SFA Oxford

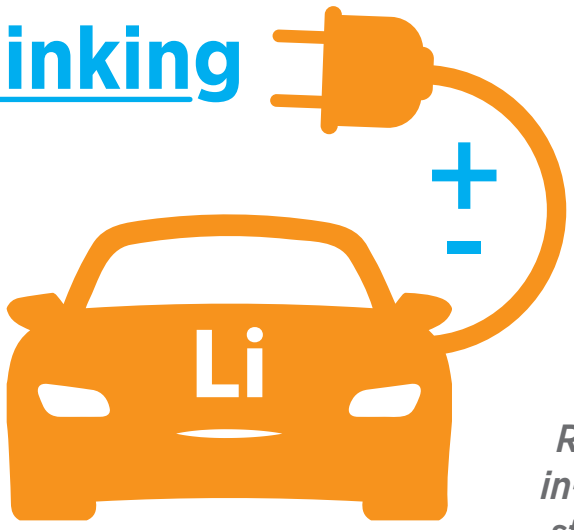
THE PLATINUM STANDARD

May 2018

One vehicle dataset, three metal forecasts

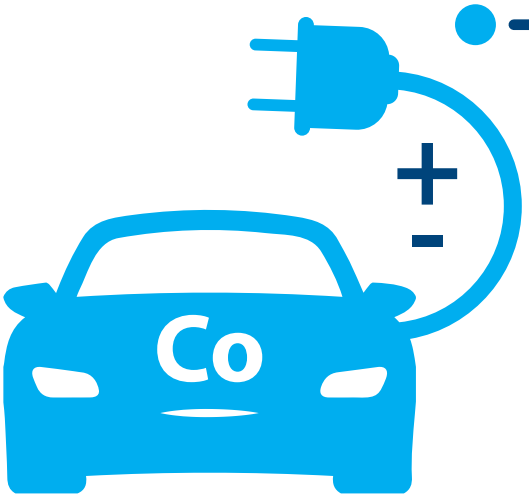
In this unique package, SFA (Oxford) takes you on a journey from today's powertrains (mostly ICE) to the powertrains of the future (BEVs, EREVs, hybrid, plug-in and fuel cell vehicles) and assesses the impact on key metals.

Equilateral Thinking

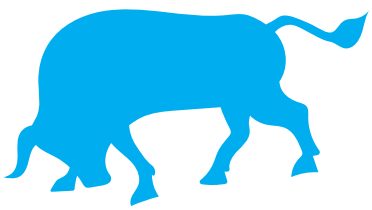


Regularly conducting in-depth lithium market studies for automotive and battery manufacturing clients since 2009

Due diligence assignments in the DRC and involvement in the cobalt industry go back ten years



Recognised world authority on PGMs



*For more information on equilateral thinking on **PGM**, **Cobalt** and **Lithium**, please contact MD, Beresford Clarke.*

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Edition 07

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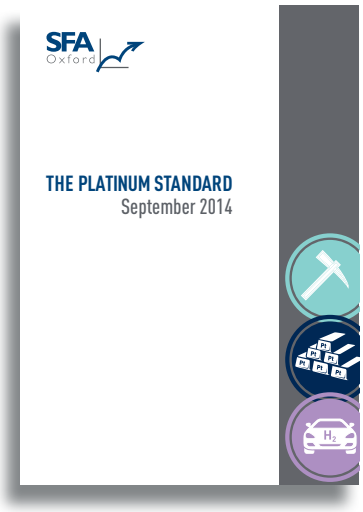
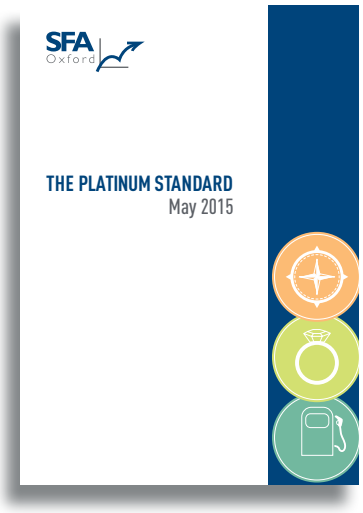
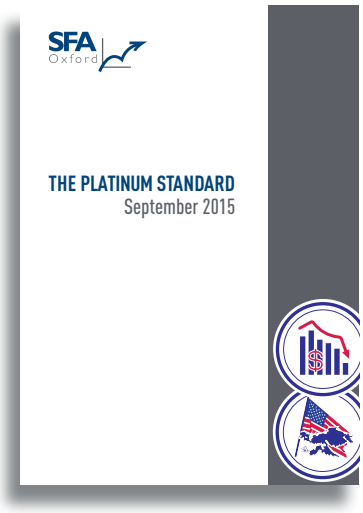
TPS COLLECTION: AGENDA-SETTING COMMENTARY

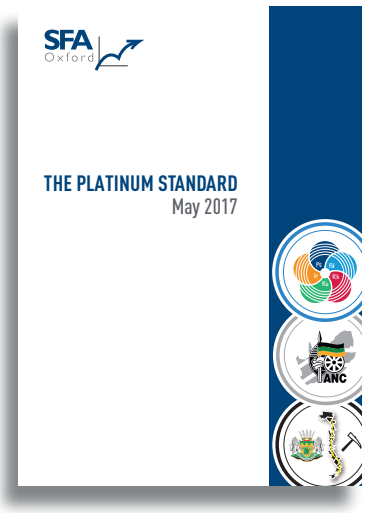


The Platinum Standard was launched in May 2014

One-half review, one-half preview, The Platinum Standard comprises analytical commentary on those issues we believe will set the PGM agenda for the years ahead







If you are interested in reading the collection, please contact our Head of Marketing, David Mobbs (dmobbs@sfa-oxford.com)

FOREWORD

Foreword

Nurturing smart responses to natural selection in platinum

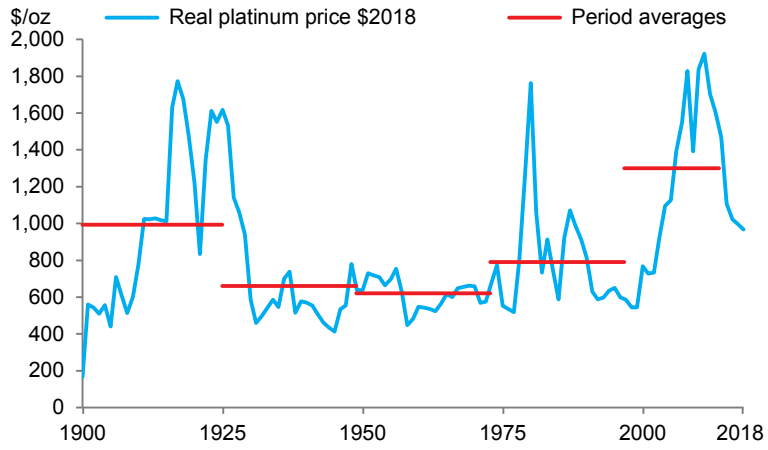
"There is a struggle for existence leading to the preservation of each profitable deviation of structure or instinct"

Charles Darwin, **'The Origin of Species', 1859**

Twenty years before *The Origin of Species* was published, William Grove invented a "voltaic battery of extraordinary energy" and then the fuel cell, both with platinum electrodes[1]. So platinum has been at the centre of "profitable deviations of structure", adding unfailingly to the sum of human welfare, longer than the theory of natural selection has been shaping the way we think about the evolution of humankind. Indeed, it's more than likely that Grove and Darwin crossed paths and ideas – Darwin became a member of the Royal Society in 1839, just over a year before Grove. Would they consider platinum 'a survivor' now?

Evolution is not straight-line progress – witness two steps backward, two steps forward in the real platinum price (in 25-year periods) since 1900. Everything relating to demand and supply – see the chart below – has changed in over a century, yet much, real-price-wise, remains the same! Johnson Matthey's (JM) first (unpublished) analysis of the market in 1930 "expressed deep concern about the [then] future", with the prospect of declining post-Depression demand and increased (mine) supply (see *JM Platinum Review 2005*). And here we are, still in the economic shadow of the financial crisis and with increased recycled supply now 'the new South Africa'.

Steps in platinum's price evolution

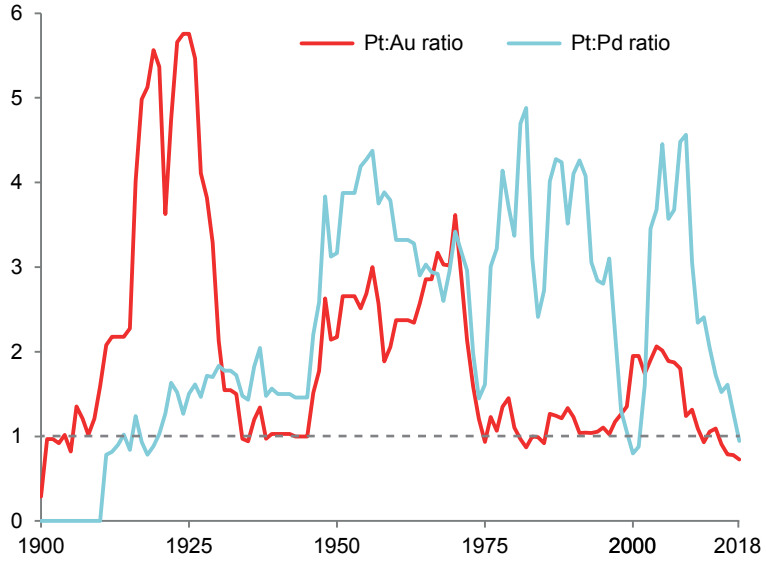


Source: SFA (Oxford)

[1] *Johnson Matthey, 1985.*

This unease that platinum's struggle for mere existence is purposeless is compounded because its price appears to be back to square one, relatively speaking. It's back to parity (or worse) with gold (one metal, thanks to its monetary origins, that has never had to struggle for existence in the ebb and flow of demand and supply) and with palladium (historically, the 'runt of the PGM litter').

Platinum's close relations

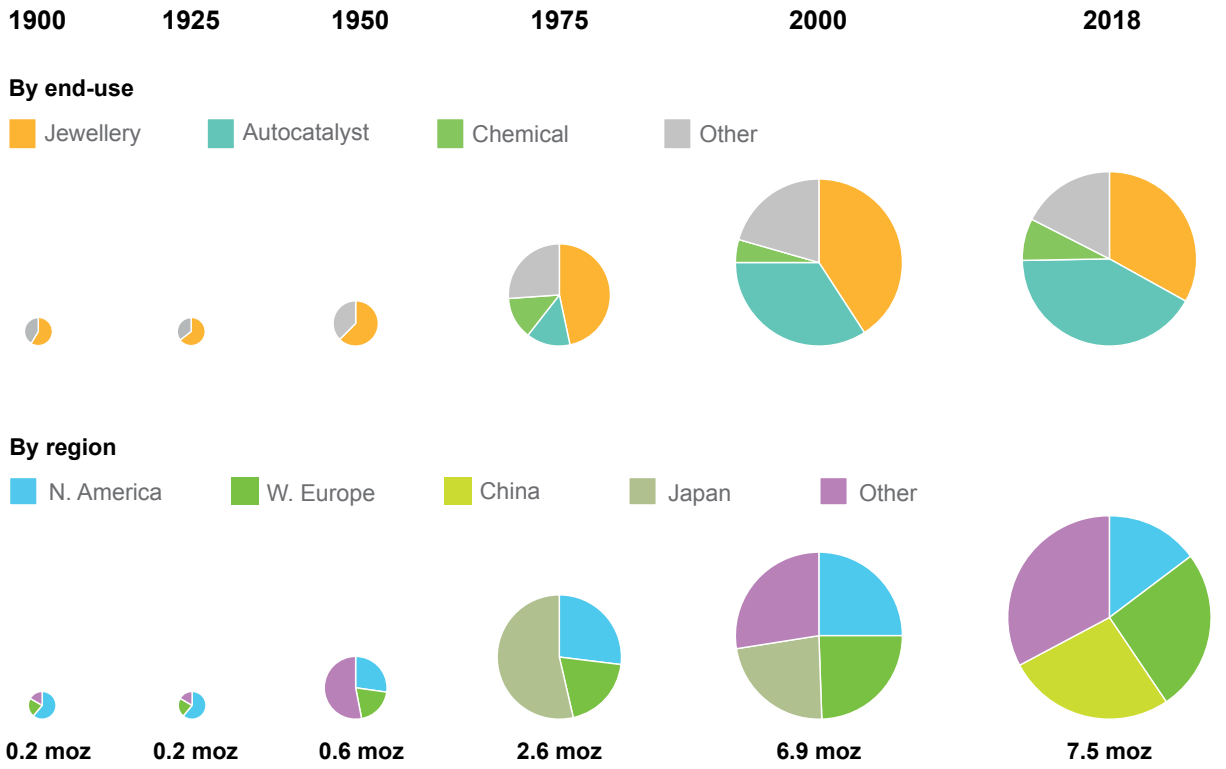


Source: SFA (Oxford)

"From so simple a beginning, endless forms most beautiful and most wonderful have been, and are being evolved"

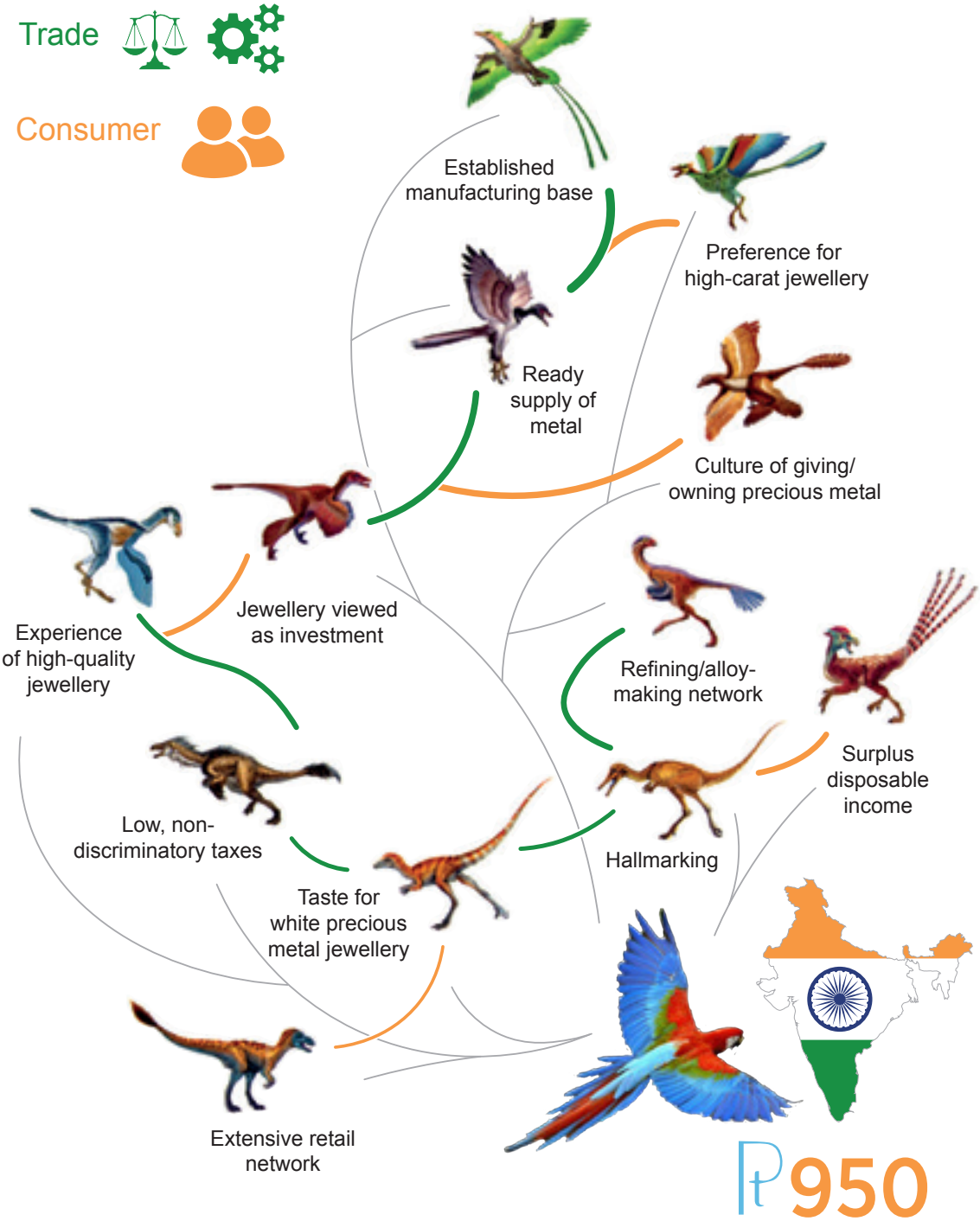
Platinum's demand by end-use and region is a Darwinian example of 'constant variation'. It's as if platinum is experimenting with which end-use and market mix survives best in an ever-changing economic climate. From mainly industrial use (in the West) to jewellery (in the US, then Japan) to autocatalysts (in the West, then China – shaped by and shaping the environment for the good). Maybe 'smartness' will eventually be identified as part of platinum's DNA?

The evolution of platinum demand species



Source: SFA (Oxford), Indicative estimates based on historical references including Johnson Matthey, Umicore, Southern African Institute of Mining and Metallurgy, and "A History of Platinum and its Allied Metals" by Donald McDonald and Leslie Hunt

Platinum jewellery in India is built on solid foundations



Source: SFA (Oxford), Palaeos

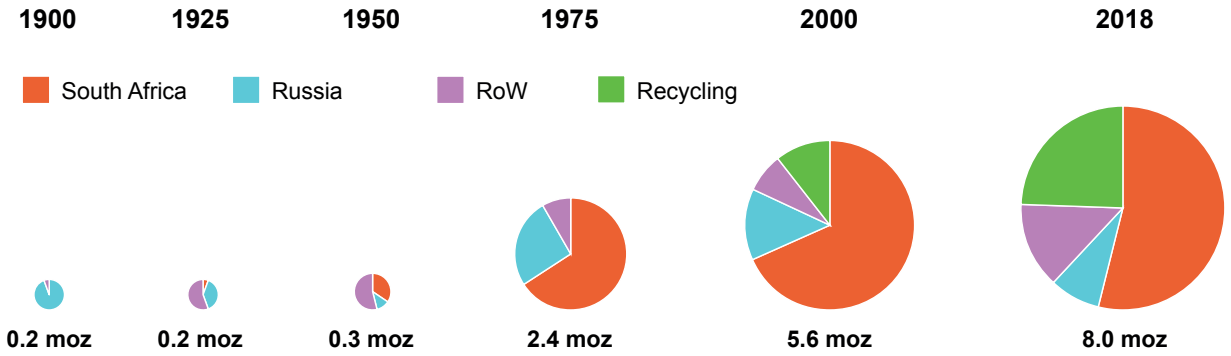
As for platinum demand's next evolutionary stage – why not jewellery in India? Jeremy Coombes writes of the challenge of introducing a new 'species' (platinum jewellery) into a perhaps uncongenial environment where another precious metal (gold) is already dominant. But he concludes that the odds of platinum more than 'surviving' there are pretty good.

Platinum's demand is also a prime Darwinian example of the 'preservation of profitable variations'. For example, China is 'leapfrogging', learning from the West, to the benefit of platinum demand. As Hans-Günter Ritter of Heraeus notes, China is already imposing Euro 6 emission standards, at less than half of Europe's income per head, and is already 'mining' local supply through state-of-the-art recycling. And China is motoring to EVs faster than the West, helping to keep palladium demand vibrant, at least for the medium term.

