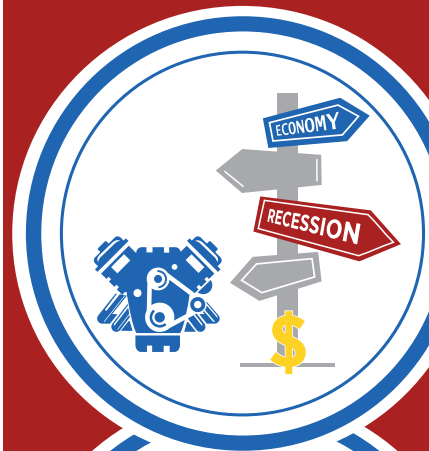
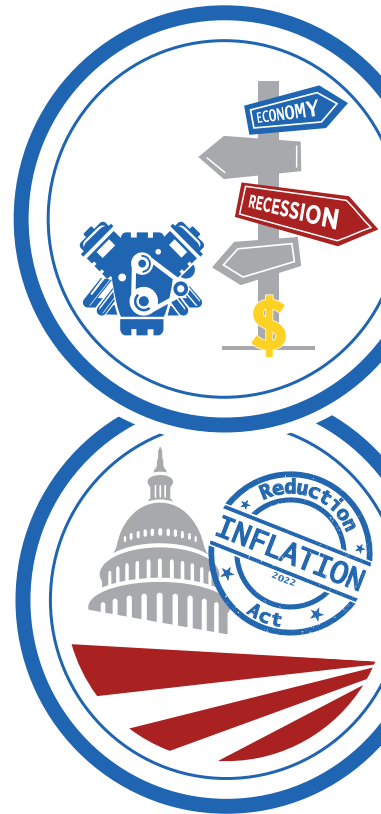




THE PALLADIUM STANDARD

September 2022





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September 2022

Issue 18

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TPS COLLECTION: AGENDA-SETTING COMMENTARY



The Palladium Standard was first published in September 2016, following the successful launch of The Platinum Standard in May 2014



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



If you are interested in reading the collection, you can now download the editions via our new website.



**FOREWORD:
COLLATERAL DAMAGE**



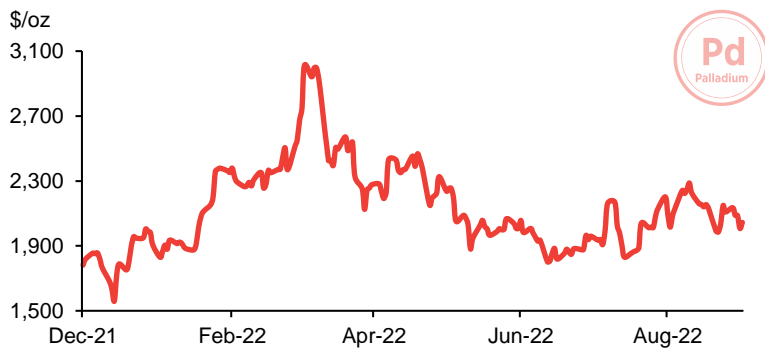
Foreword: Collateral damage

Pandemics, Putin and pipelines

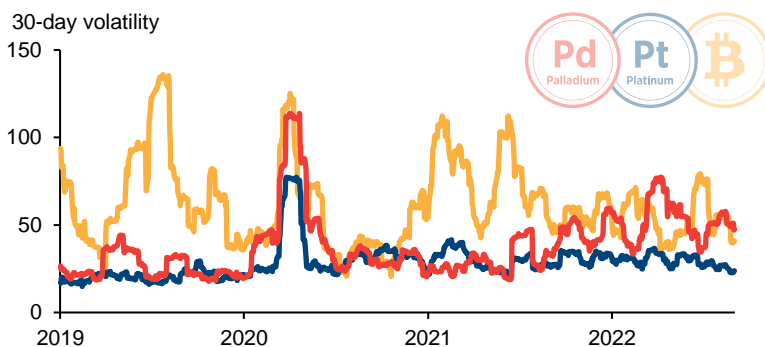
In 2022 we have witnessed another remarkable period of volatility in the price of palladium. The LBMA price more than doubled – from a low of \$1,576/oz to a high of \$3,442/oz – between December 2021 and March 2022. Improving production of autos, as the supply of scarce semiconductor components to OEMs recovered after the effects of the Covid-19 pandemic, strengthened the price in the new year. After the Russian invasion of Ukraine began in February 2022, the markets assumed that sanctions on Russia would include a ban on imports from Norinco, even though this had never happened to any producer in the past, including the darkest days of apartheid in South Africa. When this apprehension proved to be unfounded and palladium continued to reach the market, the price relapsed from the peak to pre-invasion levels. Other conditions then emerged to dampen price sentiment: a stronger US dollar; new shortages of components essential to the auto industry produced in Ukraine; the collapse of auto production in Russia after the imposition of sanctions; consumer spending and industrial output in China hampered by lockdowns in cities affected by outbreaks of Covid-19. Perhaps most significantly of all, the conflict in Europe restricted energy supplies and oil and gas prices soared, leading to a rapid onset of inflation at levels which are likely to slow economic growth. Palladium could become one of the casualties of this war.

