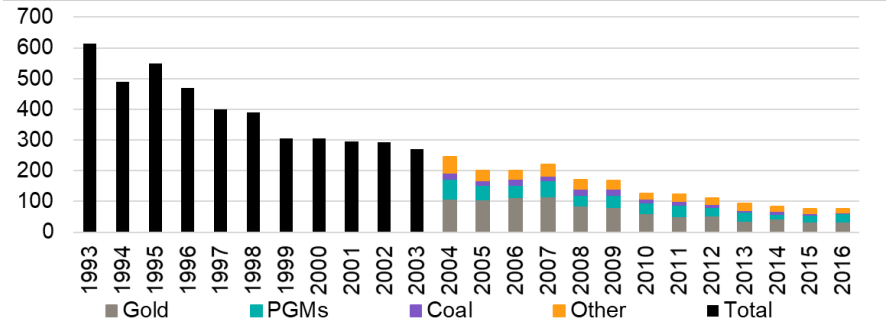
Since then South Africa has undergone many social and political changes, which has been reflected in changes to the mining industry. A significant aim of the democratically elected dominant party was for the proceeds of mining to be more equally shared between South Africa's populace.

Fatalities and safety

Given South Africa's ore deposits require more manual extraction, its mining industry has become known for its extensive labour in challenging and potentially hazardous environments. Mines can operate up to 5km underground (though platinum mines are usually <1.5km in depth) with previously temperatures reaching 60ºC, though over the past couple of decades, improvement in mine ventilation have caused mine temperatures to fall significantly. Due to challenging operating conditions, health and safety of all workers in the mining environment are a key priority.

South Africa's Mine Health and Safety act was introduced in 1996 and there has been a combined effort between mining companies, employee unions and the government to jointly promote a safe and healthy working environment. Since 1993, the number of fatalities in South Africa's mining industry has reduced by 88%. The most common causes of fatalities are fall of ground, followed by transport related injuries.

Mining fatalities by commodity (1993-2016)



Source: Department of Mineral Resources, Chamber of Mines

Water use

Water is an essential component in the mining industry, it is used for mineral processing, dust suppression, material transportation and employee requirements. Within the mining operations, mineral processing and tailing dams consume the most amount of water. Evaporation from the tailings storage facilities and entrainment losses during tailings discharge are dominant contributors to water consumption.

The use and impact of water can result in a range of environmental; social and economic risks. Mining companies take an active role in conserving and managing water use, as not doing so can affect the availability and quality of water for local communities; ultimately impacting the miners' licence to operate from a social and a regulatory perspective.

Benefits in end use

Approximately 37-40% of the world's platinum is used in the automotive industry. In catalytic converters, PGMs are used in the exhaust system where they act as a catalyst to reduce harmful emissions. If the engine

exhaust gases were not treated they would have several negative impacts on human health and the environment, especially given the increase in global mobility over the past decades.

Social impact

The PGM industry is an important element of the South African economy. It is a significant employer, with over 172,000 employees in 2016[11]; with each mine employee estimated to support a further 5-10 people. It provides numerous development benefits to the surrounding communities through company sponsored programs. Overall benefits include employment opportunities, housing, health monitoring and creation of procurement opportunities. Mining companies also collaborate with the government. On improvement to roads, schools, sanitation electricity and water supply.

Labour is important and two relatively recent incidents underscore the delicate relationship between the mining companies and its significant labour and surrounding communities. In 2012, an unprotected strike, led to community unrest and tragically what is now known as 'the Marikana tragedy' with 55 mine employees and police tragically killed near mining operations in Rustenburg. In 2014, a change in union membership led to a protected strike which lasted an unprecedented five month period. These incidents underscore the importance of a positive and productive working relationship between miners, employees and local communities.

How has an investment in platinum compared to other assets over time?

We show the real annual returns of platinum relative to other asset classes below. This demonstrates that over the long term, platinum returns are comparable to other assets.

Platinum annual returns over time

1991-1996	1996-2001	2001-2006	2006-2011	2011-2016
Macro HF (21%)	Equity HF (18%)	EM equities (27%)	Gold (20%)	Private equity (19%)
Equity HF (21%)	Private equity (12%)	Global real est. (27%)	Oil (12%)	DM equities (11%)
Global real est. (14%)	Macro HF (10%)	Oil (25%)	US fixed income (7%)	Global real est. (10%)
EM equities (13%)	US fixed income (7%)	Platinum (19%)	Macro HF (5%)	Equity HF (5%)
DM equities (11%)	DM equities (6%)	Gold (18%)	Platinum (4%)	US fixed income (2%)
Commodities (11%)	Platinum (5%)	Commodities (16%)	EM equities (3%)	EM equities (2%)
US fixed income (7%)	Global real est. (0%)	DM equities (10%)	Equity HF (1%)	Macro HF (1%)
Oil (6%)	Commodities (-1%)	Private equity (10%)	DM equities (-2%)	Gold (-6%)
Platinum (1%)	Oil (-4%)	Macro HF (9%)	Commodities (-2%)	Platinum (-8%)
Gold (1%)	Gold (-5%)	Equity HF (9%)	Global real est. (-5%)	Commodities (-9%)
	EM equities (-6%)	US fixed income (5%)	Private equity (-12%)	Oil (-12%)

Source: Bloomberg, WPIC Research

There is also a demonstrated benefit of diversification from adding platinum to a portfolio; which is a topic we will explore in a future edition of Platinum Essentials.