"We are always slow in admitting any great change of which we do not see the intermediate steps"

The evolution of platinum supply is a no less remarkable tale. Dominance in mine supply has switched from Colombia, to Russia, to South Africa. Now the market ponders whether the geographically-überadvantaged Zimbabwe (a quarter of the depth of South African deposits and twice the stope width) can make the transition from pariah to saviour in platinum mining. Sam Trickey thinks that much depends on detoxing the hostile political environment. Meanwhile, the 'mine' in the car, the circuit board, and necklace has quietly grown to rival the prime supply species. As Hans-Günter emphasises, there are almost no lengths or distances to which the supply-side will not go.

The evolution of platinum supply species



Source: SFA (Oxford), Indicative estimates based on historical references including Johnson Matthey, Vermaak, US Census Bureau 1900

Will platinum be favoured in 'the struggle for life'?

Despite over a century of market intelligence, for the future (as Darwin admitted), "The more important objections relate to questions on which we are confessedly ignorant; nor do we know how ignorant we are." So, humbly, here are two Darwinian takeaways:

1. "The greatest amount of life can be supported by great diversification of structure"

You don't have to be a renowned biologist or investment adviser to appreciate that it's best not to put all your eggs in the same basket. So, should the struggle for extra platinum demand be in jewellery, industry, or investment? Yes, yes and yes!

2. "A grain in the balance will determine...which variety or species shall increase in number, and which shall decrease, or finally become extinct"

Platinum is a market of slim margins. It increasingly turns on fine judgements, seemingly tiny events. Johnson Matthey reviews from 1985 lifted the veil, irrevocably, on the previously mysterious workings of the market. As a result, suckers have largely become extinct. We are entering an era of incremental (so sustainable) change, hard yards, not gung-ho eureka moments that fool fewer and fewer.

So, while not underestimating the challenges ahead for platinum – indeed, we've more often than not being accused of exaggerating them! – we take a measured, hopeful view: we "can see no limit to this power, in slowly and beautifully adapting each form to the most complex relations of life."

ENTER THE DRAGON: HERAEUS BUILDS THE WORLD'S MOST ADVANCED PGM FACILITY

Enter the dragon: Heraeus builds the world's most advanced PGM facility

Hans-Günter Ritter, Head of Precious Metals Trading at Heraeus Precious Metals

The largest precious metals service provider

As a major global player with extensive expertise covering the entire precious metals loop, Heraeus Precious Metals (HPM) holds an important place in the precious metals industry. In 2017, HPM acquired 100% shares of the Swiss precious metals processor Argor-Heraeus, making it the world's largest provider of industrial precious metals services. HPM aims to partner with and invest in companies that share the same level of ambition, and its commitment to expanding its leading position in precious metal supply and life-cycle services is demonstrated by the recent investment in Northam Platinum's state-of-the-art platinum smelter at Northam's Zondereinde mine in South Africa. This joint agreement strengthens HPM's global supplier network, enabling the company to offer secure and dependable access to PGMs for the next 20 years.

Enter the dragon: a major strategic investment

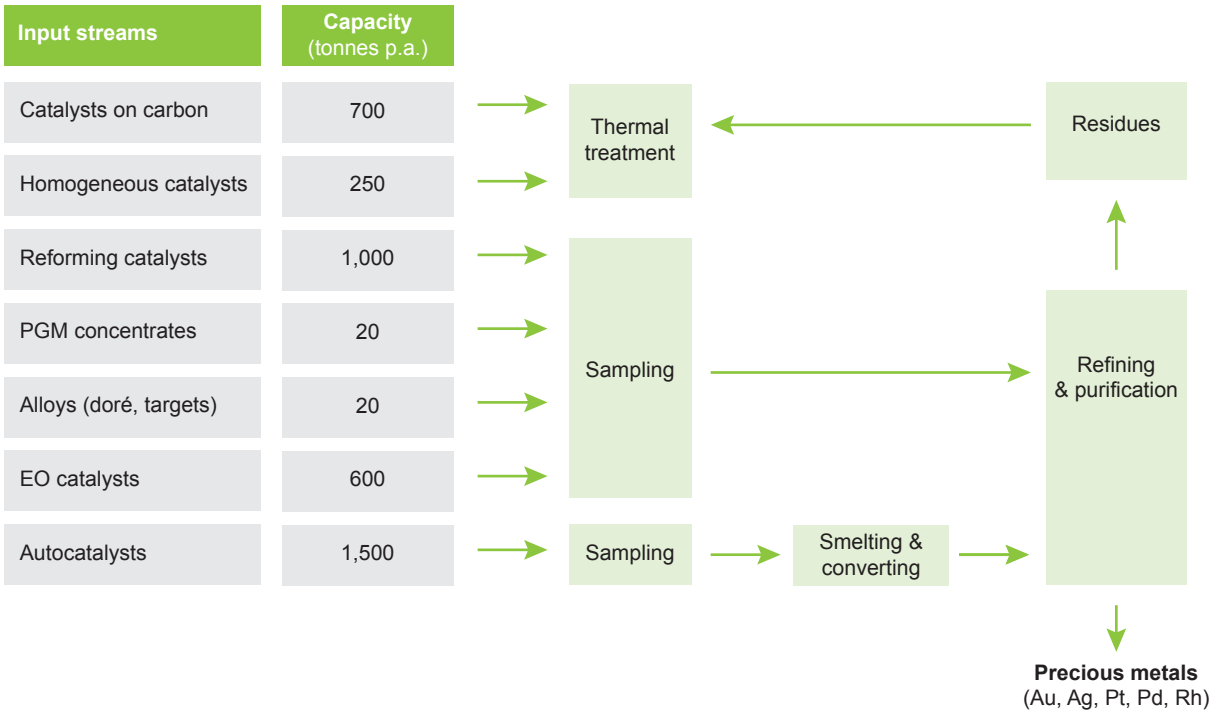
The most advanced precious metals factory, located in Nanjing, China.
Source: Heraeus Group

Heraeus Precious Metals takes strategic decision to invest in precious metals refining and recycling in China

The speed of economic development in Asia, particularly China, means that HPM's strategic decision to open a new precious metals refinery and recycling facility in Nanjing (shown above) is both timely and necessary, given the significant increase in Chinese demand for PGMs for use in key industries.

These metals are increasingly important for the manufacture and processing of many essential goods in China, for example in fertilisers, electronics, glass, chemicals, petrochemicals, pharmaceuticals, automotive catalysts, silicones, as well as photovoltaics.

Nanjing processing streams



Source: Heraeus Group

Opening in September 2018, the Nanjing facility offers both wet chemical and pyrochemical refining using the highest compliance standards to ensure sustainable production for a global market.

The new factory uses advanced technologies and will produce process catalysts based on precious metals for China's chemical industries, as well as precious-metal-based chemical compounds for automotive catalysts. For example, the new factory will manufacture Karstedt catalysts, which are used to produce silicones for industry sectors such as dental, automotive, and paper. It will also significantly enhance the company's capacity to recycle precious metals, especially PGMs. To ensure maximum resource savings, Heraeus offers enhanced recycling capabilities for catalysts and will completely re-use the retrieved precious metals for new products.

This is especially important since China has only very limited natural PGM resources and relies on either imports or recycling. In 2015 China's platinum demand was 25 times higher than the country's own mine supply. The new recycling site also offers the capacity to be a major processor of spent autocatalysts, a key local supply of palladium. The idea of a loop economy, where used raw materials such as precious metals are being recycled and re-used, and therefore kept in the product life-cycle, is one of China's governmental priorities in order to create a more sustainable economic system.

China has a very limited local supply of PGMs, so recycling is critical

HPM's Nanjing Precious Metals Factory

Heraeus's new factory is located at the Nanjing Chemical Industry Park and will comprise an area of 84,000 square metres. The factory and office buildings are designed to apply and even exceed latest EHS standards, codes and regulations by the PRC nation, Jiangsu Province, Nanjing city and Nanjing Chemical Industry Park. "With our advanced technologies we will support China's next five-year plan in all aspects: In innovation, green development and also socially: More than 200 highly skilled experts will be working in our new site by 2020", says Heraeus CEO Jan Rinnert.

The most advanced precious metals factory, located in Nanjing, China

China shifts demand from platinum to palladium

In recent years, the rapid growth in new vehicle ownership in China has been largely responsible for a switch in demand from platinum to palladium. This swing towards palladium coincides with cutbacks in South African PGM mine supply as a consequence of the low platinum price. This showed a significant effect on the profitability of producers, leading to the mothballing or closing of mines. Owing to China's high dependency on PGM imports, it is possible autocatalyst recycling could help to close the loop for China to eventually become self-sufficient in palladium. HPM is now well positioned to secure growing secondary supplies of PGMs to meet local end-user requirements.

Demonisation of diesel puts platinum under pressure

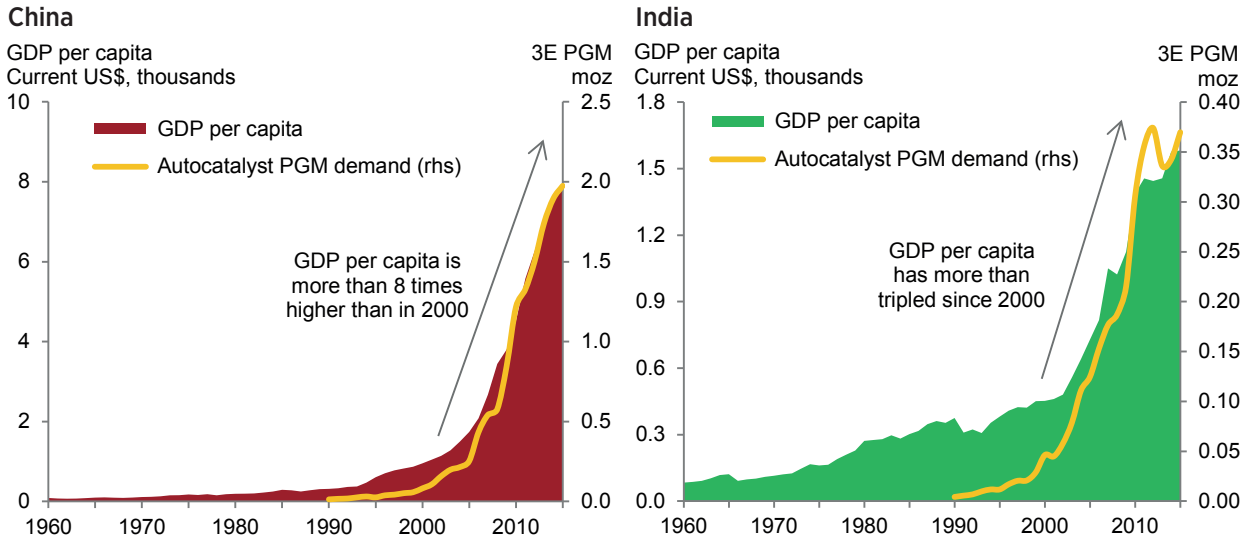
Worldwide, PGM demand is overwhelmingly reliant on the automotive market which accounts for 64% of global consumption. As vehicles are an expensive discretionary purchase, this demand can be impacted by fluctuations in the global economy. However, many of the old certainties that have governed PGM demand forecasting over the past 10 to 15 years are currently being disrupted.

Platinum is coming under pressure from the ongoing attack on diesel vehicles following the emissions scandal in 2015, with increasingly stringent air quality legislation and mayors in several major cities worldwide already announcing bans on older polluting cars.

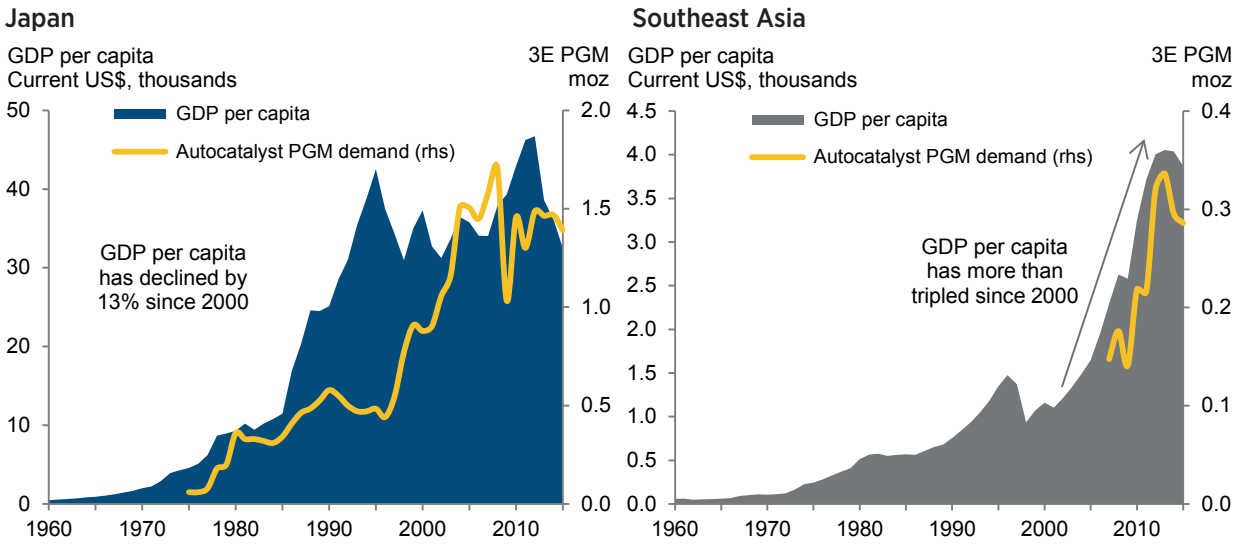
Vehicle ownership in Asia expands in line with population wealth

Rising gross domestic product per capita in Asia, which can be used as a measure of wealth, is driving PGM demand, particularly in relation to automotive demand, which can be used as a measure of wealth. The charts below show how in recent years the rapid increase in personal wealth has gone hand in hand with PGM demand in China, India and Southeast Asia. Despite an initial slight lag in Japan, PGM demand soon caught up with wealth, but tailed off as the economy matured.

Asia GDP per capita and 3E PGM demand



Source: SFA (Oxford)

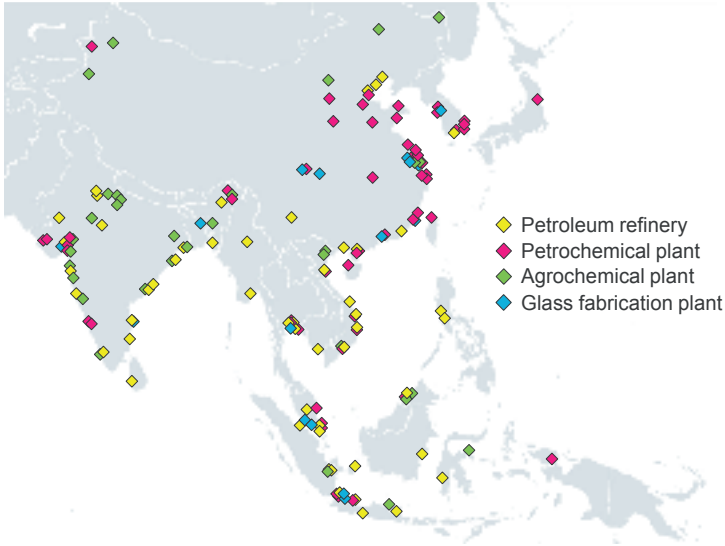


Source: SFA (Oxford)

As population wealth in Asia has risen, so too has the need to fill cars with fuel, to make nitric acid for fertiliser for food production, and to produce glass, particularly for discretionary purchase products such as flat-screen TVs. This diversity of demand arising from increasing wealth should create a secure market base for PGMs and HPM's Nanjing facility. The map shown below indicates the locations in Asia of more than 100 potential new plant projects that are likely to need PGMs in years to come. While they may not all materialise, the total could add up to 1 million ounces of platinum if all of the projects were to go ahead.

Growing population wealth in Asia creates secure market base for PGMs

Potential locations of new PGM chemical plant projects



Over 100 new potential plant projects in Asia that are likely to need PGMs

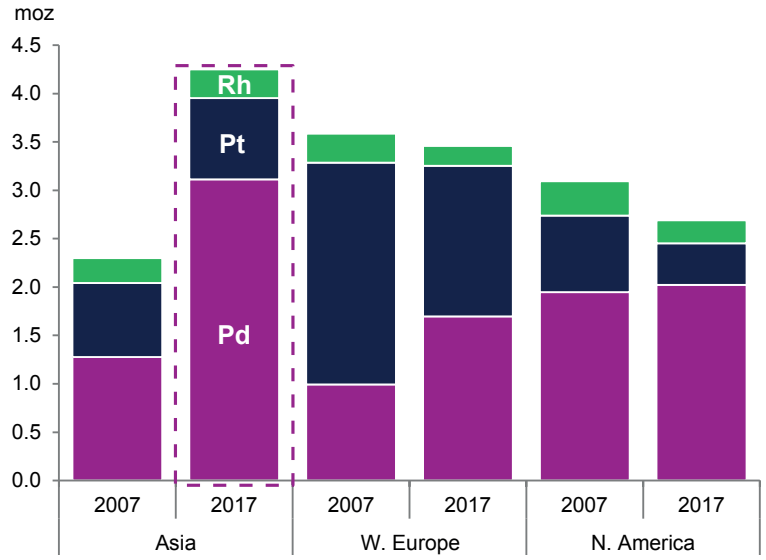
Source: SFA (Oxford)

In terms of Asia's PGM demand, which is not usually collated on a continental basis, it is palladium autocatalyst demand that has outperformed in the region since 2007, more than doubling to over 3 million ounces. This will ensure a major supply to HPM's Nanjing facility in future. However, growing automotive demand and rising prices have had an impact on other end-uses which have shown flat or negative growth over the same period, particularly jewellery.

Platinum loses ground in Asian markets

Whilst palladium demand has benefitted on the major continents, especially in Asia where the automotive markets overwhelmingly favour gasoline vehicles, the story for platinum is somewhat different. As the chart below demonstrates, platinum has lost ground in Western Europe and North America where demand is yet to recover to pre-financial crisis levels, and Asia has now become the global leading market for palladium.

Automotive PGM demand



Source: SFA (Oxford)

Palladium demand in Asia has doubled since 2007

Although strong growth in sales of new gasoline cars has boosted palladium requirements, the outlook is very different for platinum in China. There, despite rising incomes, demand for platinum jewellery peaked around five years ago and is now 650,000 ounces below peak levels. With the PGM industry overly exposed to the automotive sector, significant investment is required to divert new end-use offtake including jewellery and other industrial demand. Investment should also be maintained in the automotive industry to ensure continued PGM demand uptake.

Ongoing tight market for palladium expected

Looking back over several decades, it is apparent that cycles and patterns emerge in the palladium market which are largely driven by emissions legislation. The market has been in structural deficit since 2007 and going forward stocks will continue to decline as sales of cars containing palladium-rich catalysts rise. Historically, although the platinum market has also been driven by tightening emissions legislation, the continuing move away from diesel passenger cars and the fall in discretionary jewellery sales have played a significant role in the market being weaker when compared to palladium in recent years.