Palladium's shell shock has subsided

Palladium's wild ride in 2022



The MVP — most volatile precious metal



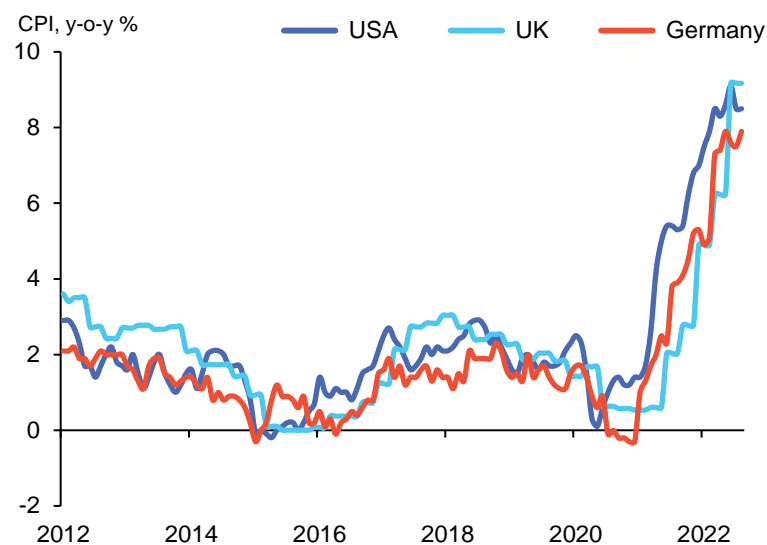
Source: SFA (Oxford), Bloomberg

The inflation problem for precious metals

Inflation is an especially dangerous beast when goaded by supply shortages rather than excess demand and trying to cage it by raising interest rates risks national economies falling into a recessionary bear pit. In our lead paper, 'Macro and PGM Markets – the Turn of the Screw', James Steel of HSBC investigates the lacklustre price performance of gold and other precious metals, in particular palladium, since the initial surge following the Russian invasion of Ukraine. James identifies the factors which led to a post-invasion sell-off, and probes the relationship between price direction and US monetary policy, dollar strength and, in particular, rising inflation. Referencing the historical behaviour of the gold price, he observes a high degree of consistency between gold and the other metals of the precious metals complex in reaction to these factors. Geopolitical events, however, tend to cause divergent behaviours between gold and the more industrial metals. A survey of likely upcoming levels of palladium demand from the auto industry follows, including analysis of supply chain constraints and other challenges which have emerged since the Ukraine crisis. James delivers a sober, almost sombre, outlook for overall palladium demand.

Geopolitics and macroeconomics as the drivers for precious metals prices

Consumer price index, 2012-2022



Source: SFA (Oxford), Bloomberg

Batteries included?

Electric vehicle sales continue to increase, and in the US in the first half of 2022 they have risen at a rate of almost 50% year-on-year, despite higher battery material costs. The US administration has now introduced the Inflation Reduction Act (IRA), which contains, inter alia, a complex new incentive programme designed to promote the production of battery materials, battery components and electric vehicles in North America. Does this sound like more bad news for palladium? Not necessarily, according to Lakshya Gupta of SFA in his article, 'Inflation Reduction Act – the Good, the Bad, the Ugly'. Lakshya points out that the current tax rebates available to consumers for buying electric vehicles have been restricted to relatively low production numbers, which the larger OEMs have already exceeded, and are structured to apply only to pure battery-driven vehicles. The new rules will allow the full rebate also to be claimed for plug-in hybrid electric vehicles (i.e. with a combustion engine and a catalyst) and fuel cell vehicles, so that manufacturers could choose to increase output of PGM-containing powertrains to benefit from the incentives on offer, provided they meet the stipulated domestic sourcing requirements. Lakshya concludes, therefore, that the IRA may lead to some upside in palladium autocatalyst demand in the near term. Whether or not the Act will reduce inflation, or survive intact if the balance of power in Congress changes in November is another matter.

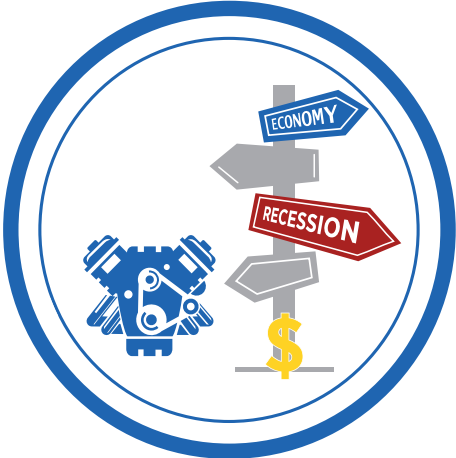
*EVs must be
"American built" to get
subsidy benefit*

Palladium wounded?

Taking everything into consideration, Ralph Grimble presents the customary SFA outlook for palladium supply, demand and price in 'The PGM Markets in 2022'. A tricky task in these most uncertain of times, but with the greater part of the year having elapsed, SFA's forecast is for a palladium market close to balance, with a slight increase in demand and a marginal reduction in total supply. The underlying details provide clues as to how the palladium market might develop in 2023. Examples from the supply side include the attritional effects of power shortages in South Africa and restricted growth in recycling as economic pressures on consumers reduce automobile scrappage rates; while the price-induced long-term decline in traditional industrial applications concentrates demand in an auto sector turning to battery electric vehicles and the substitution of palladium with less expensive platinum in autocatalysts for gasoline vehicles.

*Softened demand
recovery and lower
primary supply*

**MACRO AND PGM MARKETS —
THE TURN OF THE SCREW**



Macro and PGM markets — the turn of the screw

James Steel, Chief Precious Metals Analyst, HSBC Securities

Monetary and fiscal metals fatigue

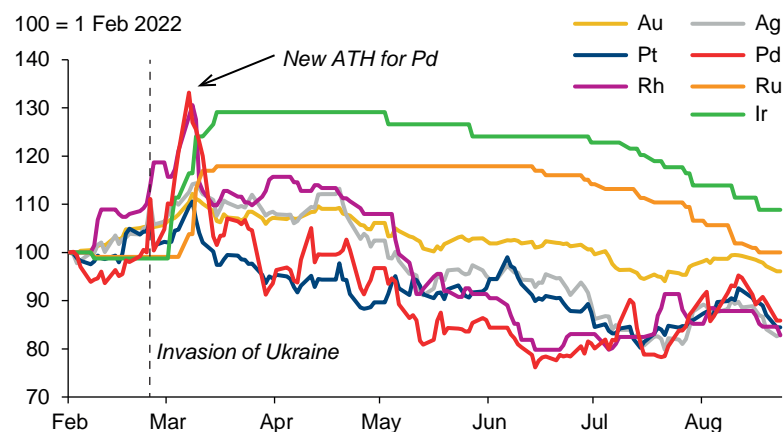
The precious metals complex has been impacted by two major developments this year: the conflict in Ukraine and the withdrawal of monetary and fiscal stimulus – notably by the US Federal Reserve – in the wake of the Covid-19 pandemic. The surge in prices across the precious metals complex following the invasion of Ukraine – particularly palladium which vaulted to a record all-time high (ATH) and gold which came within challenging distance of \$2,100/oz, both in early March – has since subsided to below pre-invasion levels. Steep rallies in silver and platinum at the time have also been reversed. As the fall in palladium was the most dramatic of all the precious metals, it merits more detailed analysis.

“War premiums” on precious metal prices were fleeting and most precious metals prices have fallen to below pre-invasion levels

The post-Ukraine invasion sell-off can be ascribed to three factors:

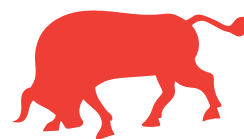
1. An initial overreaction that led to the price pendulum swinging back from highly overbought conditions.
2. Fallout from the crisis – higher energy prices and damage to consumer sentiment – has weighed on the auto sector and other sources of palladium demand.
3. Additionally, automotive and other forms of palladium demand have been constrained by rapidly tightening monetary policies, mainland China’s zero-Covid policy, and ongoing supply chain issues, some of which, such as neon production for microchips, have been worsened by the Ukraine conflict.

Precious metals price performance, 2022



Source: SFA (Oxford), Bloomberg. Note: ATH = all-time high.