Sources: WPIC Research except where separately noted

[11] *Chamber of Miners (South Africa)*

Platinum Essentials - Glossary

3E – Total of platinum, palladium and rhodium / **4E** – Total of platinum, palladium, rhodium and gold

5E – Total of platinum, palladium, rhodium, iridium and ruthenium

6E – Total of platinum, palladium, rhodium, gold, iridium and ruthenium

Alluvial – An ore deposit that is in a current or old river bed

Bushveld Igneous Complex – a large layered, saucer shaped, body of metal, more than 7km thick and 500km wide, bearing rock formed through the cooling and solidification of lava, NW of Johannesburg in South Africa. It is rich in Platinum Group Metals

By-product – In mining, a metal that contributes much less in revenue than the primary metal produced at the mine

Concentrate – The valuable minerals recovered by froth flotation

Deposit – A collection of ore that is contained in an area

Grade – A measure of concentration indicating how much valuable metal is ore. In PGM mining, grade is often commonly referred to as grams of 4E content per tonne of ore (g 4E/t)

IRR (Internal Rate of Return) – the profitability of potential investments. It is the discount rate on a project such the such that net present value (NPV) of a project is equal to zero. NPV is the present value of future (net) cash flows

koz – thousand troy ounces – equivalent to 31.1 kilograms

Matte – A layer of valuable minerals produced through smelting. In the case of platinum smelting it is enriched with platinum group metals

Merensky reef – Layer of the Bushveld Complex supplying PGMs, and yields significant quantities of copper, nickel, cobalt and gold as by-products. It is mined on both the eastern and western limbs of the Bushveld Complex

moz – million troy ounces – equivalent to 31.1 metric tonnes

Open pit – A type of mining operation whereby the ore excavation occurs at the surface of the ground

Ore – Raw material in the earth's crust that contains valuable metal. With the exception of coal and steel raw materials, most ore is further processed to produce the commodity for sale

Platinum Guild International (PGI) – Platinum Guild International (PGI) develops for and builds a commitment to platinum in jewellery. Founded in 1975 and currently supported by leading South African platinum producers and refiners, PGI has been providing information, sales support and training to all levels of the jewellery trade for almost 40 years. In addition to its headquarters in London, PGI has offices in China, India, Japan and the USA

Platinum Group Metals (PGMs) – A group of metals commonly discovered with platinum. Can refer to some or all of: platinum, palladium, rhodium, iridium, ruthenium and osmium. Commonly, measures of PGMs exclude osmium, which is also a PGM, but is discovered in quantities too small to make a meaningful economic contribution, is usually not assayed and is highly toxic. Measures of PGMs also commonly include gold given its co-occurrence with PGMs

Platreef – Ore body of the Bushveld Complex in the northern limb. It is a different nature of rock due to magma in this region reacting with the lime rich floor rocks. It is the third largest PGM deposit, after Merensky and UG2

Powertrain – used to describe the components that generate power to deliver it to the rad surface. Usually used to refer to the engine and the transmission

Prill split – ratio of Platinum Group Metals

Reef – A regularly shaped and lengthy occurrence of an ore body

Reserves – a measure of the volume of valuable material (e.g. platinum, gold, oil etc), that can be mined or extracted, and provide an adequate return to the operator, given a certain set of assumptions on technological capabilities, commodity prices, foreign exchange rates, and other variables. Commonly reported in annual reports of extractive companies (e.g. mining, oil). It includes losses that are expected to occur when the material is mined

Shaft – a deep narrow vertical column that allows access to the ore body

Troy ounce – Traditional unit of weight used to measure precious metals, equivalent to 31.1 grams (compared to a normal ounce which is 28.35 grams)

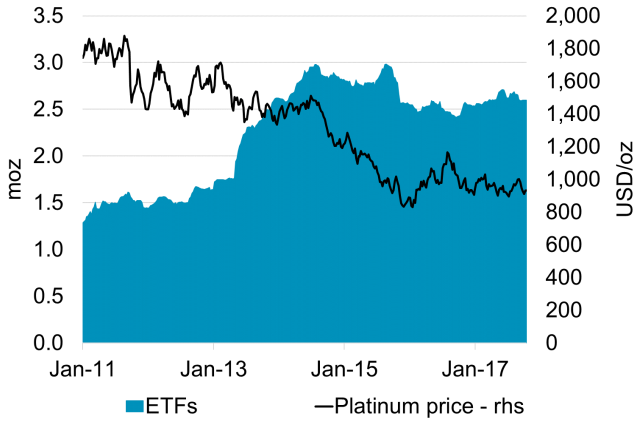
UG2 reef – Upper Group 2, layer of the Bushveld Complex, usually 20-400m below the Merensky Reef with a richer chromite content