Automotive demand dominates while industrial and jewellery face headwinds

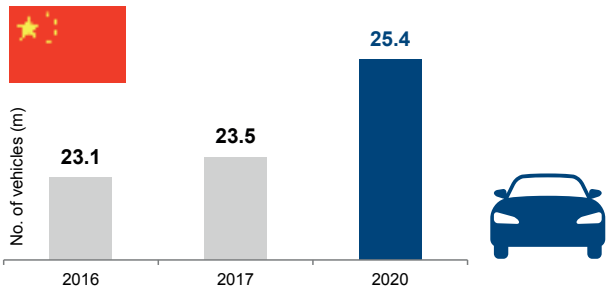
The market for palladium is likely to be tight through to 2025, but less so for platinum – a situation which may require the consideration of reverse substitution in autocatalysts. Platinum has been steadily removed from autocatalyst formulations over recent years largely on price grounds, promoting substitution by palladium. However, platinum has more diversified end-uses which means that it is not just reliant on use in autocatalysts, so there could be a shift in the demand ratio in platinum's favour despite diesel's difficulties, suggesting palladium's increasing price premium over platinum may ultimately be limited. Bosch's recent announcement of clean diesel technology might be the turning point of the negative trend. The regaining of lost trust is, however, a long way away.

China's increasing vehicle sales and more stringent legislation threaten palladium supply

The greater demand for palladium from the ever-growing global vehicle parc could begin to outstrip supply towards the middle of the next decade. Growing urbanisation in China, due to migration from small agricultural settlements to the bigger cities, is expected to continue to promote the growth in Chinese per capita vehicle ownership, although this is not likely to reach the levels seen in mature markets. In response to the huge increase in the number of vehicles which has contributed to the existing pollution problems in major cities, the Chinese government has taken definite steps to catch up with the stricter air quality legislation already imposed in the Western world. As of January 2018, all vehicles must comply with China 5 legislation, which is equivalent to Euro 5 regulations. The timeline for the introduction of Chinese regulations is given in the graphic overleaf, along with a chart illustrating the acceleration in vehicle ownership between 2016 and 2020.

Tightening Chinese emissions legislation continues to support PGM autocatalyst demand

Accelerating vehicle sales, 2016-2020



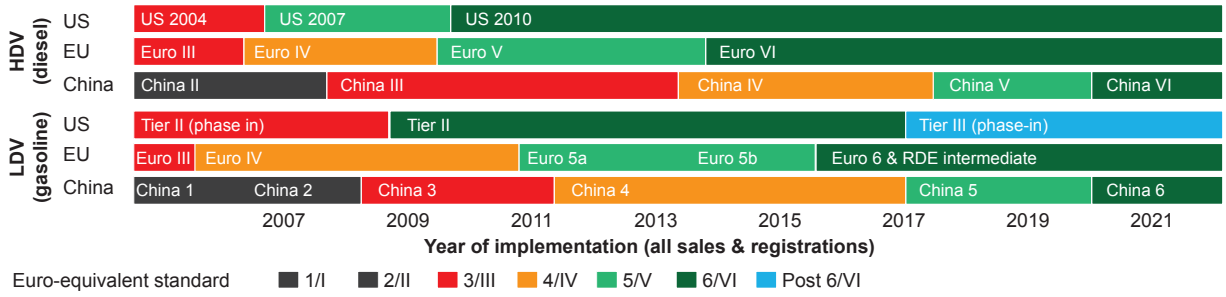
Source: Heraeus Group

Numbers of cars will grow significantly

Emission regulations will become stricter

China's government will enforce its regulations towards a green and cleaner country

Timeline for introducing Chinese regulations



Source: Heraeus Group

The rapid acceleration of the introduction of tighter emissions legislation will continue to support PGM autocatalyst demand, primarily in gasoline vehicles, so palladium demand will continue to rise, requiring innovative solutions to the potential supply shortfall.

PGM catalyst products and ingredients will become more important to China

Palladium recycling could be crucial to address supply shortfall

Recycling of palladium is likely to be a critical factor in addressing the supply shortfall and so is expected to see expansion in all regions, but growth will be especially strong in China. The Nanjing facility represents a significant investment on the part of HPM and is a major step towards driving the momentum for Chinese recycling of PGMs. In 2017, car sales in China reached over 28 million and these vehicles will be reaching the end-of-life in the middle of the next decade when their catalysts can be recovered.

Since the autocatalyst recycling industry in China is still in its infancy, it is not clear whether the market will develop sufficiently by then, unless legislation is passed to allow it to reach its potential. If this happens, very high PGM recovery of more than 90% is technically possible, although this could be curtailed by the lack of structure in the system of collection for spent catalysts.

Could China become self-sufficient in palladium?

In conclusion, China's PGM demand has swung towards palladium from platinum owing to the increasing sales of new gasoline cars.

Recycling could play a key part in maintaining PGM supply

So, this raises an important question: if higher prices for palladium result in an acceleration of autocatalyst recycling in China, could the country become self-sufficient in palladium?

In the medium term, the answer to this question would appear to be 'no' because the demand for palladium is forecast to exceed the volume of recycling and so PGMs will have to continue to be sourced from other regions, including South Africa.

Potential for Chinese self-sufficiency depends on NEV infiltration and recycling

Growth in the Chinese automobile market is likely to be constrained by several factors, including congestion in Tier 1 and 2 cities – limiting car purchases – and the potential infiltration into the vehicle market of hybrid, battery electric, and fuel cell electric vehicles (known collectively in China as New Energy Vehicles (NEVs)), which will inevitably reduce PGM demand. If battery electric vehicles were to infiltrate the Chinese automobile market at a faster rate than is currently predicted, thus displacing combustion engines and hybrids, there is a strong possibility that China could become self-sufficient in palladium through recycling. Fuel cell technology is developing rapidly, with cars and buses now commercially available that are on a par with conventionally powered vehicles. If it chooses, China is well placed to build a fuelling infrastructure, often regarded as one of the barriers to wider deployment of fuel cell vehicles. Platinum loadings in fuel cells continue to fall, as is necessary for them to achieve competitive pricing with other powertrains, at which point volumes can rise to become a useful additional stream of platinum demand.

The construction of the precious metals refinery and recycling facility in Nanjing ensures that Heraeus continues to be a key provider of PGMs, particularly palladium, to growth industries in China. The company is also strategically well positioned to secure PGM supplies as the local availability of PGM-loaded autocatalysts increases in future.

About Heraeus

Heraeus Precious Metals (HPM) is a global business unit of German technology group Heraeus. The Hanau-based, family-owned technology group – which started out as a pharmacy in 1660 and was founded as a company in 1851 – has a portfolio of businesses under the umbrella of the holding. These businesses are focused on themes such as the environment, energy, health, mobility, and industrial applications. In the 2017 financial year, the FORTUNE Global 500 listed company generated a total revenue of €21.8 bn. With approximately 13,000 employees worldwide in more than 100 subsidiaries in 40 countries, Heraeus holds a leading position in its global markets.

WEALTH OR STEALTH: WILL ZIMBABWE UNLOCK ITS FULL MINING POTENTIAL?

Wealth or stealth: will Zimbabwe unlock its full mining potential?

Samantha Trickey, Principal Supply Analyst, SFA (Oxford) Ltd

Ongoing fiscal and regulatory uncertainty

Robert Mugabe was succeeded as president by his former deputy, Emmerson Mnangagwa, on 24 November 2017 following a coup d'état by the Zimbabwe Defence Forces (ZDF). Mnangagwa is currently serving as interim president ahead of a general election, scheduled to take place in July 2018.

Among Mnangagwa's cabinet appointments, Winston Chitando was made Minister of Mines and Mine Development. Chitando replaces Walter Chidhakwa, who is being investigated by the Zimbabwe Anti-Corruption Commission relating to his activities with the Minerals Marketing Corporation of Zimbabwe (MMCZ). Chitando is Chairman of the Platinum Producers Association and, having held senior positions with a number of mining companies operating in Zimbabwe – including Mimosa Holdings and Anglo American Corporation – is at least cognisant of the challenges that producers face. While Chitando has been vocal about ensuring policy clarity and promoting new mining investment since his appointment, the government has yet to work out many of the technicalities on issues such as ground ownership, taxation, indigenisation and beneficiation before it can set out comprehensive mineral development policies.

The new Mines Minister has a long affiliation with mining

The key barriers to conducting business in Zimbabwe have been access to financing, political instability, corruption, lack of infrastructure, and property rights protection. The Indigenisation and Economic Empowerment Act (IEEA), ratified by Mugabe in 2007, is one of the key areas of concern and uncertainty for the Zimbabwean mining sector. The IEEA aimed to transfer the country's wealth to indigenous Zimbabweans but there has been no clarity on whether or not companies would be able to sell a stake at market value. This ownership requirement is now under review. Chitando is limiting application of the law to just diamond and platinum mines, and has stated that the 51% ownership threshold will be maintained but not increased, while the Mines and Energy Portfolio Committee Chairperson, Temba Mliswa, would like to see the level reduced to 20-30%. At the same time, new hurdles are being discussed, including a possible requisite listing of mining companies on the local exchange in return for the award of mining rights – although there is unlikely to be sufficient liquidity to support this move.

Zimbabwe "open for business" but needs to put in place a clear regulatory framework

Regulatory fees for miners also mount up, but some concessions have been made in the 2018 budget statement. Historically, royalty rates have been charged at 10% of gross platinum sales, but have temporarily been reduced to 2.5% owing to depressed platinum prices.

Levies are imposed by local councils and the MMCZ, and mining ground rental fees (previously $3,000/hectare per year, but reduced to $225/ha) and community/social expenditure requirements all raise the barrier to entry. Introduction of a tax on raw and semi-beneficiated platinum exports has been deferred multiple times since 2013, and is currently expected to be imposed from January 2019. Initially set at a broad-brush 15%, the tax has now been restructured to a sliding scale of 5% for concentrate exports, 2.5% for white matte, 1% for BMR stage, and 0% for fully refined platinum.

July 2018 elections: not a sure thing

Over 100 political parties are lining up to take part in the July elections. The major parties include: the Zanu-PF; the politically volatile MDC Alliance (comprising seven parties) led by 40-year old Nelson Chamisa; the fragmented People's Rainbow Coalition of former vice president Joice Mujuru; Nkosana Moyo's novice Alliance for People's Agenda; Dumiso Dabengwa's peripheral and ethnic-based Zapu; and retired brigadier Ambrose Mutinhiri's New Patriotic Front which embraces Mugabe, his wife, and disgruntled Zanu-PF members of the Generation 40 faction.

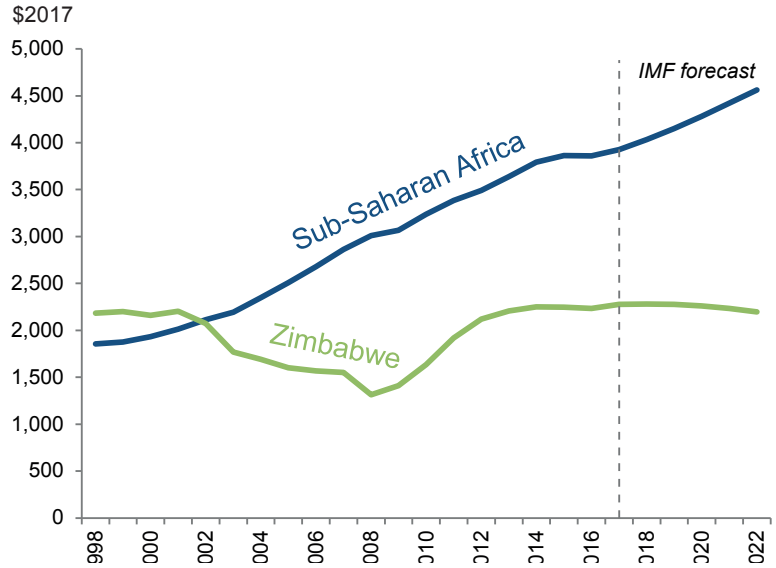
The July 2018 election is not a guaranteed victory for Mnangagwa. The association between the government and the military remains strong, with Mnangagwa giving high profile cabinet positions to military figures. The vice president's (a former military commander) hard-line handling of recent industrial action by members of the Zimbabwe Nurses' Association will have done little to improve party popularity or help to soothe past grievances, and sends mixed messages at a time when Zimbabwe's leaders need to present a united front. Moreover, Zimbabwe's poor economic performance and social decay under Zanu-PF rule allows a foot in the door for the leader of the MDC Alliance party – but a coalition government is more likely than an all-out opposition victory, as Zanu-PF holds 71% of senatorial seats and 76% of parliamentary seats.

Victory is not guaranteed for Mnangagwa

The Zimbabwean economy is fragile because of uncertainties and inconsistencies in policy, and GDP growth has been undermined by droughts, cash shortages, commodity price declines and a strengthening US dollar. While dollarisation somewhat stabilised the economy between 2009 and 2012, Zimbabwe has been deprived of its own currency and is at the mercy of foreign investors. The trade deficit has reduced significantly since the early 2010s, but the country is suffering a severe cash shortage and the central bank has issued

$500 million in low denomination bond notes since November 2016. The country has to attract dollars with an environment attractive to investors, but the imposition of sanctions by the EU and US over the past two decades means that Zimbabwe is lagging behind other African economies in this respect. Long delays in the processing of foreign payments because of cash shortages has also caused problems for local miners and negatively impacted on production volumes.

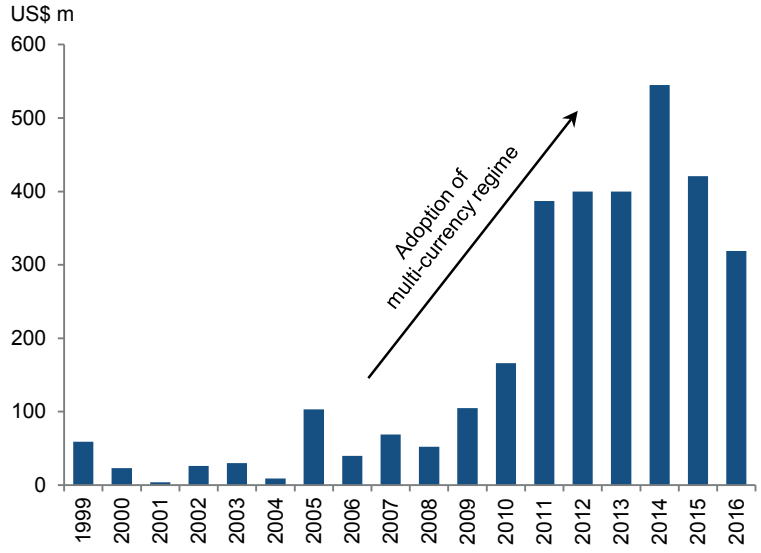
GDP per capita, purchasing power parity



Source: SFA (Oxford), IMF

Zimbabwe's economy has massively underperformed

Foreign direct investment flows



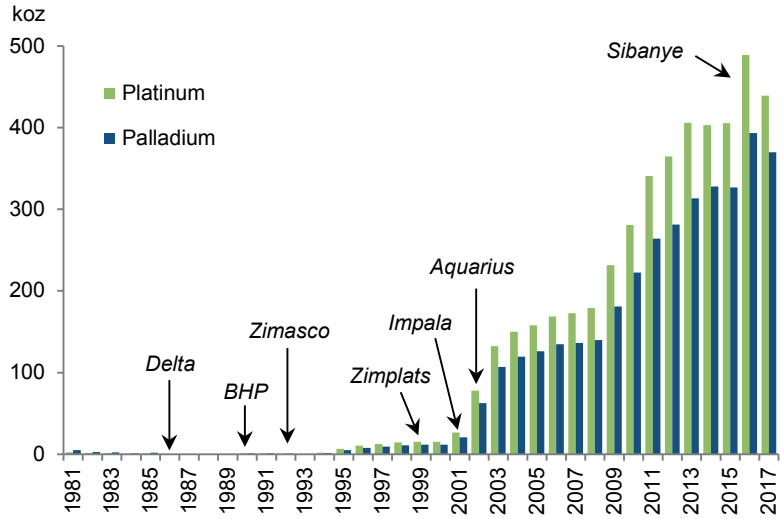
Source: SFA (Oxford), World Investment Report

Attracting FDI is critical for Zimbabwe's recovery

The mining sector is performing far below its potential

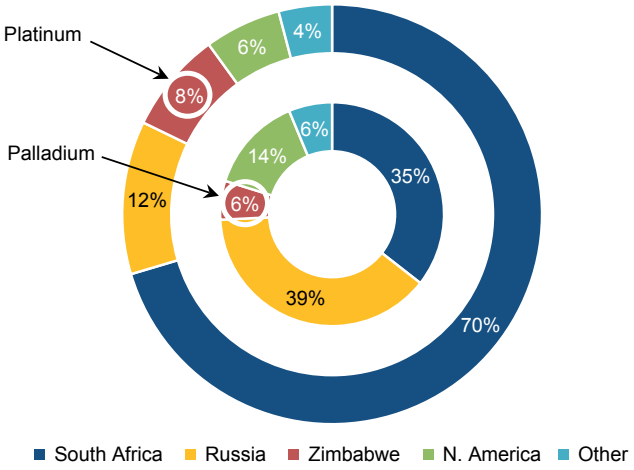
The mining sector contributes nearly $2 billion, or 12%, to Zimbabwe's GDP. Export earnings from the mining sector totalled $3.4 billion in 2017, and are forecast to increase to $3.7 billion this year. But this is only a fraction (<20%) of what the country's mines could be generating. PGM exploration activities have taken place on many different areas of the Great Dyke since the 1960s, yet production is currently limited to three mines, contributing just 8% of global platinum supply and 6% of palladium supply. The following chart shows the increase in platinum and palladium production in Zimbabwe from just a few ounces in the 1990s.

Historical production from Zimbabwe



Source: SFA (Oxford), company reports

Production by region, 2017



Source: SFA (Oxford)

Zimbabwe accounts for just 8% of global platinum supply and 6% of palladium supply

Despite limited development, the PGM-bearing Main Sulphide Zone (MSZ) is a very attractive ore body. The MSZ is wide, accommodating stoping widths of approximately 2-2.5 m. This allows for a high degree of mechanisation, which is not only more efficient and lower-cost than conventional mining techniques, but also reduces the reliance on people and is therefore inherently safer. The labour cost component for conventional mines is typically over 60%, compared to 40% or less for mechanised mines and less than 20% for open-pit operations. Average stoping widths on the Western and Eastern Bushveld are around 1.2 m, often requiring conventional stoping methods. A narrow grade distribution for the Merensky Reef also means that there can be excessive dilution (overbreak).