As perceived safe havens, precious metals are sensitive to monetary and, to a lesser degree, fiscal policies principally – though not exclusively – as set by the US authorities. Effectively, the Ukraine situation and other assorted risks have been superseded by the pronounced shift in the policies of the Fed and other central banks towards tightening which, in conjunction with greater fiscal prudence, is weighing on bullion, notably gold and silver but also platinum-group metals (PGMs). The shift away from the era of easy money, low interest rates and very high public spending – given momentum by the Fed and other US authorities – is a heavy counterweight to any bullish gold or silver argument and has negative implications for PGMs also. There is a weight of academic and empirical work that clearly demonstrates that lax monetary conditions are generally gold bullish and restrictive policies are price negative, as illustrated in the chart below. HSBC precious metals research believes this applies equally to silver and PGMs.

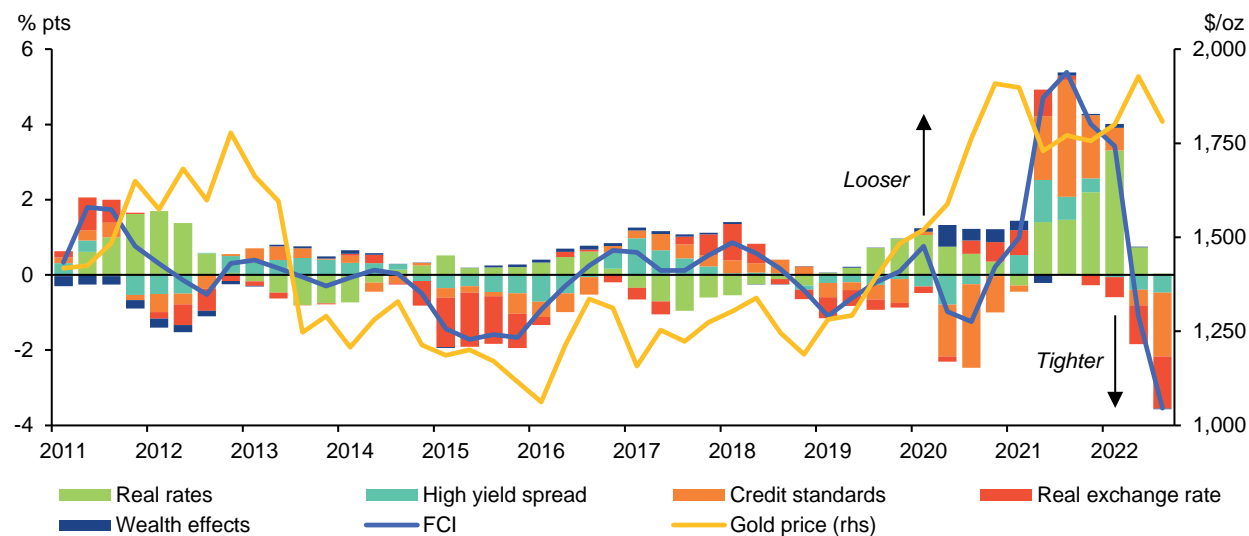


Saying goodbye to easy money



The views of HSBC’s US Economist, Ryan Wang, on monetary policy imply a tough road ahead for gold and the rest of the precious metals, including PGMs. He forecasts that the Federal Open Market Committee (FOMC) could decide to continue raising interest rates at all the remaining meetings of 2022 and early 2023. This would take the federal funds target range up to 3.75-4.00%. The implications of this for the precious metals including gold, silver, platinum and palladium are broadly negative. The Fed has also begun reducing the size of its balance sheet and HSBC’s economics team expects the balance sheet to shrink by about \$1.4 trn over the next 18 months as the Federal Reserve’s holdings of Treasury securities and mortgage-backed securities diminish. Markets are pricing in significantly more rate rises and trying to assess the impact of quantitative tightening. This is a considerable decline, and just as HSBC’s team concludes that the expansion of the holdings helped to boost gold and other precious metals prices, it is believed that shrinkage will help to constrain bullion prices across the board.

United States financial conditions indicator, 2011-2022



Source: Bloomberg, HSBC

The Palladium Standard

That the US Federal Reserve has embarked on monetary tightening sooner and harder than other monetary authorities has implications for precious metals as it will tend to support the US dollar. The strength of the dollar has been negative for bullion prices all year. There is an inverse relationship between the US dollar and precious metals, as well as other commodities, which rests on the fact that commodities are traded globally in US dollars and its exchange rate impacts both production and consumption decisions. The dollar may also be supported by the relative resilience and strength of the US economy compared to its major trading partners. Should the US dollar remain firm, it is likely to act as a headwind to bullion rallies and, while this may be most visible with regard to gold, platinum and palladium may also be impacted.

Record dollar strength has helped to pin down the precious metals this year

Monetary policy has been described as a sledgehammer rather than a scalpel. As central banks including the Fed have stated, monetary authorities cannot influence global supply shocks. They can only respond by having to combat inflation through lowering domestic demand to bring it more in line with the still constrained supply in order to curb wage growth and prevent a wage-price spiral. Their recent actions are intended to demonstrate that they are ready to do whatever it takes to truly control inflation. While this is most obviously negative for gold, the bearish implications for platinum and palladium are also clear. The constraints on consumer demand as a consequence of Fed policy will strike at industrial demand which will also constrain platinum and palladium demand, most obviously in the auto sector.

The Fed cannot directly influence the global supply chain, so to control inflation, it must attempt to quell excess demand through policy

Inflation and precious metals: not what you may think

Where does rising inflation fit into the precious metals dynamic? Bullion's relationship with inflation is not straightforward. Inflationary pressures have risen markedly, and this is intuitively supportive of gold, silver, platinum and palladium, and hard assets in general. However, despite this intuitive reasoning, there has been no compelling argument historically for gold as an inflation hedge. Indeed, the academic literature supports the view that gold has, on balance, been an unreliable hedge at best. HSBC's precious metals research is also of the view that this rationale applies to the rest of the precious metals. What persistently high inflation in the US is more likely to guarantee is a forceful Fed response and higher rates, which are more likely to weaken than support precious metals prices. Inflation concerns have not, as yet, triggered greater institutional demand for any of the major precious metals and although retail demand for gold and silver is quite pronounced, this is not enough to buoy the price.