ZAR – South African Rand

Platinum Essentials – Charts – October 2017

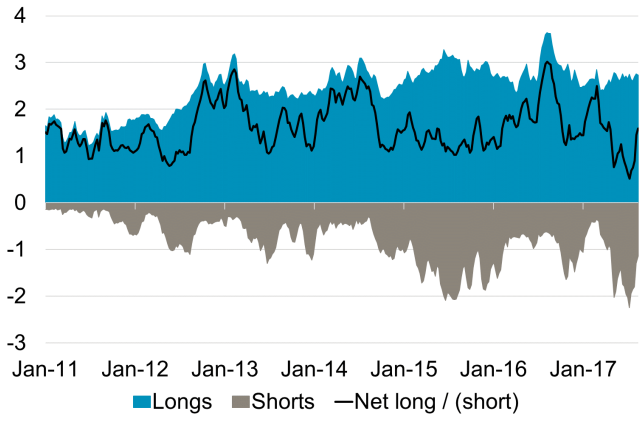
We show a summary of platinum investment holdings and price comparisons with other precious metals below

ETF holdings (moz) robust, platinum price USD/oz) driven by speculative positioning



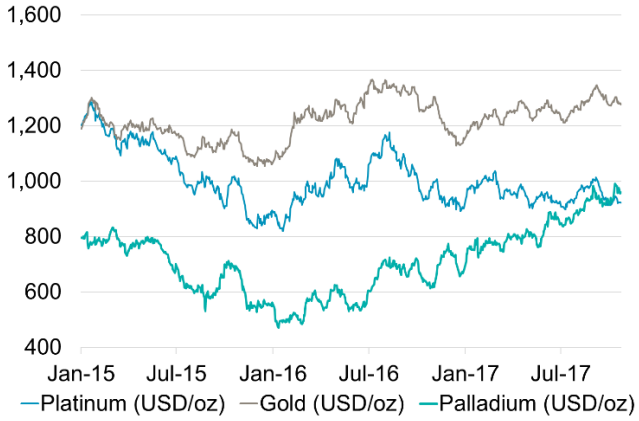
Source: Bloomberg, WPIC Research

Nymex positioning (moz); short positions at >2moz near the highest ever recorded



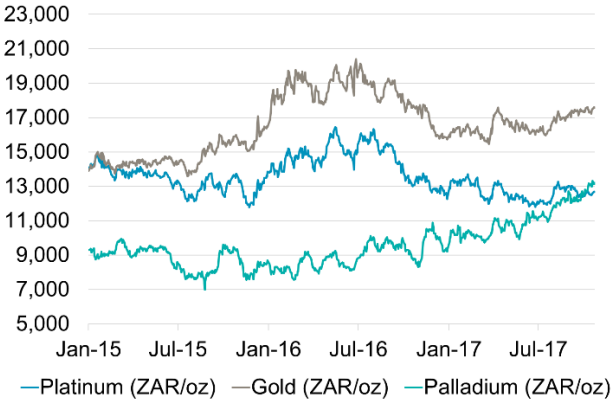
Source: Bloomberg, WPIC research

Platinum, palladium, gold prices (USD/oz)



Source: Bloomberg

Platinum, palladium, gold prices (ZAR/oz)

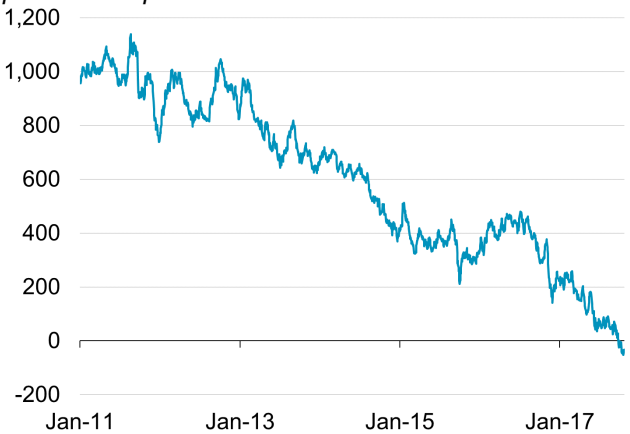


Source: Bloomberg, WPIC research

Platinum premium / (discount) to gold (USD/oz) - discount to gold at all time high

Source: Bloomberg, WPIC research

Platinum premium / (discount) to palladium (USD/oz) - premium to palladium at all time low



Source: Bloomberg, WPIC research

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