The MSZ is a high-quality, low-cost PGM ore body to mine

The MSZ is a shallow ore body that can be accessed via less capital-intensive decline shafts – the average shaft depth is less than 250 metres below surface (mbs), compared to around 1,000 mbs in South Africa. Shaft depth is a significant contributor to a lower cost profile for Zimbabwe – mines are almost twice as efficient as Western Bushveld operations on an ounce per worker basis. The nickel and copper content of the ore (up to 0.22% Ni and 0.14% Cu in the Selukwe sub-chamber) also serves to reduce cash costs. Net cash costs for Zimbabwean mines typically average 45% lower than total cash costs ($/4E oz basis)

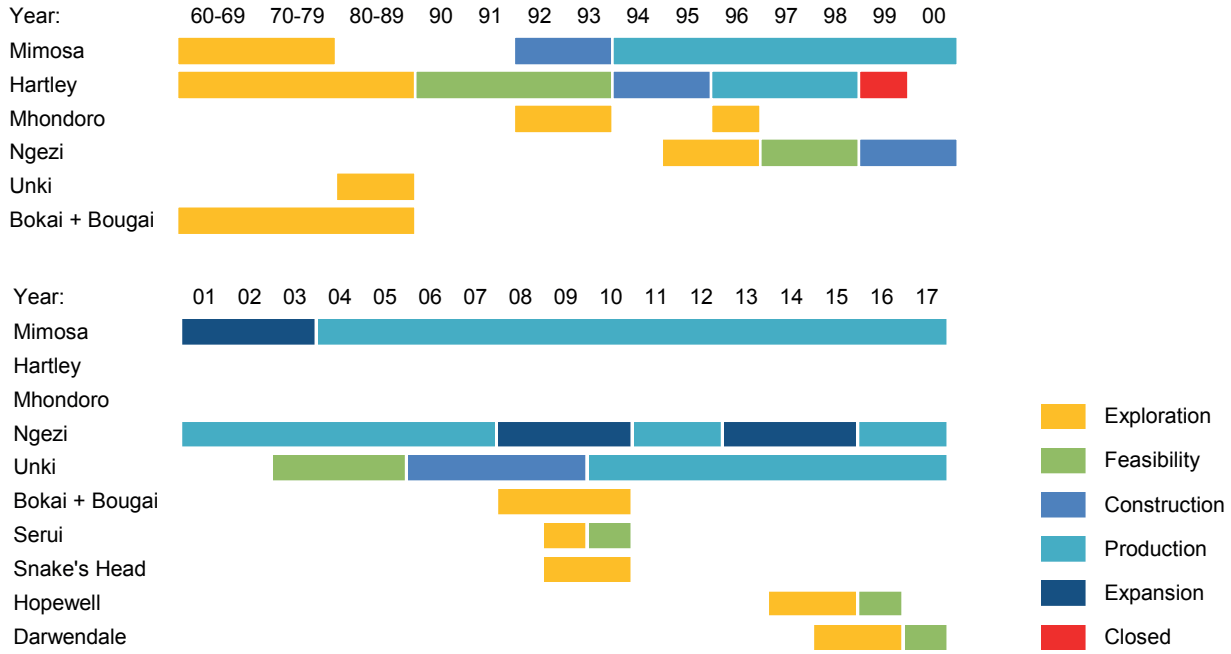
PGM sector could generate $7.7 bn in investments and 25,000 jobs

There is little in the way of greenfield resource development currently underway in Zimbabwe. The large-scale Darwendale project, for which a feasibility study has been completed, is the main project that has been progressed over the past four years by Great Dyke Investments (GDI, a Russia-Zimbabwe joint venture). GDI is planning to invest $400 million initially to develop a mine, and may spend up to $3 billion to include a metallurgical complex. At full scale, annual PGM production could total 855 koz.

The success rate for projects is very low

A number of other projects have been staked out over the past ten years, but none have yet come to fruition. Exploration work on the Bokai, Kameni and Serui projects all terminated around 2010. ENRC acquired CAMEC, owner of the Bokai project (240 km south of Harare), in September 2009 but scoping studies ceased towards the end of 2010. Early estimates indicated annual PGM production of around 160 koz at a cost of $250 million, with expansion potential up to 400 koz.

Historical PGM exploration and production in Zimbabwe



Source: SFA (Oxford)

Kameni Platinum – a Loucas Pouroulis venture exploring ground adjacent to Bokai (all property relinquished by Anglo American Platinum) – planned to list on the Johannesburg Stock Exchange (JSE) in March 2010, but failed to do so and its project was held back by government red tape and ownership issues. Pouroulis has re-emerged in 2018 with the rebranded Karo Resources. The company has stated the intention to develop a mine and refinery over the next four years.

The Serui project is owned by Zimari Platinum, a joint venture between Amari Resources and Zimbabwe Mining Development Corporation (ZMBC). Pre-feasibility work on the project (located 70 km south-west of Harare) commenced in June 2010, but was not completed. Zimari Platinum had intended to develop a $200 million platinum mine by 2014. Similarly, Chinese-Zimbabwean consortium Global Platinum Resources was preparing to start pre-feasibility work at its Hopewell project (80 km south-west of Harare) in early 2015, but the project stalled.

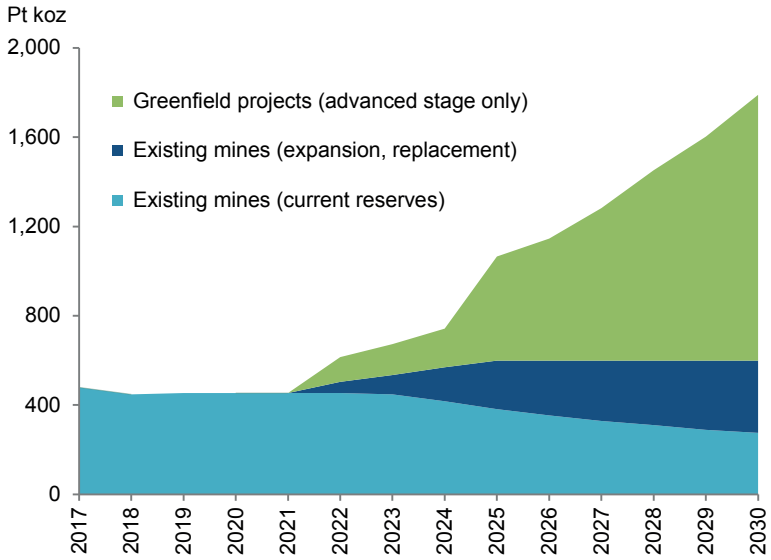
Resource estimates for these properties total 65-70 moz PGMs, with combined annual PGM production capacity in the region of 2.6 to 2.9 moz. Investment potential in the PGM sector is at least $1.25 billion for mine-only development, and $7.7 billion including processing infrastructure. This excludes any new properties that may crop up, and the Great Dyke is relatively under-explored compared to the Bushveld Complex.

Resource estimates for projects total 65-70 moz PGMs

If just the above projects were re-started and completed, these would create over 25,000 jobs. Together with workers at Unki, Zimplats and Mimosa, full-scale project development would lift the employee complement in Zimbabwe to around 22% of that on the Bushveld (currently at 6%). The associated corporate social investment would also be extremely beneficial for Zimbabwe.

Expansion or life-of-mine extension at existing Zimbabwean operations (theoretical) plus intended mine development by GDI and Karo Resources could see platinum production grow to almost 40% of global supply within ten years (stated timings). Zimbabwe has the potential to become a very significant contributor to global PGM supply on a longer 15-20 year timeframe.

Potential output from Zimbabwe



Source: SFA (Oxford)

There is scope for Zimbabwe to become a major PGM supplier

That said, there is unlikely to be a repeat of the capital injection by PGM producers that took place in the early/mid-2000s without serious dialogue with the government, settling of outstanding land claims, and lifting of export restrictions on intermediate PGM products. Given the multi-faceted and broader funding requirements needed to grow output in the future, there is a very real risk that capital investment in the PGM sector may have actually peaked and the depletion curve for this base load profile could accelerate.

Without material change, the depletion profile could accelerate

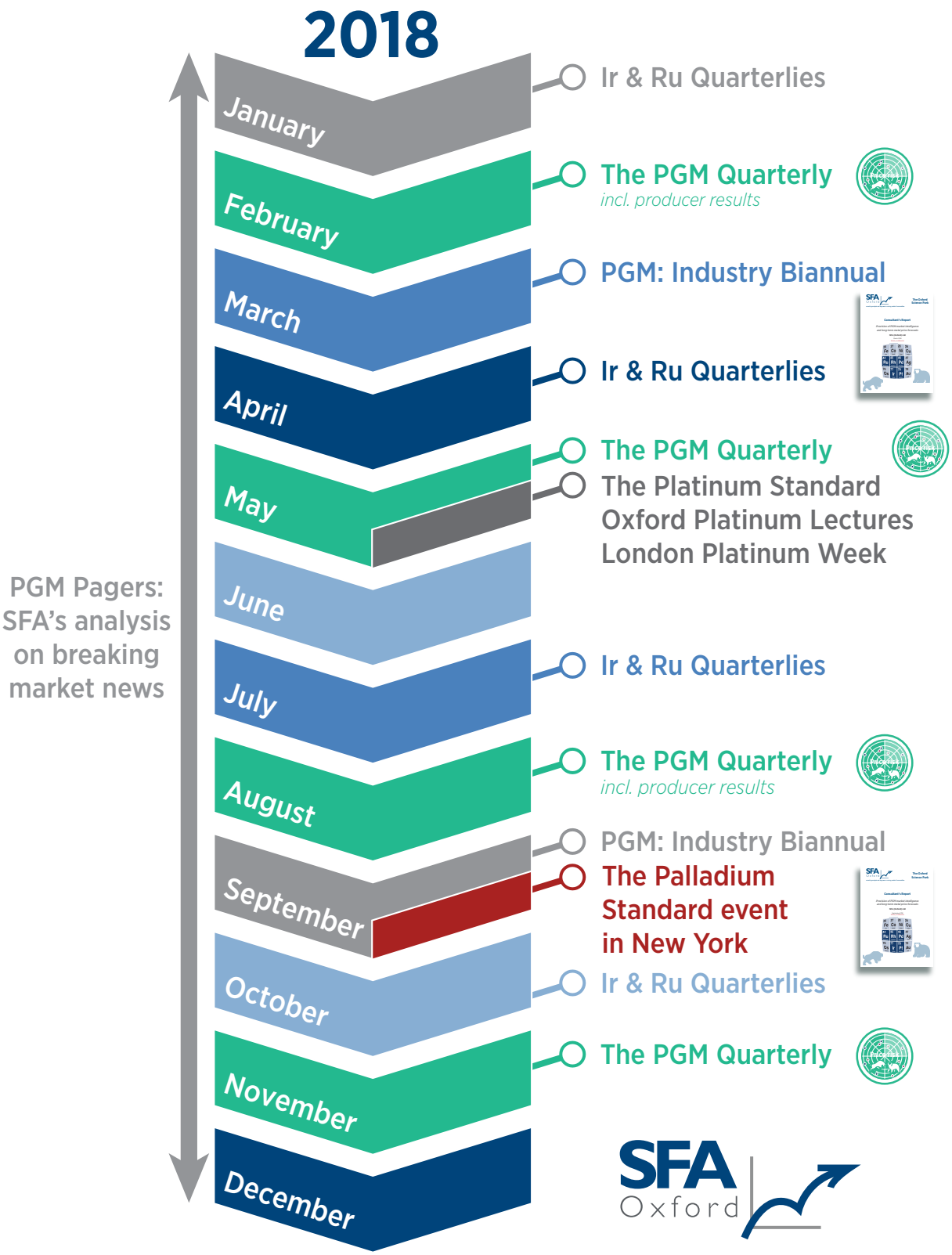
A sound track record needed before investors will commit

Including other major commodities – gold, diamonds, nickel, chrome, coal, lithium, iron and steel – Zimbabwe could realistically become Southern Africa's regional mining giant and industrial hub. However, regardless of the inherent mineral wealth that the country has, mining expansion will be constrained until the considerable checklist of critical issues – foremost running free and fair elections, and security of company ownership and land tenure – is addressed.

New leadership is an opportunity to lay the groundwork for stimulating economic development, promoting foreign investment and putting in place clear legislative guidelines for mining companies, which will allow the PGM industry to thrive. Generating large inflows of foreign direct investment (FDI) would strongly flip Zimbabwe's balance of trade, and stimulate increases in synergies and downstream spending into the economy to the benefit of the extractive, manufacturing, distributive, service and financial sectors. Zimbabwe's poor track record means it will still take time to entice investors back, even if the government implements all of the above.

A long checklist of issues to address before Zimbabwe can fully leverage its mineral wealth

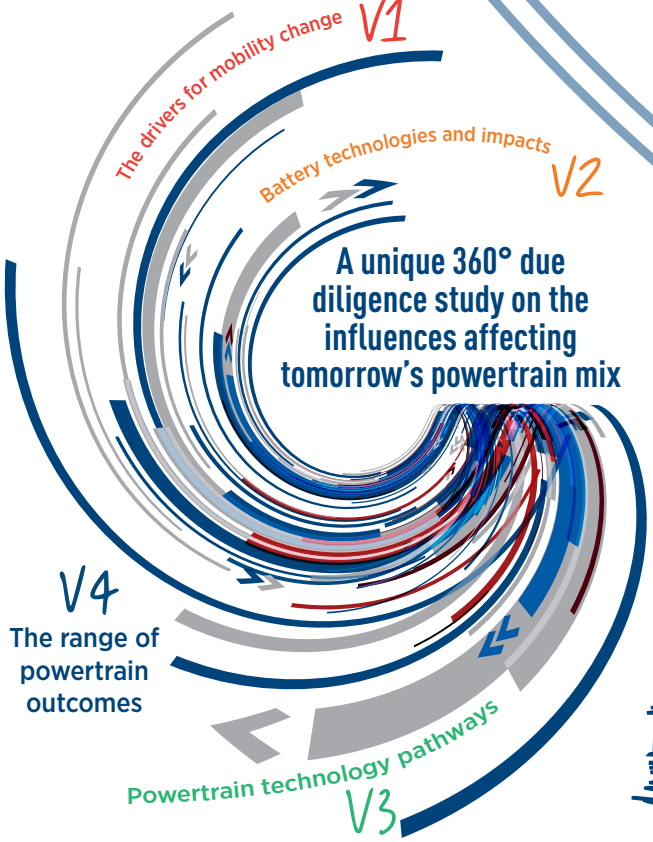
SFA'S PRINCIPAL PGM REPORTING TIMELINE



SFA Oxford

consulting analysts, scientists and engineers in strategic commodities

Future powertrains: Joining the dots to 2050



FUTURE POWERTRAINS: JOINING THE DOTS TO 2050

A unique 360° due diligence study on the influences affecting tomorrow's powertrain mix

SFA (Oxford) is proud to announce its ground-breaking assignment "Future powertrains: Joining the dots to 2050" study. This arose from our recognition that powertrains are changing and there is a huge amount of agenda-driven and corporate-driven material out there. We feel obliged to try to make analytical, objective sense of it all; while no-one can, in all honesty, predict the precise rate of powertrain evolution, at SFA (Oxford) we are well-placed to unpack all the influences, and provide some intellectually rigorous signposts at this momentous crossroads.

As the future of both SFA (Oxford) and its clients is critically dependent on the powertrain pathways of tomorrow, **it is essential that we provide our clients with the best possible strategic direction**. A one-dimensional study won't cut it. We believe this problem needs to be considered through 360°, **from the megatrends of urbanisation, air quality and digitisation, to a deep-dive due diligence study on battery technology and all the degrees in between**.

"Future powertrains: Joining the dots to 2050" will **remove the 'noise' and diversely opinionated automobility sector forecasts clouding your judgements and provide the realistic powertrain scenarios** that will guide your strategic assessments. Spread across four volumes (V1-V4), **the series will answer the important questions that SFA (Oxford) is regularly asked** by its clients, covering:

- **Drivers for change: mass transit solutions vs. personal mobility (V1)**
- **What are the latest automotive battery developments and what is their impact likely to be? (V2)**
- **What are the potential pathways for powertrains? (V3)**
- **What is the range of automobility outcomes to 2025 and beyond to 2050? (V4)**

SFA (Oxford) would also be able to provide additional support to you that complements the study, in the form of a **presentation of the key findings to your Board or Exco**, thereby ensuring the Board and senior executives are fully appraised of "Future powertrains". In addition, SFA (Oxford) would be willing to **facilitate workshops** that investigate the future of powertrains and the corporate implications for you. In the future, **SFA (Oxford) will also be developing supplementary reports** that look at the implications of powertrain evolution for a range of metals. These services will be subject to your bespoke requirements and will therefore be quoted separately.

Why this report is a necessity for you:

- Obtain the most **comprehensive due diligence on tomorrow's powertrain mix**, carried out by a multi-disciplined team of analysts that understand PGMs
- Realign your business and marketing with **tomorrow's powertrain pathways** in a timely manner
- Cut through the hype and understand the **length of the internal combustion engine tail**
- Understand the **risks from potential technology** and **policy inflection** points ahead
- Discover **which commodities are the winners and losers**, and when
- Examine the **opportunities and risks** for your company

PLATINUM JEWELLERY DEMAND IN INDIA: AN AMBITION REALISED?

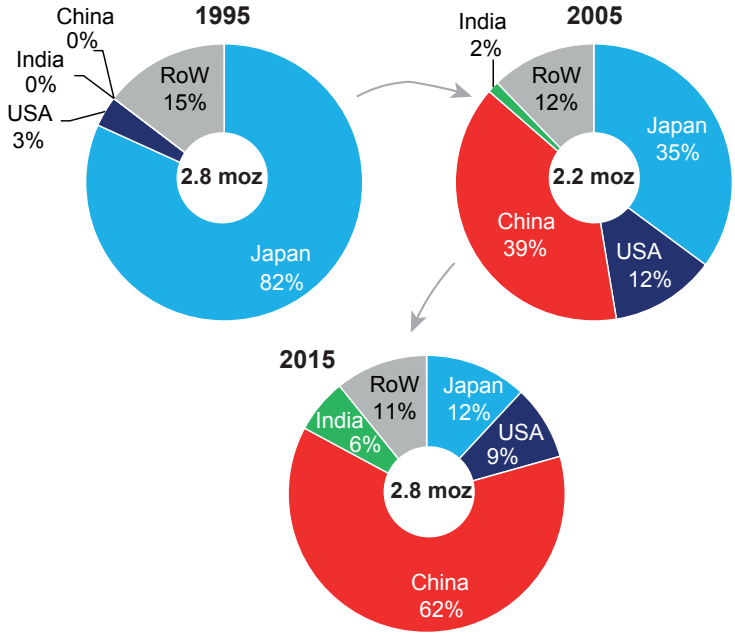
Platinum jewellery demand in India: An ambition realised?

Jeremy Coombes, Precious Metals Consultant

The opportunity and the challenge

During the 1990s, a campaign to develop and extend the manufacture and sales of platinum jewellery was introduced in mainland China, with astonishingly successful results. This market was growing apace, with demand for platinum rising from virtually zero to over a million ounces in less than ten years. Clever and focused promotion by Platinum Guild International (PGI), exploiting conditions conducive to the uptake of platinum jewellery, had demonstrated what could be achieved with a firm financial commitment to securing new long-term offtake. The demand from China had arrived at the right time, just as the Japanese market, the powerhouse of demand for platinum jewellery since the 1960s, was entering a period of decline.

Platinum jewellery demand by region



Source: SFA (Oxford)

To bolster this replacement demand and secure further growth, the platinum industry began to think about where to find another populous national market, with a tradition of precious metal jewellery purchases and a growing middle class with spare disposable income, which could be developed for platinum jewellery. The obvious answer to this question was the emerging market economy of India.

India was always a potential Pt market

India, with its large population and its pervasive penchant for high-carat gold jewellery, had always looked a likely prize for platinum jewellery at some point in time. But while it languished as a centrally-planned, heavily-regulated and bureaucratically-controlled economy prior to the 1990s, there seemed little chance of persuading Indians to diversify their jewellery purchasing habits, focused as they were on pure gold for dowries and investment as the prime stimuli for jewellery purchasing. The liberalisation that started under Prime Minister Narasimha Rao in 1991 began to change that view. With deregulation, reduction in tariffs and taxes and greater foreign investment, the economy expanded, middle-class disposable incomes rose and a new generation of Indians became more open to international cultural influences. The opportunity to establish a niche for platinum jewellery, which could grow into a major force for demand, became apparent, and in the year 2000 PGI India was set up to lead a promotional campaign from its new headquarters in Mumbai. However, as much as India appeared to have great potential for platinum, it also posed unique challenges that had not been encountered in other major world platinum jewellery markets.