The instinctual notion that precious metals are a good hedge against inflation is about to be tested

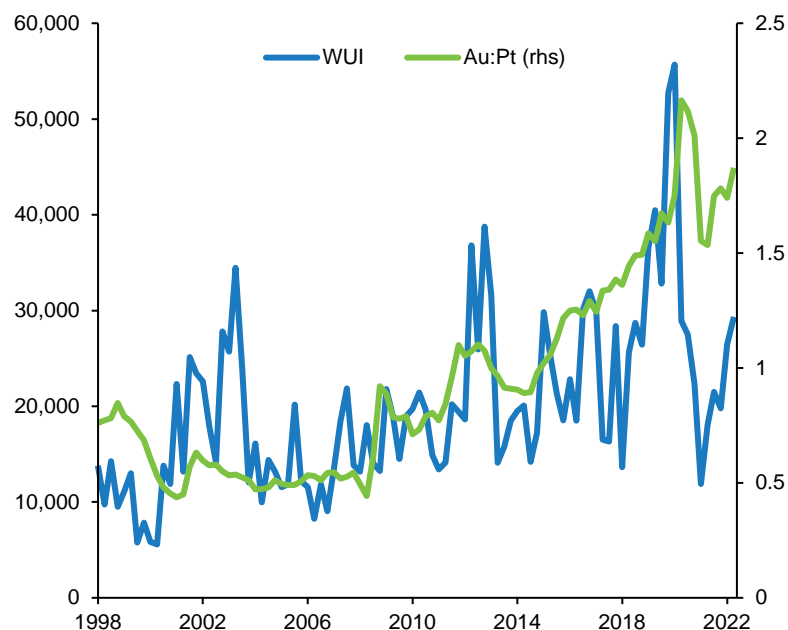
Geopolitics is a mixed bag for precious metals

Gold has long been sensitive to geopolitical risks. As a safe haven, gold is often in demand when geopolitical risks rise. Put briefly, while often not a primary driver of gold prices, geopolitical risks are an important secondary influence on them. Such risks may remain high going forward and this has ramifications for gold. Although HSBC’s analysts have argued that precious metals are a flawed hedge against inflation, the effect of certain types of inflation on geopolitics may have a more positive impact on precious metals. A report in *The Economist* on 25 June 2022 pointed to the historical relationship between food- and fuel-price inflation and political unrest. Escalating food and fuel prices have led to political violence and supported gold in the past. Falls in living standards and the resultant unrest have had adverse impacts on financial markets, ending up supporting gold. Political violence – even if it does not result in a change of government – has added to economic dislocation. Social disorder has deterred both direct and portfolio investment and this has reduced GDP, weakened equity markets, and boosted safe-haven buying in gold. Although gold may still be more sensitive to monetary policy and US dollar levels than overall inflation, in certain circumstances food and energy may nonetheless exert influence on bullion. This helps to reaffirm HSBC’s precious metals research’s view that while gold prices are likely to remain under pressure as a consequence of tightening monetary policies, more moderate fiscal policies and a strong US dollar, these likely losses should be tempered and measured as geopolitical risks from high food and energy prices may persist.

As geopolitical risk rises, demand for gold often rises...

...but this is not often a primary driver of gold prices

World Uncertainty Index vs. gold:platinum ratio



Source: SFA (Oxford), World Uncertainty Index, Bloomberg. Note: The WUI is computed by counting the percentage of the word “uncertain” (or its variant) in the Economist Intelligence Unit country reports. The WUI is then rescaled by multiplying by 1,000,000. A higher number means higher uncertainty and vice versa.

The Palladium Standard

While the impact of geopolitical risks is positive for gold, the opposite is the case for the other precious metals including palladium. The slowing in industrial production as a consequence of geopolitics, including events in Ukraine, is a negative for the more industrial precious metals including silver, platinum and palladium. As palladium has the largest industrial component of all the precious metals, the precious metals team at HSBC believes the impact on palladium of geopolitical risks may be the most direct.

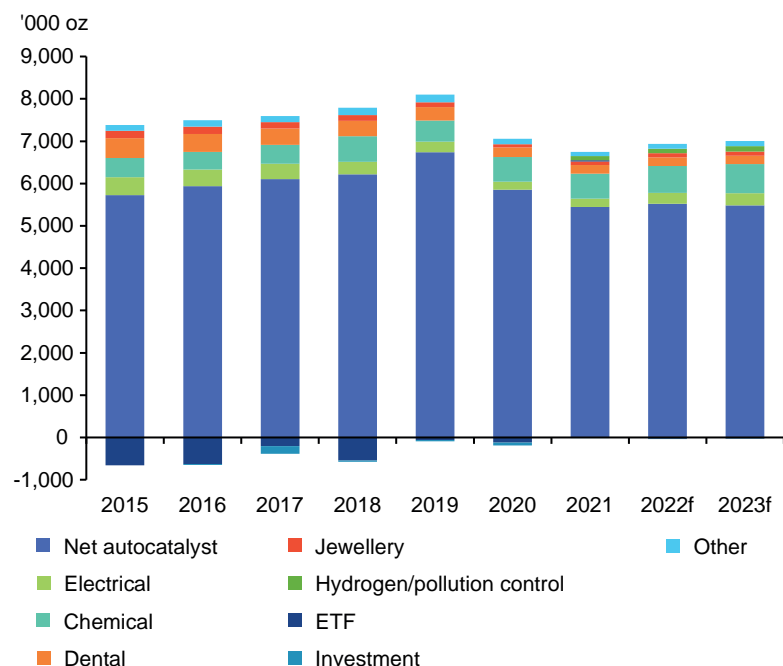
Autos shift to low gear

Palladium is unique among the major precious metals in that the primary source of palladium demand is the auto sector, with around 85% of end-use demand. This makes palladium demand largely a function of ICE automotive demand. Johnson Matthey reported global gross palladium demand in the auto sector of 8.3 moz, down -2% from 8.5 moz the previous year. Thus, demand remained notably below the pre-Covid levels of 9.7 moz reached in 2019. The climate looked set to change last year in line with the economic recovery, notably owing to pent-up consumer demand and Covid vaccine progress. Initial forecasts of automotive production and PGM demand looked positive for 2021 and 2022, although this uplift has not materialised to date. While underlying consumer demand in 2021 was robust – fuelled by pent-up demand, low interest rates, and economic recovery – the global automotive industry found itself severely challenged by a worldwide microchip shortage, which has restricted output. Despite expectations that production shortages would begin to clear up in H2'21, the lack of microchips stifled automotive production which increased only 3.5% to 77.2 m units in 2021, according to S&P Global Mobility data and HSBC estimates. A respectable increase in most years, but below initial expectations of a strong rebound. The chart below shows HSBC's global palladium demand estimates.