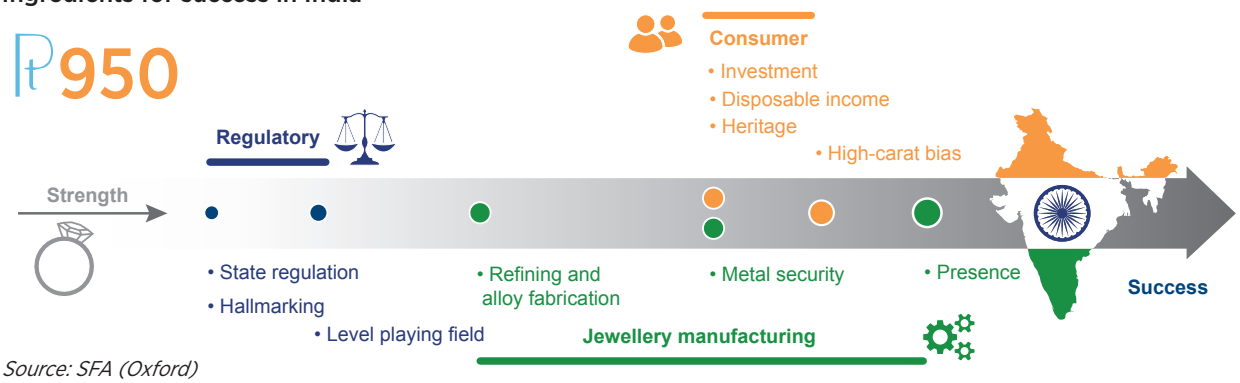
1990s' deregulation created a demand growth opportunity

Foundations of demand

There has to be a foundation on which to build platinum jewellery demand in any new market – trying to start it from scratch is extremely challenging. A combination of at least some of the following factors should be in place if a long, arduous, expensive and possibly futile process of consumer and trade education is to be avoided. On the trade side, the list of desirable elements would include an established manufacturing base, with jewellers experienced in crafting high-quality jewellery; a ready supply of metal and a network of refining and alloy manufacturing facilities; low and non-discriminatory taxes and duties on precious metals; a hallmarking system, preferably state-regulated, to provide confidence in jewellery quality standards; and an extensive retail network. From the consumer perspective it is helpful if consumers prefer high-carat jewellery; have a cultural tradition of giving or owning precious metal jewellery and a perception of jewellery as a valuable investment; possess surplus disposable income; and already have a liking for white-coloured precious jewellery and diamonds.

Platinum jewellery markets need certain preconditions

Ingredients for success in India



Source: SFA (Oxford)

How did India in 2000 shape up for platinum in terms of this ideal profile? The economic changes of the previous ten years had certainly begun to reveal a new raft of middle-class consumers with money available for luxury purchases; supply of platinum materials was readily available from several well-established domestic precious metals refiners and fabricators; manufacturing of platinum jewellery was well understood by the diamond sightholders and jewellery exporters located in the special economic zone (SEEPZ) outside Mumbai; and there were plenty of sales outlets – more than 30,000 formal and informal retailers across the nation. So far, so good.

India had several advantages but also a few difficult barriers

Platinum was not taxed equally to gold, so this was one of the first hurdles to be crossed, but after a period of lobbying, in cooperation with its trade partners, PGI succeeded in persuading the Indian government to reduce tariffs on platinum to parity with those on gold.

Twenty years ago there was little recognition of platinum as a jewellery metal by consumers in India and, not surprisingly, platinum was not included when the Bureau of Indian Standards set up a hallmarking system for gold jewellery in 2000. This specified (although it did not mandate) that gold should be marked as 14, 18 or 22 carat. To provide potential consumers with confidence in the value of platinum jewellery, PGI introduced a Quality Assurance Scheme, under which all authentic platinum jewellery in India bears the purity hallmark 'Pt 950', stamped inside the piece, and comes with a Quality Assurance Card which also serves as an assurance of a 'buy back' programme.

Indian jewellery culture

The major barriers to success in India were the country's cultural traditions, which were expressed in several different forms. First, Indians did not have any history of platinum as a jewellery metal – unlike the Japanese, for example, who had been encouraged by their government to buy platinum rings in the 1930s and for whom, for many years after World War II, platinum was the only precious metal jewellery available because the owning of gold was prohibited. While there is a word for gold and diamonds in India's scriptures, there is nothing for platinum. (Similarly in China, the Chinese characters originally stamped on platinum jewellery translate as "pure white gold". Only with the adoption of the 'PT' mark was this confusion resolved.)

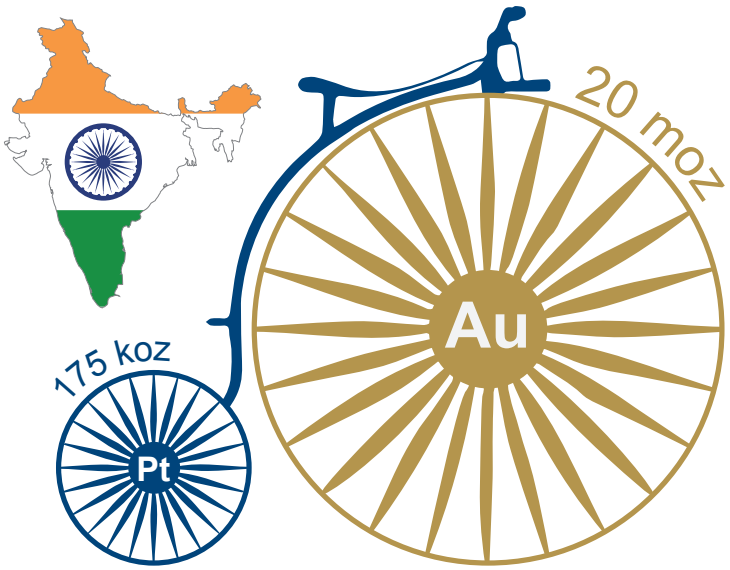
Gold the dominant jewellery metal, platinum little known

Second, whereas in Japan and later in China it had been possible for platinum rings to be accepted by couples and their families as valid alternatives to gold rings exchanged on engagement and marriage, in India the wedding tradition is deeply intertwined with the gifting of gold, not just as marriage rings but as a transfer and store of wealth in the form of ornate necklaces, earrings, bangles, belts and ornaments. Some 60% of gold jewellery sales in India are for wedding occasions and the gifting of gold jewellery can be worth around US$10,000. It would have been pointless for platinum to try to compete directly in this space.

Gold owns the wedding space

Third, although Indian women were becoming more independent in their choices and open to buying alternative precious materials for jewellery, they were still, to a significant extent, influenced by the opinions of the older generations of their families, whose preferences were, naturally, still rooted in the gold tradition.

Platinum vs. gold jewellery demand



Source: SFA (Oxford)

Although promoting the attractions of platinum jewellery to consumers was a challenge, conveying the advantages to the trade was a little more straightforward. Gold jewellery attracts around a 6-8% margin for retailers, diamonds achieve around 15-20%, while platinum is offered with >25% margin, according to PGI. And whereas in stores the gold price is displayed, the platinum price is not, so avoiding the commoditisation of the white metal. The Indian jewellery trade, particularly in the middle and southern conurbations of Mumbai, Chennai and Bangalore, was interested in the platinum offer and prepared to work with PGI to develop separate platinum jewellery counters and signage in stores to differentiate platinum from gold, and also to report the volume of their retail transactions as an aid in measuring the effect of promotional campaigns.

Jewellery trade saw profit in platinum

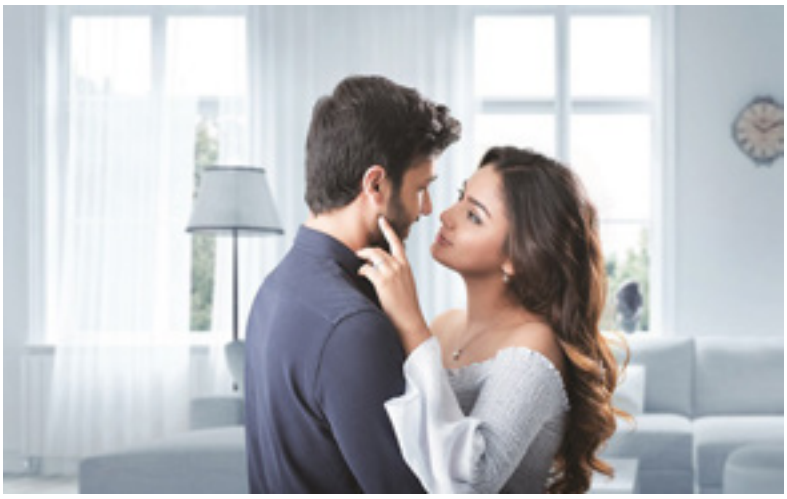
Progress of platinum jewellery demand

Once the trade was on board, the genius of PGI India was not to fight head-on at the outset for a share of the traditional gold jewellery market but to invent and exploit a series of jewellery gift and self-purchase occasions which were complementary to mainstream gold purchases. Initially progress was slow, the early concept of gem-studded platinum jewellery as a fashion item failing to stir the market to any great extent, while sales were handicapped by platinum's significant price premium over gold (something of a contrast with China, where platinum's higher value was part of its appeal to consumers). Thus, **in its first phase** demand for platinum grew slowly, reaching a level of around 35,000 ounces in 2008.

PGI found new angles for promoting platinum

The financial crisis of 2008 brought platinum and gold prices close to parity, and in these more favourable conditions PGI introduced the Platinum Day of Love campaign, a clever appeal to couples who, having probably had their marriage arranged for them, have since grown in fondness for each other and want to celebrate their deepening relationship with platinum.

Platinum Day of Love campaign



Source: Platinum Guild International

"Our match was arranged, but when it all started to fall in place, when it felt right & when we felt ready to take that leap of faith – we knew what we shared was extremely beautiful and rare."

PGI followed up with a campaign to associate platinum with Akshaya Tritiya, a springtime festival of the Hindus and the Jains and an auspicious day for new ventures, investments and marriages. This was also an attempt to even out the balance of demand, which in India is concentrated in the wedding season running from October to January. A third campaign targeted platinum jewellery for men, mainly as a self-purchase item. The wearing of platinum by sporting icon Sachin Tendulkar, and the prohibition on Muslim men wearing gold jewellery helped to create an incipient men's market for heavy platinum chains and bracelets. During this **second phase of market development** demand increased steadily, reaching 180,000 ounces in 2015. This was, at least temporarily, a high point for platinum demand in India, for fabrication demand dropped in 2016 to 145,000 ounces and recovered to only 175,000 ounces in 2017.

Men's jewellery a successful niche

Source: Platinum Guild International

The decline was partly due to a series of external developments which buffeted the Indian jewellery industry during this period. Floods in Chennai – the largest retail market for platinum – disrupted jewellery purchases during the wedding season of 2015. Jewellers then went on a 42-day strike in March 2016 against the government's imposition of a 1% excise duty on all non-silver jewellery. In November 2016, in an attempt to eliminate untraceable cash transactions, the state announced that 1,000 and 500 rupee notes would cease to be legal tender overnight and would have to be converted to new notes at a bank. This was difficult for many people, leading to a sudden loss of liquidity just as the 2016 wedding season was getting underway. Furthermore, a requirement for consumers to prove their identity for any purchase worth more than 200,000 rupees (US$2,900) was introduced. In July 2017 a national Goods and Services Tax (GST) was imposed – the rate applied to jewellery raised prices by a little under 3% – and in August the government reduced the threshold for purchases without identification to 50,000 rupees, only to return it to 200,000 rupees three months later.

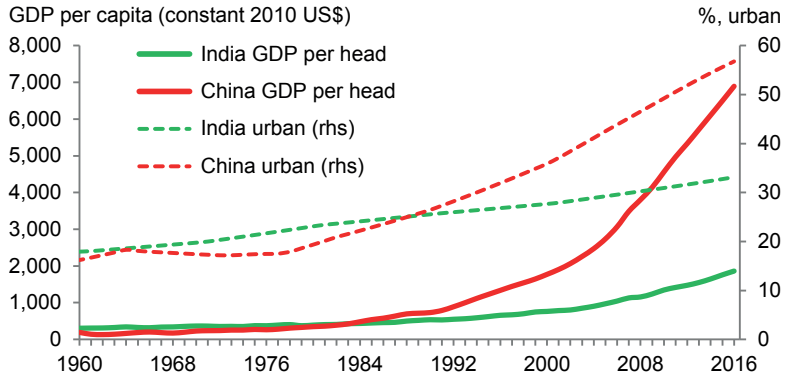
Temporary setback in growth in 2015-17

Although retail turnover of platinum jewellery was affected by these changes to some extent, PGI continued to report annual growth in retail sales from its trade partners, the majority of whom are large concerns which are better equipped to handle the burden of administering new taxes than the smaller and informal retailers whose main focus is on gold jewellery. What appears to have stalled the manufacturing demand for platinum in the last two years was a reduction of inventory in retail stores, a reflection, perhaps, of a more cautious attitude to business by the trade. It was probably a temporary hiatus, because there is enough potential in India and momentum in the promotion of platinum jewellery for growth to continue over the longer term. However, key questions remain to be answered about the pace, extent and diversity of demand growth.

The potential from here

Can India fulfil the industry's hope to be a second China in terms of platinum jewellery demand? India's population is almost as large (1.32 billion to China's 1.38 billion in 2016) but its GDP per capita is only a fifth of China's (US$1,709 versus US$8,123). That is reflected in the relative degree of urbanisation – 57% of Chinese people living in cities against only 33% of Indians. Yet the raw number of those urbanised – 435 million – is already large enough to provide an effective potential market.

India and China GDP per capita and urbanisation



Source: SFA (Oxford), World Bank

Indian demographics are favourable – more than 50% of the population is below the age of 25, and most of these young people are likely to become married. PGI is counting on its Evara Blessings campaign, introduced in late 2015, to create a niche for platinum in the lucrative but gold-dominated wedding market. Traditionally, parents choose gold jewellery for their children's wedding, gifted and worn during the marriage cermony, but stored away afterwards as accumulated wealth. Evara platinum bracelets and neckchains are designed to appeal to brides and grooms as additional items of wedding jewellery which are wearable every day, to be given to the wedding couple by the parents and family elders as a blessing.

Demographics in India are favourable

There may be regional opportunities for growth. Platinum in India is a "southern" metal (just as platinum is a "northern" metal in Europe – most demand is in the UK, Scandinavia, Germany and Switzerland). The south of India values high-quality jewellery, while the north prefers quantity – for example, in the south consumers prefer to buy diamonds of the highest quality, while in the north the size of the stone matters more. The regional split of platinum jewellery sales is striking: 40% in the south (Chennai, Bangalore and surrounds), 37-38% in the west (Mumbai and surrounds), 18% in the north (Delhi, etc.) and the rest in the east. Can platinum increase its penetration where consumers tend to spend less and "feel the width" rather than consider the quality?

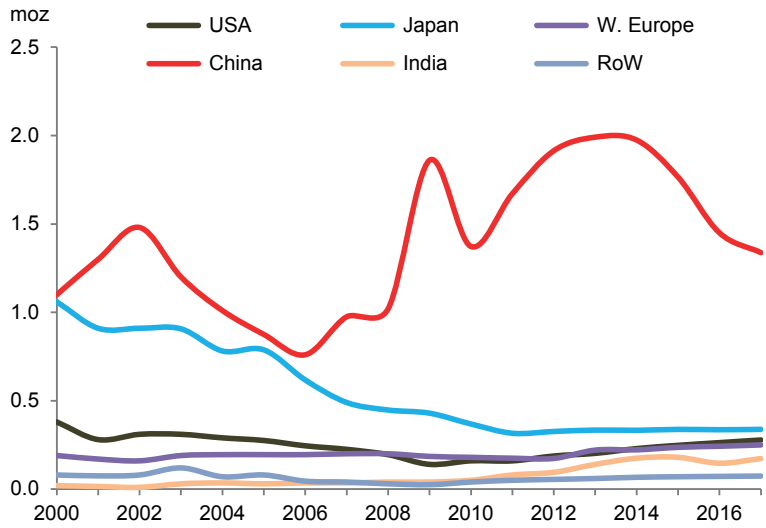
Demand could grow beyond the core market of south and west India

How far can distribution extend? Currently, the proportion of India's 30,000 retailers carrying platinum is tiny: PGI India has a partnership model with selected retailers and manufacturers with shared development costs. From just a handful in the early 2000s, platinum is now offered in close to 1,000 stores nationwide and the target is 1,100. Platinum is offered in almost 50 cities (before 2009 it was just 6-8 cities) and PGI aims to double this as its campaign spreads to Tier 2 and 3 cities.

Will Indians continue their traditional love affair with precious jewellery? The chances are that they will, as it is so deeply ingrained in Indian culture. But in other platinum jewellery markets, Japan and the USA being prime examples, platinum's core demand is for marriage rings. If platinum jewellery fails to win a place at the wedding occasion, could demand for it as a fashion item be limited by competition from white gold – cheaper, just as shining white when plated with rhodium, and easier to manufacture?

Will white gold be a threat, as in other markets?

Platinum jewellery demand by region



Source: SFA (Oxford)

Platinum will never have more than a minor share of the Indian jewellery market, particularly as the centuries-old allure of gold is so entrenched, not just as a jewellery and investment metal but also as a transactional medium in the informal economy. Nonetheless, it is probable that if intelligent and well-funded promotion is sustained, Indian platinum jewellery demand will continue to head into **a third phase of growth** which can continue for some time to come. Eventually demand is likely to stabilise, as it has in the USA and Japan, and as it may now have in China. But if it levels off at even half of current Chinese demand, India will have become established as substantially the second-largest market in the world for platinum jewellery, and will have gone a long way to meet the ambitions of the India promotional campaign close to two decades ago.

THE RUTHENIUM MARKET

The Ruthenium Market report offers a robust, independent outlook for this niche strategic commodity. It provides a granular overview of the technological developments and underlying evolution of demand and end-use applications – electrical, chemical catalysis, electrochemical, and aerospace.

The main application, namely higher-density data storage (electrical demand), is covered in detail, in particular: manufacturing bases, players and regions; price and performance drivers encouraging the use of ruthenium; and threats to ruthenium at current prices (substitution, new technologies).

The Quarterly Ruthenium Market report is also available providing a short-term supply, demand and price outlook.

Electrical demand

- Use of ruthenium in hard-disk drives (HDD)
- Technology evolution and main players
- Technology substitution threats from solid-state drives (SSD)
- Forecast memory capacity requirements and HDD manufacture
- Impact of changing technology on ruthenium demand outlook

Electrochemical demand

- Industrial process requirements of anodes coated with PGMs
- Chloralkali products and output, growth, capacity requirements and PGM top-up requirements

Chemical demand

- Forecast regional production of ammonia and acetic acid
- CATIVA™, KAAP™ and Grubbs catalyst technologies
- Technology evolution: growth and substitution threats
- Installed capacity versus production outlook
- Forecast demand for ruthenium from new plant capacity and top-up requirements

New applications and potential upside

- Aerospace, environmental legislation and the economics of using ruthenium in turbine blades
- Fuel cells: technologies, outlook, potential hydrogen requirements and opportunities for ruthenium use in catalysts

Ruthenium supply and stocks

- Forecast (primary) supply, by producer and by region
- Reserve and resource depletion analysis
- Estimated stocks (stockpiles, working inventories), producers, traders and recyclers, and quantification of unrefined stock
- Stocks in weeks of demand

Pricing of ruthenium

- Pricing trends out to 2022

THE IRIDIUM MARKET

The Iridium Market report provides a short- to medium-term supply, demand and price forecast in a focused outlook for iridium end-use applications (existing and future), in particular: LEDs, biomedical, jewellery, automotive and catalysis; manufacturing and fabrication bases, players and regions; price and performance drivers encouraging the use of iridium; threats to iridium (within substrate, tooling sector) at current prices (substitution by molybdenum and tungsten etc.); new technologies; and opportunities for iridium growth in new LED applications (automotive, industrial and residential lighting, signs, etc.) and chemical demand.

The Quarterly Iridium Market report is also available providing a short-term supply, demand and price outlook.

Electrical demand

- The LED market: new technology, energy efficiency, costs and market share
- Demand growth and capacity builds for LED TVs and lighting
- The iridium crucible market and the role of sapphire in LED production
- Gallium nitride (GaN) on sapphire versus GaN on silicon
- The threat of substitution from molybdenum and tungsten in high-temperature melting applications
- Iridium demand for crucibles used in LED production
- Outlook for OLED displays and potential impacts on iridium demand

Electrochemical demand

17 Cl 35.5 Chlorine

- The chloralkali process and iridium demand
- Substitution of a mercury-based process by an iridium-based process

Automotive demand

- Automotive demand for iridium-tipped spark plugs
- Substitution threats from molybdenum

Chemical demand

$C_2H_4O_2$

- The CATIVA™ process and acetic acid demand, including capacity requirements

Other demand

- Jewellery
- Medical
- Novel end-uses

Iridium supply and stocks

- Forecast (primary) supply, by producer and by region
- Reserve and resource depletion analysis
- Industry stock levels
- Movements of stock by producers and quantification of unrefined stock
- Stocks in weeks of demand

Pricing of iridium

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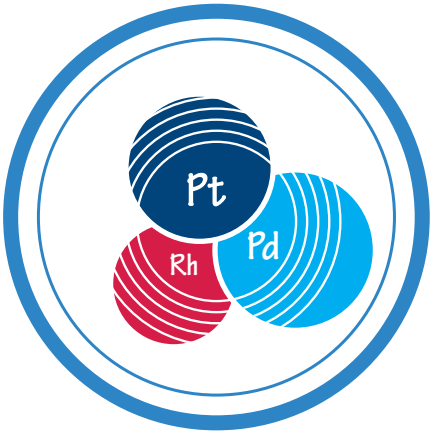
- Pricing trends out to 2022

THE PGM MARKETS IN 2017/18



The PGM markets in 2017/18

SFA (Oxford) Ltd

The platinum market

Summary

The platinum market has been building an industrial surplus since 2016, and in 2017 it widened to 0.5 moz. Mine production grew by 110 koz, supplemented by an additional 50 koz from recycled sources, while demand fell by 280 koz.

An industrial market surplus of 0.5 moz in 2017

The surplus should narrow in 2018 as supply cuts that took place in the second half of 2017 remove over 100 koz this year. With the platinum price now heading south of $900/oz, further supply adjustments are probable. Demand (net of recycling) is forecast to remain stable, however, leaving a surplus equivalent to 10% of South African supply.

Surplus to narrow in 2018 following supply cuts

Mine supply

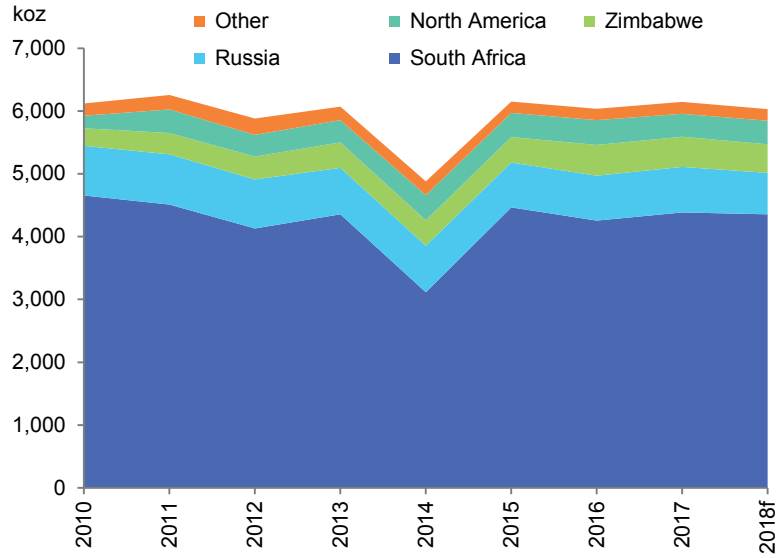
PGM producers exceeded expectation in 2017. While there were one-off incidences such as pipeline material releases that helped to bolster the supply total, it was operational changes implemented across a number of mines and processing operations that had a material positive impact on production levels. Many of the smaller producers (annual capacity of 150 koz Pt or less) had already closed out between 2009 and 2016, leaving the major and mid-tier producers to focus heavily on optimisation amid low platinum prices before they commit to large-scale mine closures and job losses.

Optimisation work is continuing in 2018, but global platinum supply is forecast to decrease by 1.8% to 6,035 koz. Loss of production from price-induced and depleted shaft closures is expected to exceed 130 koz this year, including Bokoni and Maseve, some production areas at Lonmin (and not supplemented by pipeline ounces), and alluvial operations in Russia. Nornickel indicates a lower production total for 2018 owing to a potential lock-up in the pipeline, despite outperforming its target last year.

Replacement and expansion projects at the Lease Area, BRPM and Booysendal in South Africa, and Stillwater and Lac des Iles in North America are forecast to add up to 120 koz in 2018. Output is also expected to increase at Mototolo (post-dam leak) and Marula (community disruption impacted production in the March 2017 quarter). Overall, South African supply (adjusted) is forecast to fall by 0.7% to 4,355 koz, with Zimbabwean supply normalising at 455

koz (-5.2%) and Russian output totalling 660 koz (-9.0%). After a 30 koz drop in 2017, mine expansion in North America should lift supply for the region by 2.7% to 375 koz.

Primary platinum supply by region



Source: SFA (Oxford)

Recycling

A steady recovery in scrap steel prices and higher palladium and rhodium prices are motivating an increase in autocatalyst recycling. Supply from recycled autocatalysts grew by 9.4% year-on-year in 2017 (+115 koz) to 1,340 koz. Jewellery recycling is expected to fall in Japan and stabilise in China. Recycling of platinum from all sources rose by 50 koz (+2.7%) in 2017 and is forecast to grow by another 55 koz (+2.9%) in 2018.

Demand

Global demand for platinum fell by 3.6% year-on-year to 7,505 koz in 2017 (excluding investment buying), with reductions in all major end-uses. Automotive demand decreased by 100 koz (-2.9%) to 3,390 koz and jewellery demand by 45 koz (-1.8%, led by China) to 2,460 koz. Industrial platinum demand fell the most (-135 koz or 7.5%) to 1,655 koz, weakened by a substantial drop in net petroleum demand and a decline in glass fabrication and chemical catalysis.

Demand fell in all sectors last year

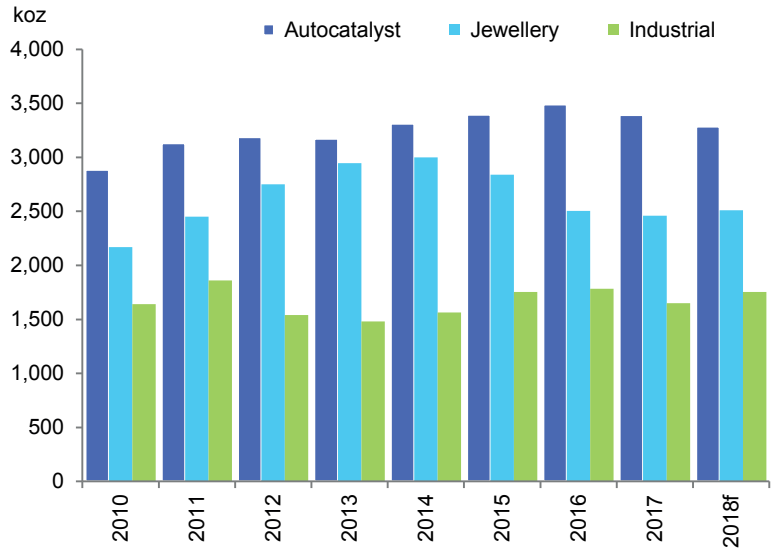
Automotive demand

Automotive demand is expected to continue trending lower owing to ongoing weakness in light-duty diesel sales. A reduction of 10% (-150 koz) is forecast for the largest regional market, Western Europe. Japan and China are also predicted to fall, by 6.3% and 10.0% respectively (-50 koz combined).

Diesel car sales in the US, by contrast, are estimated to be strong, and while vehicle numbers are much smaller than the European market, the impact on platinum demand from autocatalysts is higher as US diesel cars tend to be much larger than their European counterparts. Demand in North America is forecast to grow by 11.6% year-on-year to 480 koz. Fleet renewal in India should also lift demand here (+9.1% to 180 koz), and the RoW is expected to grow by 5.4% to 590 koz. Global automotive demand is forecast at 3,285 koz (-3.1% year-on-year).

Autocatalyst demand will trend lower in 2018

Platinum demand by key application



Source: SFA (Oxford)

Jewellery demand

Jewellery demand should recover to above 2,500 koz in 2018, owing to small increases in North America, Western Europe and India. However, Chinese demand (the largest region) is likely to remain largely flat at 1,345 koz, with most of the growth anticipated to be in gold jewellery sales. Low economic growth in Japan is also likely to keep platinum jewellery sales unchanged from last year.

India to push jewellery demand higher this year

Industrial demand

Petroleum demand is set to recover in 2018 owing to fewer, if any, refining capacity reductions in Japan, and expansion of capacity in the RoW. However, a slower rate of capacity growth in China and North America limits overall demand growth.

A recovery in petroleum demand expected

Expansion in glass fabrication, chemical catalysis and other end-uses (robust growth in the fuel cell sector, especially in Japan) is also expected to bolster platinum requirements this year, more than offsetting a drop in electrical demand, whilst medical usage remains flat. Industrial demand is forecast to total 1,750 koz (+5.7%) this year.

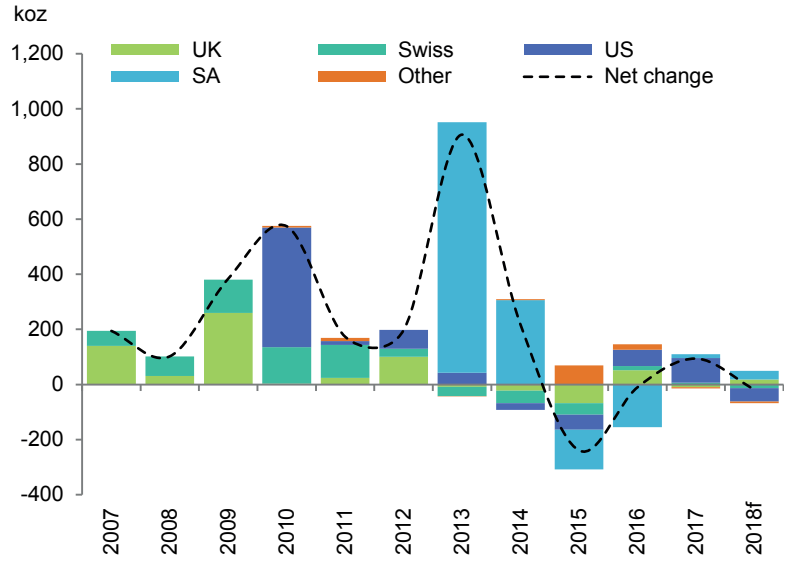
Investment and movement of above-ground stocks

Global platinum ETF holdings increased by 94 koz during 2017, taking total holdings to just under 2.6 moz. US investors were responsible for the majority of the gain, adding 90 koz to their holdings, while Swiss ETFs gained 6 koz and South African ETFs rose by 13 koz. Two regions suffered small declines in their ETF holdings: UK investors sold a net 10 koz during the year and the Japanese ETF was down by 4 koz.

ETF holdings increased by 94 koz in 2017

Global platinum ETF holdings have slipped 18 koz so far in 2018, with falls in the US (-49 koz) and Switzerland (-13 koz) being mostly offset by gains in the UK (+18 koz) and South Africa (+31 koz). A new platinum ETF was launched in the US this year and so far holds 4.5 koz, but this has failed to make up for the decline from the US ETFS fund which was down 44 koz at the end of April.

Annual change in platinum ETF holdings



Source: SFA (Oxford), Bloomberg

In 2017, Japanese platinum bar purchases were 136 koz, a notable drop from the 377 koz seen in 2016. Japanese investors had taken advantage of the price falling below ¥4,000/g in 2015 and 2016 and boosted their bar purchases, but even with the price remaining relatively low, bar buying has subsided and it needed the price to fall below ¥3,400/g to stimulate more buying during 2017. Forecasts for the yen and the platinum price in 2018 suggest that bar purchases are likely to be similar to those of last year.

Bar purchasing slowed in 2017; likely to remain flat this year

The palladium market

Deficit narrowed in 2017

The industrial deficit in the palladium market totalled 1.26 moz in 2016, and narrowed to 800 koz in 2017. This should stabilise in 2018 with lower anticipated supply from South Africa, Russia and Zimbabwe (-100 koz) offsetting an 80 koz reduction in net demand.

ETF outflows slowed down

The contraction in palladium ETF holdings slowed to 372 koz in 2017 and overall holdings fell below 1.3 moz. All of the major ETF investing regions saw holdings shrink, with the UK-based funds suffering the largest outflow of 186 koz. Over 1.7 moz of palladium has been returned to the market since ETF holdings peaked in August 2014.

Autocatalyst demand continues to rise, but at a slower pace

Autocatalyst demand rose by 1.1% in 2017 to 8,160 koz, led by Western Europe and the RoW. However, a 7% reduction in North America slowed down demand growth from 3.9% in 2016. This year, consumption is forecast to fall in North America and Western Europe, but growth in China, India and the RoW is set to give an overall 0.6% rise.

Industrial demand lower in the dental and electrical sectors

Industrial palladium demand dropped by 5.4% (-105 koz) to 1,855 koz last year, following a substantial fall in dental consumption, as well as lower requirements for electrical components. Dental demand declined in the mature markets of Japan, North America and Western Europe, as high palladium prices and changing consumer preferences led to substitution away from palladium-based alloys, whilst product miniaturisation (thrifting) of key electrical components also reduced palladium requirements in the electrical sector. Industrial demand is forecast to fall for the third consecutive year to 1,780 koz in 2018, with ongoing contraction in the electrical and dental sectors.

Global palladium supply rose to 7,080 koz in 2017 (+4.0% year-on-year). The palladium price increased by 42% year-on-year, while the platinum price fell by 4%, resulting in significantly higher supply growth in palladium terms for South Africa and Zimbabwe.

Price rise boosted supply in 2017, but lower production likely in 2018

Total palladium production is forecast to decrease by 1.4% this year, to 6,980 koz. The pipeline material that boosted palladium production last year results in a larger drop in South African (-3.0% year-on-year to 2,440 koz) and Zimbabwean (-8.9% to 360 koz) output versus platinum. Conversely, the lack of depleting alluvial palladium mines (platinum-only operations) and expansion at palladium-rich North American operations (+7.1% to 1,055 koz) almost offset the decrease in Africa.

The rhodium market

A fall in primary supply this year to reduce the surplus built in 2017

The industrial balance for rhodium rose to 65 koz in 2017, with total supply increasing by 35 koz and demand falling by a similar amount. The surplus is anticipated to narrow this year to 25 koz owing to a reduction in primary supply.

Global rhodium supply grew by 1.9% year-on-year to 785 koz in 2017, a similar increase to platinum. Production is forecast to decline by 5.7% to 740 koz in 2018. South African output is expected to decrease by 5.7% year-on-year to 580 koz, with the closure of Bokoni, and lower refined supply from Lonmin and Anglo American Platinum. Zimbabwean production normalises at a steady state 40 koz (-11.1% year-on-year). Supply from Russia drops by 6.7% year-on-year to 70 koz in line with an expected fall in output from Nornickel, and the lack of rhodium in the expanding North American mines means depletion in the Sudbury region contributes to lower production levels here too (-20.0% year-on-year to 20 koz).

Gross demand is forecast to increase by 1.5% year-on-year to 1,040 koz in 2018, with industrial demand growing but autocatalyst demand shrinking slightly. This will be matched by recycling, which is estimated at 325 koz (+6.6%).

Industrial demand to recover this year with new glass fibre capacity

Industrial rhodium requirements fell by 10.3% (-20 koz) to 175 koz in 2017 following a significant contraction in glass fabrication demand, as slower capacity expansion in China and the construction of fewer new glass fibre facilities in the US and the RoW reduced new metal buying by glass producers last year. The higher rhodium price ($1,107/oz vs. $694/oz in 2016) may have also encouraged some glass fibre fabricators to switch to bushings with lower rhodium content.

This year, industrial demand is set to recover by 14.3% (+25 koz) to 200 koz. New glass fibre capacity in Western Europe and the RoW is anticipated to boost overall rhodium usage, although if higher rhodium prices persist throughout much of this year, further switching to low-rhodium content bushings would be expected, hindering glass demand growth in 2018.

The price outlook for the next six months

Platinum $965/oz

Automotive demand is declining steadily as diesel car market share continues to contract in Western Europe, but this is partially being offset by growth in commercial vehicles. Jewellery demand is reliant on China, where a recovery in the gold jewellery market has not yet helped platinum, but overall consumption is edging higher in 2018 as industrial demand recovers.

Supply cuts in South Africa in 2017 have not been sufficient to balance the market in 2018, but with the basket price still trading into the cost curve more cuts are likely. However, this may simply balance the market, so while it should be price supportive, a strong recovery seems unlikely.

Changes to South African supply could be key for PGM prices this year

Palladium $1,025/oz

The palladium price has pulled back from its peak of over $1,100/oz early in the year and the Pt:Pd ratio briefly made it back to parity before palladium resumed its outperformance.

Global automotive sales are not rising as fast as they have been so autocatalyst demand is only inching up this year, as demand is forecast to fall in North America and Western Europe but grow in China, India and the RoW. However, industrial demand is expected to decline for the third consecutive year in 2018, with ongoing contraction in the electrical and dental sectors, which will pull down total palladium demand by 0.3%.

Palladium demand growth has lost momentum

Fundamentals still show a market with a substantial deficit (excl. investment) and with ETF holdings now below 1.2 moz, sales can only help to plug the gap for so long. While palladium looks fully priced north of $950/oz, lease rates remain elevated and any cuts to supply in South Africa could give the price fresh upside momentum.