Palladium demand is highly dependent on automotive production

Semiconductor chip shortages forecast to persist through 2022

Global palladium demand, 2015-2023



Source: Johnson Matthey, HSBC forecasts

Auto parts

While automotive output is increasing, a fully-fledged recovery to pre-Covid production levels still appears some way off. This serves to keep automotive industry demand for palladium, and also platinum, below what would otherwise be the case. The forecasts for PGM autocatalyst demand are based on HSBC's automotive forecasts and S&P Global Mobility data. The vast bulk of vehicle production (and PGM demand) worldwide is for light vehicles, and mostly for gasoline engines, which heavily favour palladium loadings in their autocatalytic converters.

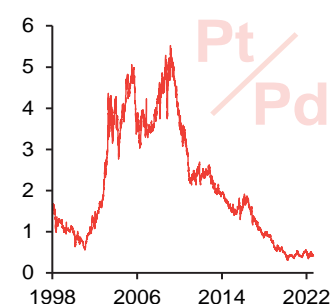
The HSBC automotive team forecasts automotive light-vehicle production this year of 78.6 m units, an increase of 1.8%, followed by a more vigorous increase of 5.8% to 83.1 m units in 2023. This is a smaller rebound in production than was generally anticipated at the beginning of the year. At that time, however, some important issues that are now acting to drag down automotive production had not fully materialised. These include the invasion of Ukraine and the damage done to automotive demand in the region, as well as to neon production, 40-50% of which comes from the country and is required to manufacture microchips. Lockdowns in mainland China halted automotive production for weeks in the cities affected and contributed to tailbacks in the supply chain of automotive components.

The Palladium Standard

Despite economic headwinds from higher interest rates, inflation and economic slowdown, auto sales are likely to improve, with the potential for double-digit growth in the EU and mainland China. This is ostensibly good for palladium demand, but sales volumes are still likely to be capped by production bottlenecks, including semiconductor shortages that will limit production and sales. Nonetheless, the automotive team at HSBC expects global auto sales to improve from Q3'22 onwards as, with the exception of a post-Covid rebound in H1'22, sales have been under pressure since 2018 and may be ready to improve.

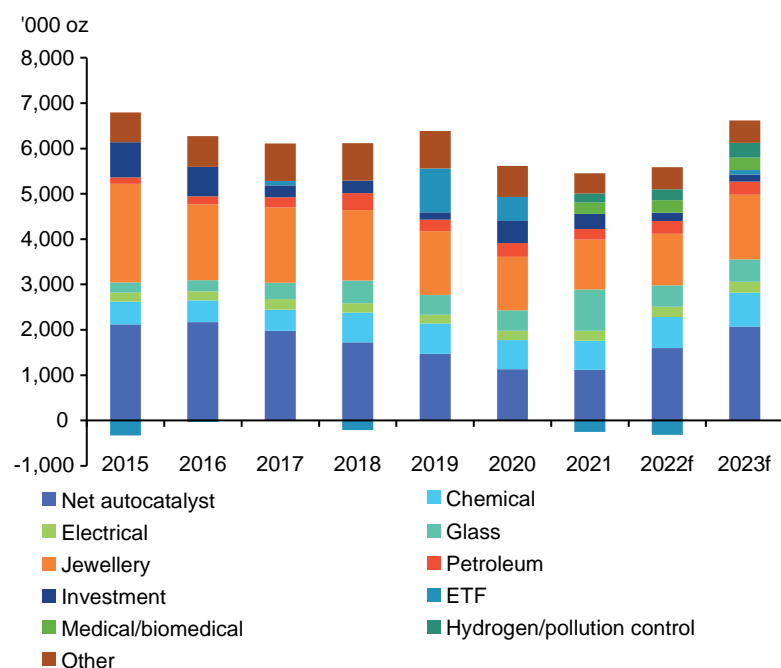
The HSBC forecast for 2023 is a more dynamic 5.8% increase to 83.5 m units, but is still far below the levels produced pre-Covid in 2019 of 89 m units. Even with a recovery, auto industry demand for PGMs will likely remain below historical levels, with the HSBC automotive team not expecting global automotive production to reach the 2017 level of 95 m units until later in the decade, with recovery in European demand expected to be particularly slow. This is a key factor in the HSBC precious metals team's calculations for modest 2022 and 2023 forecasts for palladium demand from the auto sector. It is estimated that 2022 and 2023 gross automotive demand for palladium will be 8.5 moz and 8.9 moz respectively. These forecasts also take into account underlying changes in demand for palladium across the auto sector, including a shift to heavier loadings and ongoing emissions regulations, as well as the reduction in palladium demand due to substitution with lower-priced platinum and the growth of electric vehicles, which do not require any PGM input and in H1'22 reached 4.8% market share of sales in the US. A key shift is the acceleration in substitution from higher-priced palladium to less expensive platinum in autocatalytic converters.

Platinum/palladium ratio is at a historical low



Source: SFA (Oxford), Bloomberg

Global platinum demand, 2015-2023



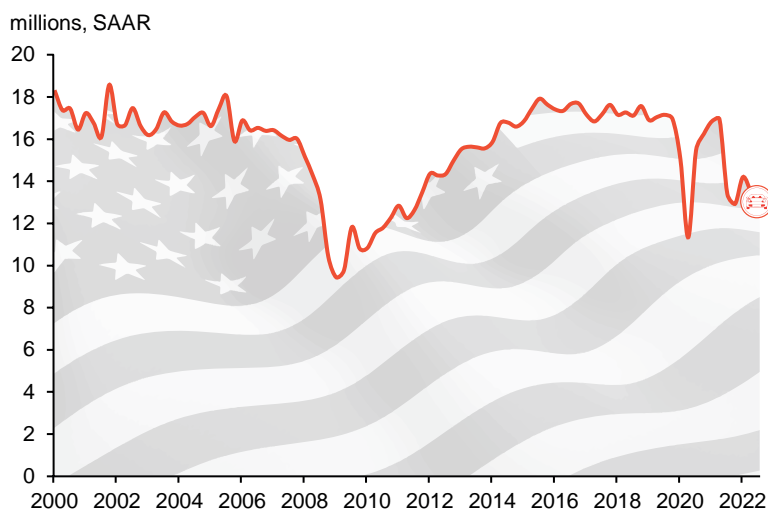
Platinum demand forecast to exceed pre-Covid levels by next year

Source: Johnson Matthey, HSBC forecasts

The Palladium Standard

Unlike in Europe, the US automotive market had recovered its historical peak levels of unit sales after the 2008-09 recession, and retained that level for a few years. Between 2015 and 2019, it exceeded 17 m of annual sales consistently. The Covid lockdowns in 2020 were a temporary setback, followed by supply disruptions, which drove the seasonally adjusted annual rate (SAAR) to 12-15 m in 2021-22. HSBC's automotive research expects the current bottlenecks on volumes to weigh on 2022 volume growth (-1%) but, as they start to ease, US sales may grow by 7% in 2023 and 2% in 2024, taking market volumes to 16.3 m, still 6% short of the 2018 peak. The market may then remain stable until 2030.