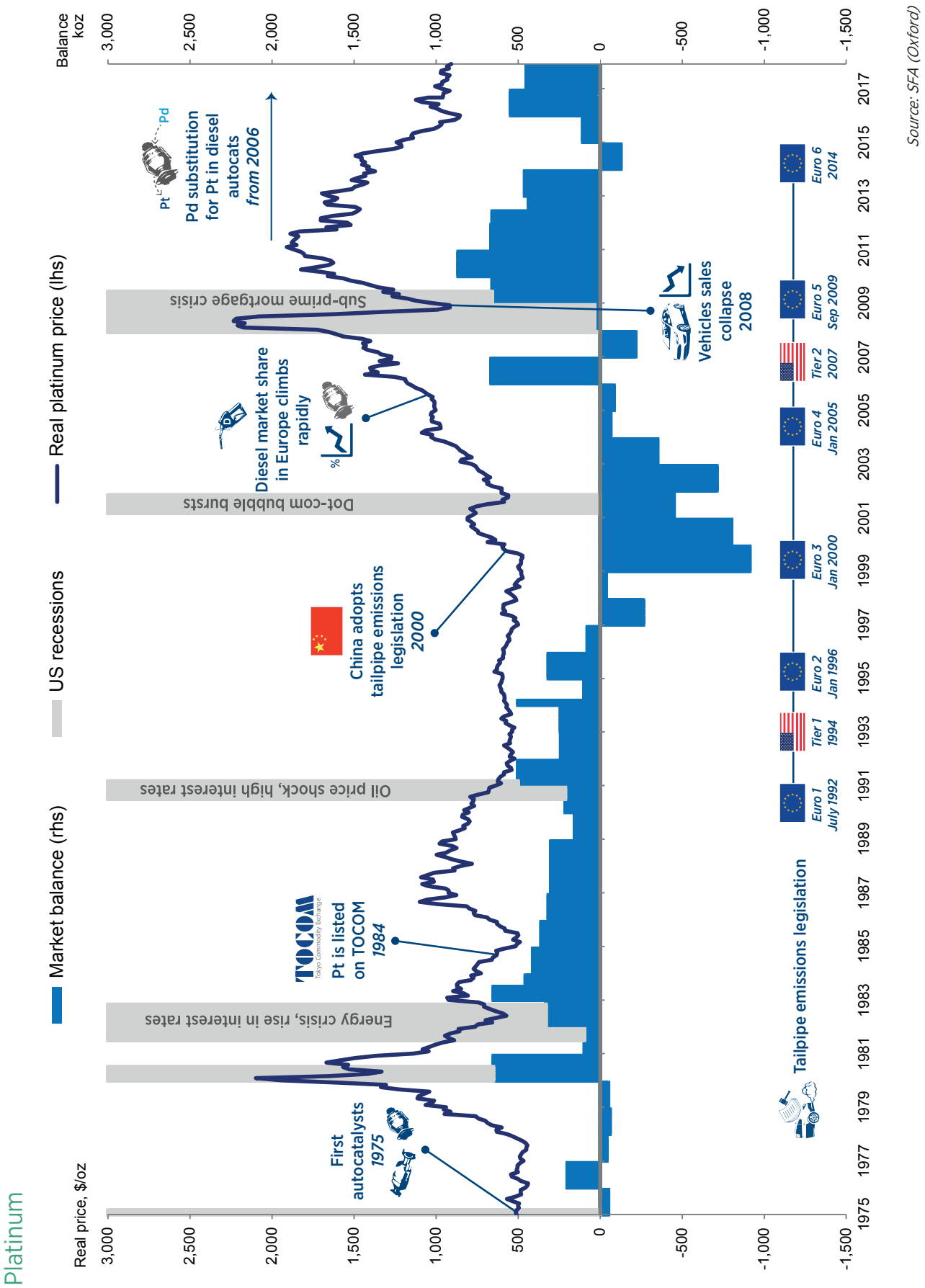
Palladium market still in substantial deficit

Rhodium $1,845/oz

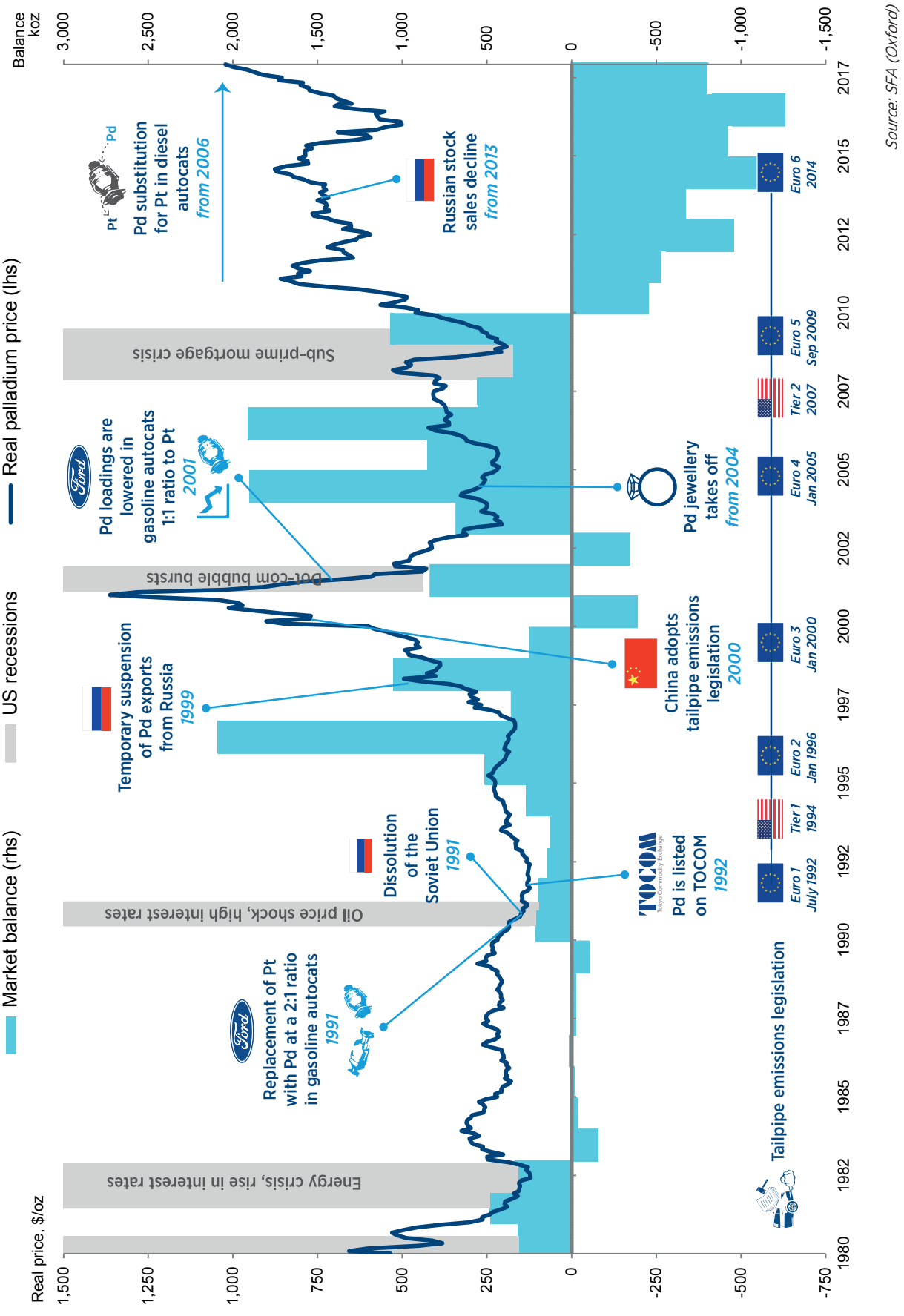
Automotive demand growth has largely stalled outside China and it is gains in other industrial uses that are lifting total rhodium demand this year. Last year's supply cuts in South Africa have not done enough to balance the market yet, but it will not take much to tip it into deficit. Rhodium lease rates remain elevated along with the price and should supply cuts emerge in South Africa, further price volatility is likely.

Possible supply cuts could give the price fresh impetus

PGM PRICE HISTORY

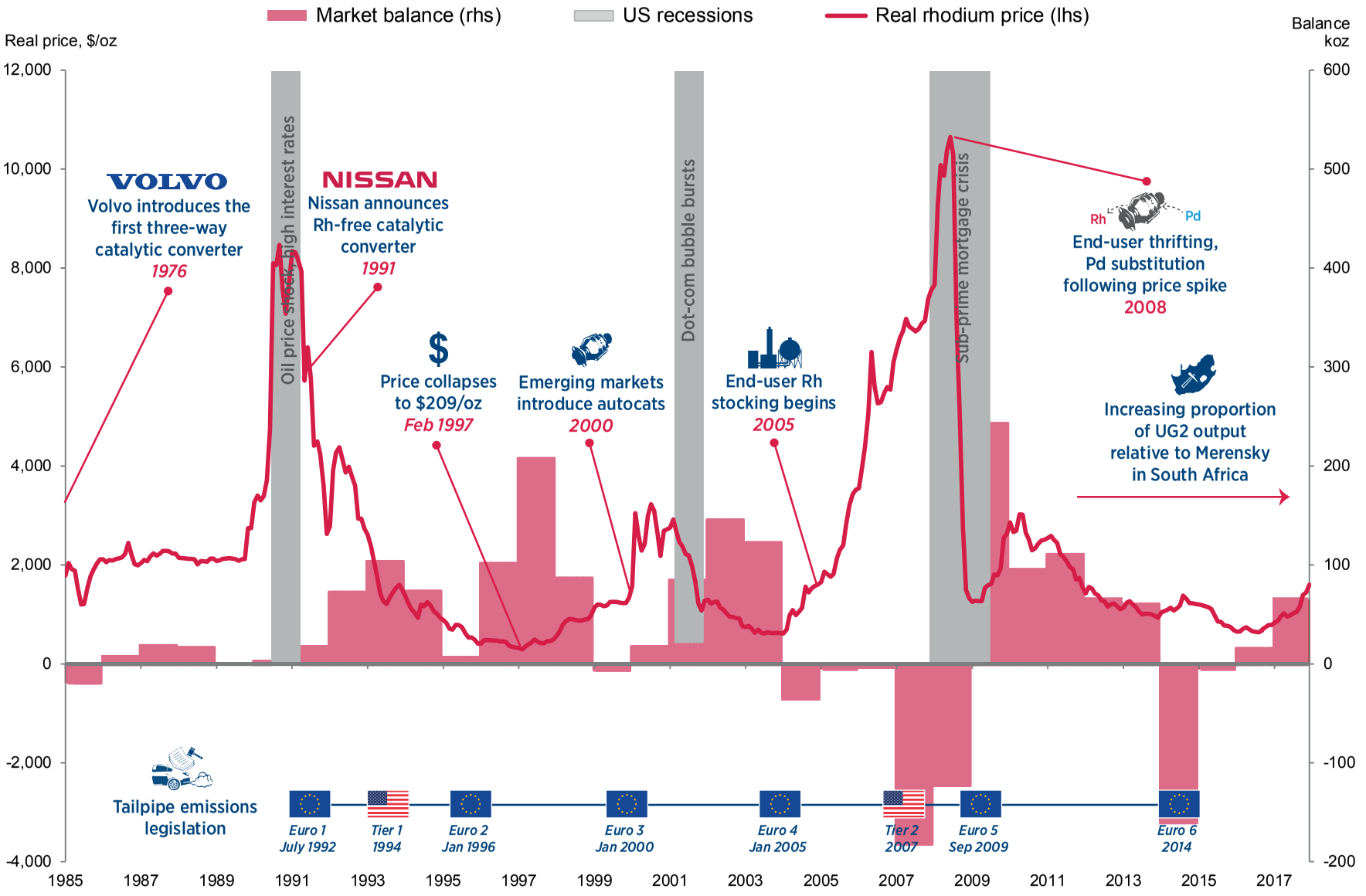


Source: SFA (Oxford)



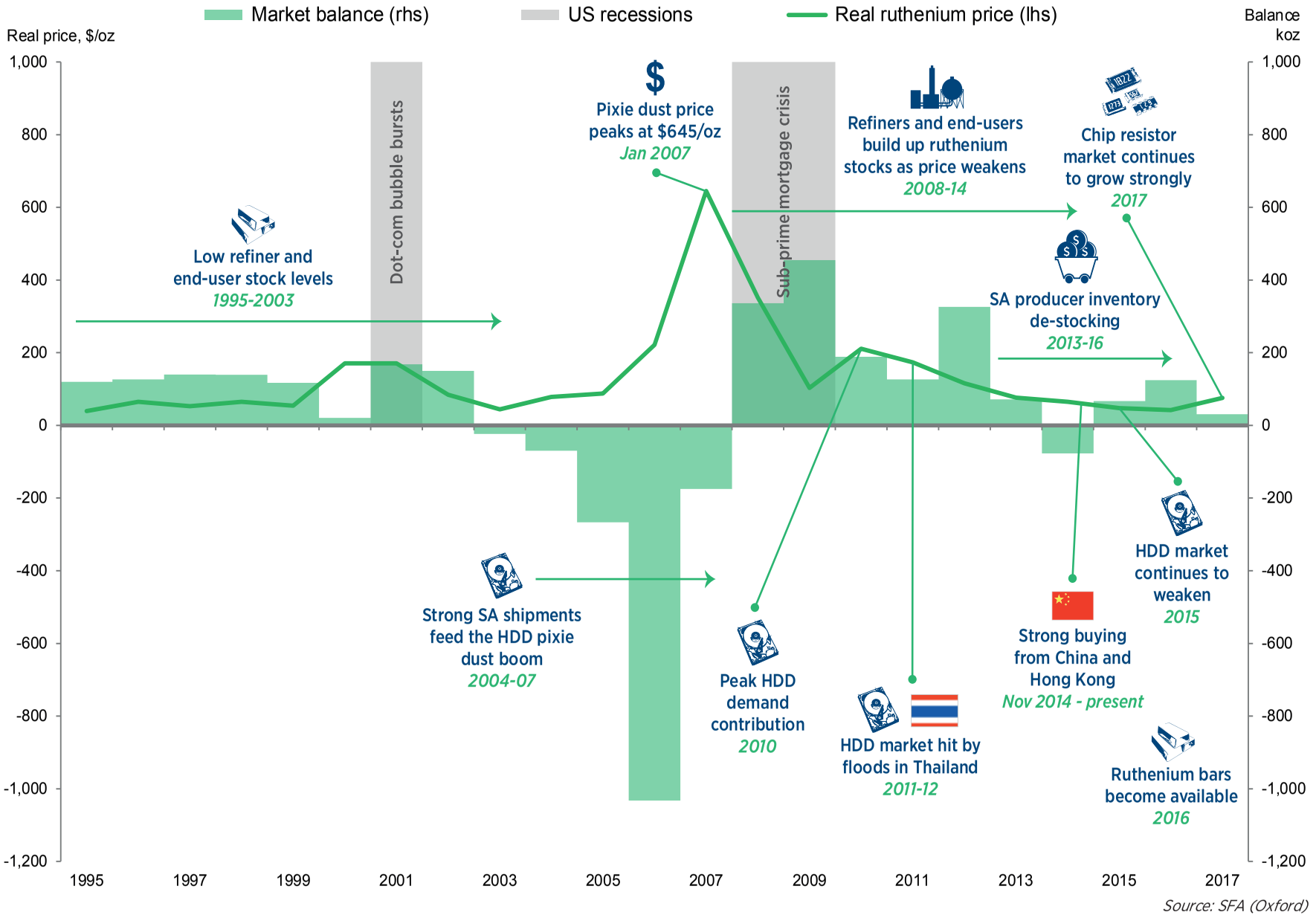
Source: SFA (Oxford)

Rhodium

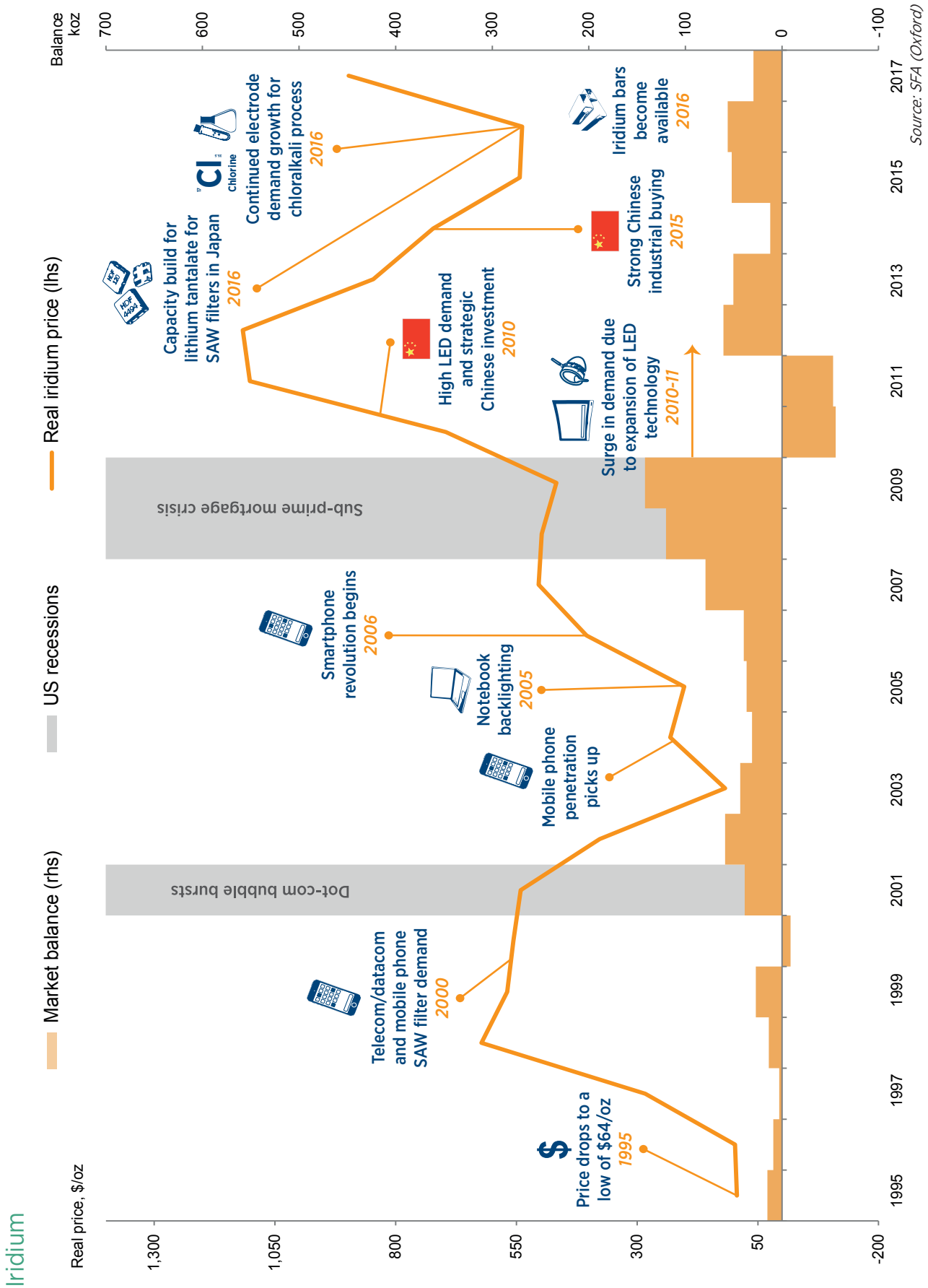


Source: SFA (Oxford)

Ruthenium



Source: SFA (Oxford)


Iridium
Real price, $/oz
Balance koz
Real iridium price (lhs)
US recessions
Market balance (rhs)
1,300
1,050
800
550
300
50
-200
700
600
500
400
300
200
100
0
-100
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
Dot-com bubble bursts
Sub-prime mortgage crisis
Price drops to a low of $64/oz 1995
Telecom/datacom and mobile phone SAW filter demand 2000
Mobile phone penetration picks up
Notebook backlighting 2005
Smartphone revolution begins 2006
High LED demand and strategic Chinese investment 2010
Surge in demand due to expansion of LED technology 2010-11
Capacity build for lithium tantalate for SAW filters in Japan 2016
Continued electrode demand growth for chloralkali process 2016
Strong Chinese industrial buying 2015
Iridium bars become available 2016
Chlorine
Source: SFA (Oxford)