United States light-vehicle sales, 2000-2022



Source: SFA (Oxford), Federal Reserve Bank of St. Louis

Summing up PGMs

Platinum is a much more diversified precious metal than palladium. While automotive demand is rising, many of the gains are due to substitution with higher-priced palladium. Other industrial sources of platinum consumption are also firm, although demand is weighed down by the international rate environment and slowing growth. However, if mainland China's jewellery demand can increase after years of decline, the market may move from a likely surplus this year to a deficit, given tight supply. Palladium is a much more one-dimensional metal and is reliant on automotive demand which is certainly rising but at a measured pace and is curbed by sluggish auto sales and substitution. Current and foreseeable conditions leave palladium in a tough spot and price appreciation from here is difficult to assume.

**INFLATION REDUCTION ACT:
THE GOOD, THE BAD, THE UGLY
(... for EVs)**



Inflation Reduction Act: the good, the bad, the ugly (...for EVs)

Lakshya Gupta, Senior Battery Technology Analyst, SFA (Oxford)

An amended (watered down) iteration of the previously rejected Build Back Better Act was signed into US law by President Biden on 16th August. It is (rightfully) up for debate about how effective the Inflation Reduction Act (IRA) will be in achieving reduced inflation, but it does present upside for North America's EV market... eventually.

The IRA has updated the eligibility criteria for the federal EV tax credits. In the long term, these revisions are considered a net positive for EVs as they simultaneously lower the EV sticker price and stimulate development of the North American battery supply chain. While both of these are inherently negative for palladium demand, there could be some near-term upside as the supply chain adjusts.

Palladium boost as EV supply chain adjusts?

The Good

There are four main benefits for North America's EV sector from the passing of the IRA, mostly from the changes around the tax rebate. While the full rebate amount has not been changed (\$7,500), the eligibility criteria have been updated to be more favourable for both automakers and consumers. Furthermore, the 10-year horizon for the bill provides a significant window of support while EVs are still more expensive than their internal combustion engine (ICE) counterparts.

Firstly, automakers are no longer punished for being first to market, as the cap on the tax rebate has been removed. Under the previous legislation only the first 200,000 EVs sold by an OEM, including plug-in hybrids, were eligible for the full \$7,500 rebate. The greatest beneficiaries (from 2023 onwards) are General Motors and Tesla, with Toyota also now benefitting as it sold its 200,000th EV in Q2'22, triggering the rebate phase-out by Q4'22.

Secondly, used EVs are now eligible for a rebate of 30% of their value, capped at \$4,000, where no rebate was available previously. While this will have little impact in today's market, owing to limited availability (supply chain woes) and strong consumer demand pushing up second-hand EV prices (to above those for new vehicles in some cases), the intent is clear: make second-hand EVs competitive (with ICE) for those who do not buy new cars, be it through choice or a lack of purchasing power.

The Palladium Standard

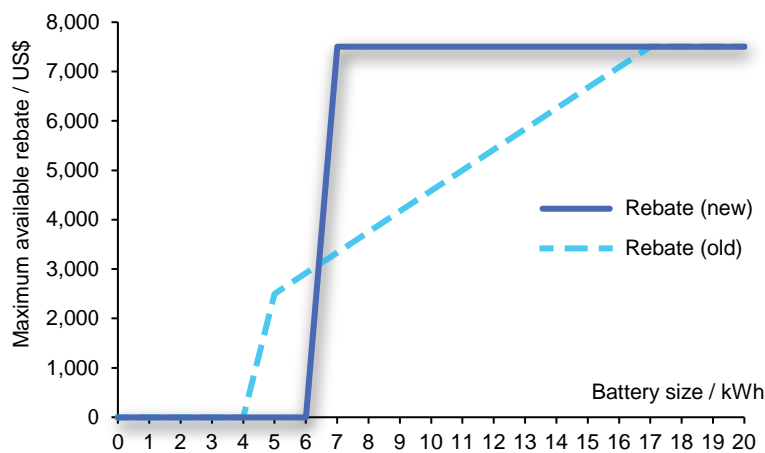
Thirdly, the full tax rebate will be available at the point of sale, although it is not clear from when this will be applicable. Presently, consumers have to file for the rebate during their tax returns at the end of the fiscal year. This means that, in the worst case, the economic benefit for consumers is not realised until the following year. This change will effectively lower the sticker price of the EV, benefitting those with lower purchasing power.

Lastly, the rebate amount is no longer tied to battery size or even explicitly restricted to plug-in electric vehicles. This means that autocatalyst-equipped plug-in hybrids (PHEVs) are eligible for the full federal rebate of \$7,500, irrespective of battery size. Furthermore, fuel cell vehicles are now also eligible for the rebate amount (upside for platinum demand), but none currently qualify owing to the North America based manufacturing requirement.

*Pd-containing PHEVs
qualify for
EV incentives*

It should be noted that the minimum battery capacity requirements still exist, at 7 kWh for EVs and 1 kWh for fuel cell vehicles. The difference is that the rebate amount (\$7,500) does not scale with battery capacity. Previously, a minimum battery capacity of 17 kWh was required for an EV to be eligible for the full rebate.

US EV tax rebate changes (w.r.t. battery size)



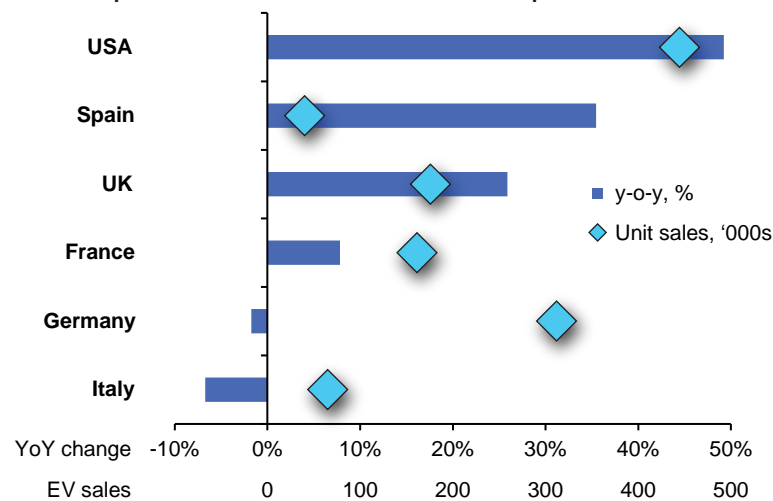
Source: SFA (Oxford), IRS

The Bad

There are some notable caveats in the IRA that could disrupt EV sales for the next couple of years, potentially dampening EV uptake just when the US has started to gain some momentum, with sales growth in H1'22 outperforming that of major European nations.

To start with, the rebate changes in the IRA only come into effect from 1 January 2023. This means EVs from Tesla, GM and Toyota are not eligible for the \$7,500 for the remainder of 2022. Toyota will still get the reduced (phasing out) credit under the old system for Q3'22, assuming the North American manufacturing clause is satisfied.

EV sales performance in H1'22 - US vs. EU Top 5



Source: SFA (Oxford), EV-Volumes. Note: This includes BEVs and PHEVs.

As alluded to above, any EV must be manufactured in North America for it to qualify for any of the \$7,500 rebate. In contrast with the rest of the rebate changes, this requirement comes into effect at the signing of the IRA (i.e. 16 August). Combining these two factors means that of the top ten selling BEVs in the US in H1'22, only two are eligible for tax rebates for the rest of the calendar year. The two eligible models (Ford's Mach-E and Nissan's Leaf) represented just over 7% of total US BEV sales in H1'22.

Only two of the top ten selling BEVs eligible for tax rebates

Furthermore, the \$7,500 rebate will be split into two equivalent components (\$3,750 each) from 2023 onwards, with each component having its own qualification criteria.

Top 10 selling BEV models in US, H1'22

Model	Sold in H1'22	Subsidy eligibility		Reason
		until end-2022	from Jan-2023	
Tesla Model Y	121,640	✓	?	Sales cap met
Tesla Model 3	86,040	✓	?	Sales cap met
Tesla Model S	19,460	✓	?	Sales cap met
Ford Mustang Mach-E BEV	17,675	✓	?	Manufactured in Mexico
Hyundai Ioniq-5 BEV	13,692	✗	✗	Non-NA manufacturing
Kia EV6 BEV	12,568	✗	✗	Non-NA manufacturing
Tesla Model X	9,900	✓	?	Sales cap met
Nissan Leaf BEV	7,622	✓	?	Manufactured in Tennessee
Audi e-tron Quattro BEV	6,818	✗	✗	Non-NA manufacturing
Kia e-Niro BEV	6,274	✗	✗	Non-NA manufacturing

Tesla re-eligible for the full subsidy from 2023

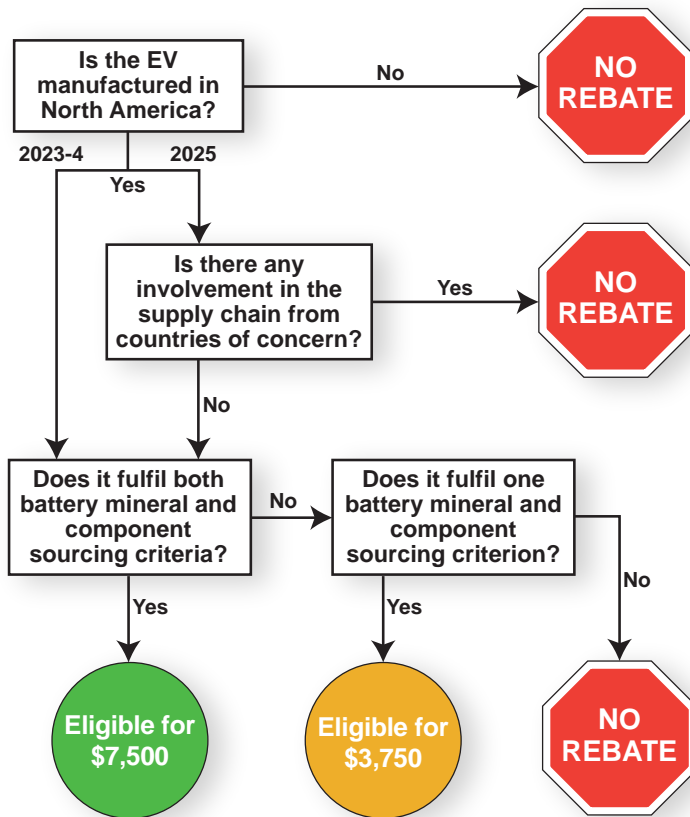
Source: SFA (Oxford), EV-Volumes. Note: Top 10 models represent 82% of US BEV sales in H1'22.

To be eligible for the first half of the rebate from 2023, a minimum percentage (by value) of battery critical minerals must be extracted (or processed) in the US, or a country with a free-trade agreement with the US. The threshold starts at 40% in the first year, increasing annually in 10% increments up to a maximum of 80% in 2027.

The second half of the rebate has a similar basis as the first but in relation to the components of the battery pack itself. In 2023, at least 50% of the battery pack components (again, by value) must come from the US or countries with a free-trade agreement with the US. Again, this threshold increases over time: 60% in 2024, 70% in 2026 and then in 10% annual increments, up to 100% in 2029.

The intent behind splitting the rebate into these two components is quite clear: to develop the domestic battery supply chain. It is certainly working as intended. Since 16 August, multiple OEMs have announced new, or accelerated existing, plans to move manufacturing to North America, including Honda, Hyundai, and LG Energy. However, these manufacturing plants will not come online overnight and so there will be a significant period during which many EVs on the market are not eligible for the rebates.

Eligibility criteria for EV tax rebate from 1 January 2023



Source: SFA (Oxford)

The last sticking point of the IRA is that it is still in the form of a tax rebate rather than a subsidy, regardless of being applied at point of sale. As such, consumers will only be able to claim up to their annual tax liability (up to \$7,500). There are two things to note here:

Incentive linked to tax liability - does not benefit lower income households

1. This precludes lower income households from taking advantage of the full rebate amount and switching to EVs.
2. The rebate is not index-linked, so will lose value over the act’s 10-year horizon.

The Palladium Standard

There are also some clauses which could impact near-term EV sales, but these are fairly comparable with other subsidy schemes:

1. Maximum allowed MSRP for eligible EVs (new): \$50,000 for passenger cars, \$80,000 for SUVs, trucks and vans.
2. Gross household income limits for rebate eligibility: \$150,000 for individuals, \$225,000 for head of household and \$300,000 for joint returns.
3. Maximum allowed MSRP for eligible EVs (used): \$25,000.
4. Gross income limits for rebate eligibility (used EVs): \$75,000 for individuals, \$112,500 for head of household and \$150,000 for joint returns.

The Ugly

... for EVs

The IRA presents a considerable disruption to North America's battery supply chain, should automakers require the tax rebates to offer an attractive price point in an extremely competitive market.

Localising production has definitely moved up the agenda in recent years for both supply chain resilience (industry focus) and securing long-term economic benefits (government focus), so the policy is in line with, and accelerates, the industry trend.