APPENDIX

Platinum supply-demand balance

koz	2010	2011	2012	2013	2014	2015	2016	2017	2018f
Primary supply									
Regional									
South Africa	4,655	4,510	4,130	4,355	3,115	4,465	4,255	4,385	4,355
Russia	790	800	780	740	740	715	715	725	660
Zimbabwe	280	340	365	405	405	405	490	480	455
North America	200	375	345	355	400	385	395	365	375
Other	195	230	260	215	220	180	180	190	185
Total	**6,120**	**6,255**	**5,880**	**6,070**	**4,880**	**6,150**	**6,035**	**6,145**	**6,035**
Demand & recycling									
Autocatalyst									
Gross demand	2,885	3,130	3,175	3,170	3,310	3,395	3,490	3,390	3,285
Recycling	955	1,210	1,175	1,120	1,255	1,190	1,225	1,340	1,405
Net demand	1,930	1,920	2,000	2,050	2,055	2,205	2,265	2,050	1,880
Jewellery									
Gross demand	2,170	2,450	2,750	2,945	3,000	2,840	2,505	2,460	2,510
Recycling	475	630	840	855	775	515	625	560	550
Net demand	1,695	1,820	1,910	2,090	2,225	2,325	1,880	1,900	1,960
Industrial demand	1,640	1,860	1,540	1,475	1,565	1,750	1,790	1,655	1,750
Other recycling	10	10	5	5	5	5	5	5	5
Gross demand	6,695	7,440	7,465	7,590	7,875	7,985	7,785	7,505	7,545
Recycling	1,440	1,850	2,020	1,980	2,035	1,710	1,855	1,905	1,960
Net demand	**5,255**	**5,590**	**5,445**	**5,610**	**5,840**	**6,275**	**5,930**	**5,600**	**5,585**
Market balance									
Balance (before ETFs)	865	665	435	460	-960	-125	105	545	450
ETFs (stock allocation)	575	175	200	905	215	-240	-10	95	
Balance after ETFs	**290**	**505**	**240**	**-445**	**-1,175**	**115**	**115**	**450**	

Source: SFA (Oxford)

Platinum demand and recycling summary

koz	2010	2011	2012	2013	2014	2015	2016	2017	2018f
Gross demand									
Autocatalyst									
North America	370	385	425	425	465	470	425	430	480
Western Europe	1,315	1,95	1,340	1,350	1,440	1,550	1,700	1,555	1,405
Japan	480	500	600	580	590	530	490	480	450
China	135	120	115	130	120	125	170	200	180
India	145	180	200	160	160	175	165	165	180
RoW	440	450	495	525	535	545	540	560	590
Total	**2,885**	**3,130**	**3,175**	**3,170**	**3,310**	**3,395**	**3,490**	**3,390**	**3,285**
Jewellery									
North America	160	160	185	200	230	250	265	280	290
Western Europe	180	175	175	220	220	235	240	250	260
Japan	370	315	325	335	335	340	335	340	340
China	1,370	1,670	1,915	1,990	1,975	1,765	1,450	1,340	1,345
India	50	80	95	140	175	180	145	175	200
RoW	40	50	55	60	65	70	70	75	75
Total	**2,170**	**2,450**	**2,750**	**2,945**	**3,000**	**2,840**	**2,505**	**2,460**	**2,510**
Industrial									
North America	265	265	320	325	325	265	400	345	350
Western Europe	295	290	260	185	240	315	280	280	290
Japan	145	200	90	90	35	95	95	55	125
China	390	305	370	515	445	540	570	525	480
RoW	545	800	500	360	520	535	445	450	505
Total	**1,640**	**1,860**	**1,540**	**1,475**	**1,565**	**1,750**	**1,790**	**1,655**	**1,750**
Total gross demand									
North America	795	810	930	950	1,020	985	1,090	1,055	1,120
Western Europe	1,790	1,960	1,775	1,755	1,900	2,100	2,220	2,085	1,955
Japan	995	1,015	1,015	1,005	960	965	920	875	915
China	1,895	2,095	2,400	2,635	2,540	2,430	2,190	2,065	2,005
RoW	1,220	1,560	1,345	1,245	1,455	1,505	1,365	1,425	1,550
Total	**6,695**	**7,440**	**7,465**	**7,590**	**7,875**	**7,985**	**7,785**	**7,505**	**7,545**
Recycling									
Autocatalyst									
North America	580	600	575	560	560	505	535	585	615
Western Europe	195	420	405	365	470	450	480	530	555
Japan	145	115	115	95	105	95	90	100	105
China	0	5	10	20	30	55	40	40	35
RoW	35	70	70	80	90	85	80	85	95
Total	**955**	**1,210**	**1,175**	**1,120**	**1,255**	**1,190**	**1,225**	**1,340**	**1,405**
Jewellery									
North America	0	0	0	0	0	5	5	5	5
Western Europe	0	0	0	0	5	5	5	5	5
Japan	150	285	285	250	235	160	150	160	150
China	325	345	555	600	530	340	460	385	385
RoW	0	0	0	5	5	5	5	5	5
Total	**475**	**630**	**840**	**855**	**775**	**515**	**625**	**560**	**550**
WEEE	**10**	**10**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
Total recycling									
North America	580	600	575	560	565	515	540	590	620
Western Europe	200	425	405	365	475	455	485	535	560
Japan	295	400	400	345	340	255	240	260	255
China	325	355	570	620	560	395	500	425	420
RoW	40	70	70	90	95	90	90	95	105
Total	**1,440**	**1,850**	**2,020**	**1,980**	**2,035**	**1,710**	**1,855**	**1,905**	**1,960**

Source: SFA (Oxford)

Palladium supply-demand balance

koz	2010	2011	2012	2013	2014	2015	2016	2017	2018f
Primary supply									
Regional									
South Africa	2,565	2,515	2,325	2,320	1,815	2,550	2,340	2,515	2,440
Russia	2,720	2,705	2,630	2,580	2,690	2,605	2,555	2,740	2,680
Zimbabwe	225	265	280	315	330	325	395	395	360
North America	580	865	895	975	1,055	995	1,065	985	1,055
Other	325	425	480	490	500	475	450	445	445
Total	**6,415**	**6,775**	**6,610**	**6,680**	**6,390**	**6,950**	**6,805**	**7,080**	**6,980**
Demand & recycling									
Autocatalyst									
Gross demand	5,615	6,195	6,690	7,145	7,535	7,765	8,070	8,160	8,205
Recycling	1,395	1,525	1,485	1,645	1,720	1,630	1,725	1,890	1,940
Net demand	4,220	4,670	5,205	5,500	5,815	6,135	6,345	6,270	6,265
Jewellery									
Gross demand	695	680	545	350	295	240	240	225	225
Recycling	100	135	130	145	120	80	80	70	70
Net demand	595	545	415	205	175	160	160	155	155
Industrial demand	2,465	2,465	2,325	2,065	1,940	2,005	1,960	1,855	1,780
Other recycling	405	370	375	410	430	435	400	400	400
Gross demand	**8,775**	**9,340**	**9,560**	**9,560**	**9,770**	**10,010**	**10,270**	**10,240**	**10,210**
Recycling	1,900	2,030	1,990	2,200	2,270	2,145	2,205	2,360	2,410
Net demand	**6,875**	**7,310**	**7,570**	**7,360**	**7,500**	**7,865**	**8,065**	**7,880**	**7,800**
Market balance									
Balance (before ETFs)	-460	-535	-960	-680	-1,110	-915	-1,260	-800	-820
ETFs (stock allocation)	1,085	-535	285	0	940	-670	-640	-370	
Balance after ETFs	**-1,545**	**-5**	**-1,245**	**-680**	**-2,050**	**-245**	**-620**	**-430**	

Source: SFA (Oxford)

Palladium demand and recycling summary

koz	2010	2011	2012	2013	2014	2015	2016	2017	2018f
Gross demand									
Autocatalyst									
North America	1,310	1,505	1,745	1,835	1,970	2,090	2,160	2,015	1,985
Western Europe	1,280	1,500	1,425	1,530	1,655	1,725	1,630	1,685	1,650
Japan	810	670	735	745	750	755	795	815	810
China	1,010	1,130	1,300	1,515	1,670	1,740	2,010	2,060	2,105
India	150	160	155	165	165	185	225	245	275
RoW	1,055	1,230	1,330	1,355	1,325	1,270	1,250	1,340	1,380
Total	**5,615**	**6,195**	**6,690**	**7,145**	**7,535**	**7,765**	**8,070**	**8,160**	**8,205**
Jewellery									
North America	65	45	45	40	35	35	35	35	35
Western Europe	65	65	80	75	60	55	55	55	55
Japan	85	90	95	65	55	50	50	50	50
China	450	450	295	145	120	75	75	60	60
RoW	30	30	30	25	25	25	25	25	25
Total	**695**	**680**	**545**	**350**	**295**	**240**	**240**	**225**	**225**
Industrial									
North America	500	495	480	420	390	405	400	365	345
Western Europe	410	375	335	305	290	295	290	275	265
Japan	575	550	565	420	430	435	420	375	355
China	435	425	405	445	395	420	410	405	395
RoW	545	620	540	475	435	450	440	435	420
Total	**2,465**	**2,465**	**2,325**	**2,065**	**1,940**	**2,005**	**1,960**	**1,855**	**1,780**
Total gross demand									
North America	1,875	2,045	2,270	2,295	2,395	2,530	2,595	2,415	2,365
Western Europe	1,755	1,940	1,840	1,910	2,005	2,075	1,975	2,015	1,970
Japan	1,470	1,310	1,395	1,230	1,235	1,240	1,265	1,240	1,215
China	1,895	2,005	2,000	2,105	2,185	2,235	2,495	2,525	2,560
RoW	1,780	2,040	2,055	2,020	1,950	1,930	1,940	2,045	2,100
Total	**8,775**	**9,340**	**9,560**	**9,560**	**9,770**	**10,010**	**10,270**	**10,240**	**10,210**
Recycling									
Autocatalyst									
North America	975	975	930	1,005	975	895	960	1,010	1,005
Western Europe	205	335	325	345	365	325	315	370	400
Japan	175	130	125	125	135	125	125	145	155
China	0	15	20	50	60	115	160	165	165
RoW	40	70	85	120	185	170	165	200	215
Total	**1,395**	**1,525**	**1,485**	**1,645**	**1,720**	**1,630**	**1,725**	**1,890**	**1,940**
Jewellery									
Japan	10	15	20	20	20	20	20	20	20
China	90	120	110	125	100	60	60	50	50
Total	100	135	130	145	120	80	80	70	70
WEEE									
North America	80	70	75	75	70	85	75	70	70
Western Europe	115	80	85	90	95	80	75	80	80
Japan	130	135	120	135	145	165	135	125	125
China	25	20	30	40	30	25	35	40	40
RoW	55	65	65	70	90	80	80	85	85
Total	**405**	**370**	**375**	**410**	**430**	**435**	**400**	**400**	**400**
Total recycling									
North America	1,055	1,045	1,005	1,080	1,045	980	1,035	1,080	1,075
Western Europe	320	415	410	435	460	405	390	450	480
Japan	315	280	265	280	300	310	280	290	300
China	115	155	160	215	190	200	255	255	255
RoW	95	135	150	190	275	250	245	285	300
Total	**1,900**	**2,030**	**1,990**	**2,200**	**2,270**	**2,145**	**2,205**	**2,360**	**2,410**

Source: SFA (Oxford)

Rhodium supply-demand balance

koz	2010	2011	2012	2013	2014	2015	2016	2017	2018f
Primary supply									
Regional									
South Africa	645	630	590	580	415	610	605	615	580
Russia	75	75	75	70	75	70	70	75	70
Zimbabwe	25	30	30	35	35	35	45	45	40
North America	15	30	30	35	30	30	25	25	20
Other	20	20	20	20	25	20	25	25	30
Total	**780**	**785**	**745**	**740**	**580**	**765**	**770**	**785**	**740**
Demand & recycling									
Autocatalyst									
Gross demand	730	740	770	785	835	865	845	850	840
Recycling	220	235	240	260	275	270	285	305	325
Net demand	510	505	530	525	560	595	560	545	515
Industrial demand	175	170	150	155	180	175	195	175	200
Other recycling	1	1	1	1	2	2	2	2	2
Gross demand	905	910	920	940	1,015	1,040	1,040	1,025	1,040
Recycling	220	235	240	260	275	270	285	305	325
Net demand	**685**	**675**	**680**	**680**	**740**	**770**	**755**	**720**	**715**
Market balance									
Balance (before ETFs)	95	110	65	60	-160	-5	15	65	25
ETFs (stock allocation)			35	50	5	-5	5	-20	
Balance after ETFs			**30**	**10**	**-165**	**0**	**10**	**85**	

Source: SFA (Oxford)

Rhodium demand and recycling summary

koz	2010	2011	2012	2013	2014	2015	2016	2017	2018f
Gross demand									
Autocatalyst									
North America	180	180	200	220	235	255	255	235	230
Western Europe	200	215	190	195	220	240	205	205	195
Japan	165	135	150	140	140	125	125	125	120
China	70	75	90	95	105	110	130	150	160
India	15	20	20	15	15	15	20	20	20
RoW	100	115	120	120	120	120	110	115	115
Total	**730**	**740**	**770**	**785**	**835**	**865**	**845**	**850**	**840**
Industrial									
North America	15	20	15	15	15	15	20	15	15
Western Europe	25	20	20	15	20	15	15	15	25
Japan	45	45	45	35	30	35	30	30	35
China	40	40	30	45	55	55	65	55	55
RoW	50	45	40	45	60	55	65	60	70
Total	**175**	**170**	**150**	**155**	**180**	**175**	**195**	**175**	**200**
Total gross demand									
North America	195	200	215	235	250	270	275	250	245
Western Europe	225	235	210	210	240	255	220	220	220
Japan	210	180	195	175	170	160	155	155	155
China	110	115	120	140	160	165	195	205	215
RoW	165	180	180	180	195	190	195	195	205
Total	**905**	**910**	**920**	**940**	**1,015**	**1,040**	**1,040**	**1,025**	**1,040**
Recycling									
Autocatalyst									
North America	160	140	145	165	160	150	160	165	175
Western Europe	30	60	60	55	60	60	60	70	75
Japan	25	25	25	25	30	30	35	35	40
China	0	0	0	5	5	10	5	5	5
RoW	5	10	10	10	20	20	25	30	30
Total	**220**	**235**	**240**	**260**	**275**	**270**	**285**	**305**	**325**

Source: SFA (Oxford)

GLOSSARY OF TERMS

Basket price

Collective revenue of metals divided by 4E oz.

By-products

Copper, nickel, iridium and ruthenium.

ETF

Exchange-traded fund.

Gross demand

A measure of intensity of use.

HDV

Heavy-duty vehicle.

koz

A thousand troy ounces.

LCV

Light commercial vehicle.

Lease rates

Fees payable for the rental of an asset.

Merensky Reef

A PGM-bearing horizon within the Bushveld Igneous Complex, South Africa. Also contains nickel and copper sulphides that are mined as by-products.

moz

A million troy ounces.

Net demand

A measure of the theoretical requirement for new metal, i.e. net of recycling.

Net supply

Proxy supply of metal surplus to requirements.

NEVs

China's New Energy Vehicle mandate aims to promote NEV passenger cars and give compliance flexibility; it targets 12% of the conventional passenger vehicle market in 2020.

OLED

Organic light-emitting diode.

oz

Troy ounce.

Platreef

A PGM-bearing horizon mined on the Northern Limb of the Bushveld Igneous Complex. Characterised by a wide reef and base metal by-products.

PGMs

Platinum-group metals.

Pixie dust

A thin layer of ruthenium only three atoms thick.

Price elastic

Susceptible to changes in price.

Primary supply

Mine production.

Producer sales

Mine output plus inventory sold to market.

Secondary supply

Recycling output.

SAW filters

Surface acoustic wave filters; increasingly ubiquitous electronic components found in wireless communications equipment, often use iridium crucibles to make lithium tantalate and lithium niobate for SAW filters.

SEEPZ

Santacruz Electronics Export Processing Zone is a special economic zone in Mumbai.

The Great Dyke

A PGM-bearing horizon in Zimbabwe.

TOCOM

Tokyo Commodity Exchange.

UG2 Reef

A PGM-bearing horizon within the Bushveld Igneous Complex, located stratigraphically below the Merensky Reef. One of the main chromite-bearing reefs of the Bushveld Igneous Complex. Typically comprises lower base metals contents than the Merensky Reef.

4E

Platinum, palladium, rhodium and gold.

5E

Platinum, palladium, rhodium, ruthenium and iridium.

Currency symbols

ZAR	South African rand.
$	US dollar.

METHODOLOGY

Primary supply is calculated from actual mine production and excludes the sale of stock in order to provide pure production data. Stock sales are treated separately in SFA's database as movement of stocks. Therefore, state stock sales from Russia are excluded in tabulations.

Gross demand is a measure of intensity of use.

Net demand is a measure of the theoretical requirement for new metal, i.e. net of recycling.

Automotive demand is based on vehicle production data not sales.

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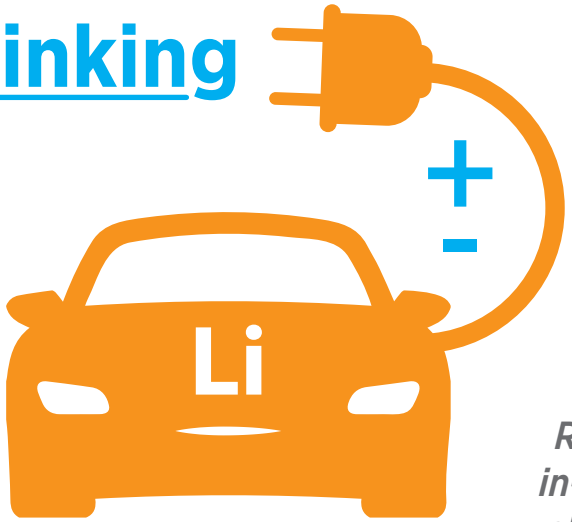
NOTES

One vehicle dataset, three metal forecasts

Equilateral Thinking

78 Pt Platinum | 46 Pd Palladium | 45 Rh Rhodium | 3 Li Lithium | 27 Co Cobalt



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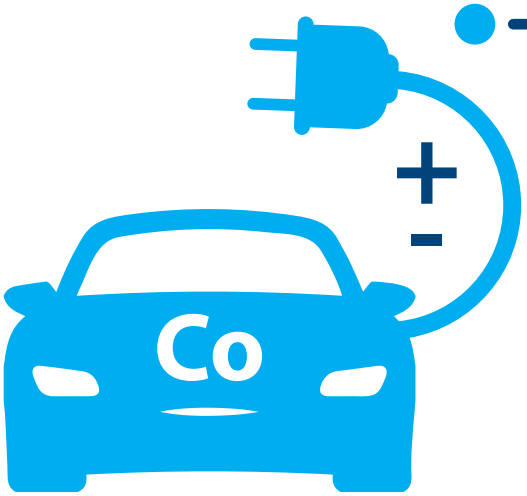
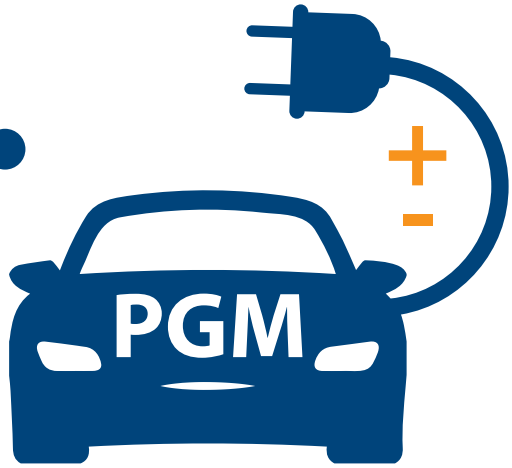
Due diligence assignments in the DRC and involvement in the cobalt industry go back ten years





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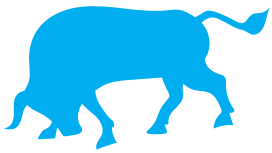
*For more information on equilateral thinking on **PGM**, **Cobalt** and **Lithium**, please contact MD, Beresford Clarke.*



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