*North America's
battery supply
chain is weak*

However, the reality is that North America's presence in the battery supply chain, compared to that of China and Europe, is (put mildly) lacking. Among the top three EV markets (China, Europe, North America), North America has the weakest gigafactory and battery component pipeline.

Regional BEV manufacturing is also limited, with only Tesla, GM, Ford and recently Volkswagen (ID.4) having a presence. Not using a phased-in approach for the North American manufacturing criterion immediately precludes a large number of EVs from eligibility for rebates, to the detriment of the consumer.

The Palladium Standard

This will be exacerbated from 2025 when EVs with a battery supply chain involving ‘foreign entities of concern’, including China, are immediately excluded from rebate eligibility. China’s dominance of the battery supply chain is well documented and it is unrealistic to scrub the nation’s presence in the sector within two years. Graphite alone, required for the anode and included in the USGS critical mineral list, will preclude the majority of EVs from being eligible.

Realistic to remove China from supply chain within two years?

The, perhaps unintended, beneficiary in all this will be the PHEVs. More automakers have a PHEV manufacturing presence in North America and may prioritise these vehicles to take advantage of the tax rebates. Audi, BMW, Chrysler, Ford, Jeep and Volvo all manufacture at least one PHEV model in North America. With PHEVs automatically qualifying for the full rebate, a higher focus on PHEV production could lead to palladium demand generation.

Top five selling PHEV models in the US, H1'22

Model	Sold in H1'22	Subsidy eligibility		N.A Manufacturing?
		until end-2022	from Jan-2023	
Jeep Wrangler	19,207	✓	?	✓
Chrysler Pacifica	8,559	✓	?	✓
BMW X5 45e	7,843	✓	?	✓
Ford Kuga/Escape	4,272	✓	?	✓
Jeep Grand Cherokee	2,500	✓	?	✓

Source: SFA (Oxford), EV-Volumes

... for palladium

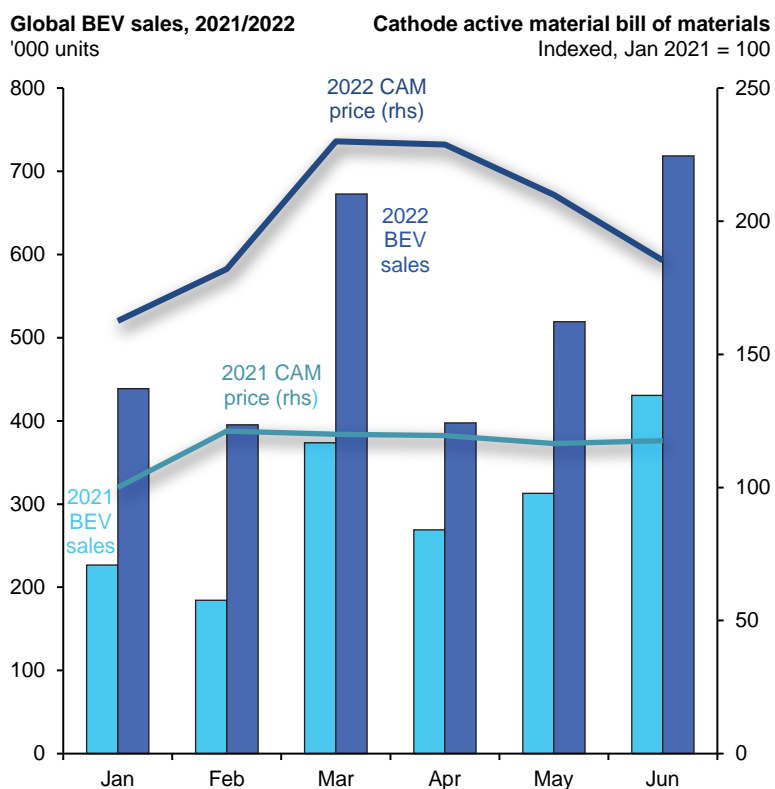
The question that must be asked is does any of the above actually matter? Do consumers need subsidies to buy EVs?

Globally, EV sales have appeared to be inelastic to battery commodity prices so far this year, with North America also showing healthy growth. Despite a global cost of living crisis, industry-wide supply chain woes and all-time high battery commodity prices, EV sales have continued to grow and consistently outperform the rest of the automotive sector. All of this while Tesla maintains the top three spots in EVs sold without any tax rebates (in North America).

Tesla tops EV sales without subsidies...

The IRA has already accelerated the build-out of North America's battery supply chain, with investments announced in the week following the act's passing and more expected going forward.

Global BEV sales inelastic to battery commodity pricing?



Source: SFA (Oxford), EV-Volumes

Automakers have also publicly announced offtake agreements with Canadian nickel producers, and more deals with Australian, Chilean and South Korean producers/refiners are expected to follow (i.e. countries with critical battery mineral resources that have free-trade agreements with the US).

The Palladium Standard

In recent years, North America has been the laggard when it has come to EV uptake. Quarterly revisions and upgrades were routinely centred around China and Europe, with North America's EV production remaining largely stagnant.

It would be fair to argue then that the IRA, in the few short weeks since its passing, is already achieving its desired effect.

*IRA achieving
desired effect*

The 10-year horizon of the IRA extends economic support well beyond the expected timelines for EVs to reach price parity with ICE vehicles (i.e. late 2020s) and provides manufacturers with enough time to develop a competitive, localised battery supply chain. The removal of the 200,000 unit cap on rebate eligibility is a big win for market leaders Tesla and GM, especially with GM aggressively ramping up its EV production in the coming years.

The feasibility of the 2025 deadline for removing countries of concern from the supply chain should certainly be queried. Removing China from the battery supply chain within two years seems very optimistic and will require some innovative solutions, possibly a faster deployment of next-generation technology (e.g. silicon anodes). These are still not going to be ready for mass deployment by 2025 however, even in the most robust projections.

As such, the IRA's aggressive timeline could lead to some upside in North America's automotive palladium demand, owing to a greater focus on PHEVs and a lack of BEVs eligible for rebates over the next three to four years.

This is all without considering:

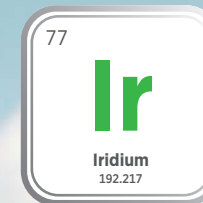
1. The ability of the Democratic Party to hold both houses in the upcoming mid-terms, required to pass any amendments.
2. Pushback from existing trade partners, especially South Korea, regarding the protectionist stance of North American manufacturing.
3. Any possible retaliation from other nations, especially China.
4. Any impact on palladium availability owing to the West's isolation of Russia.

However, the total impact (in palladium ounces) is expected to be minimal owing to the small volume of PHEVs.

In 2021, North American PHEVs consumed 25 koz of palladium, equivalent to, in the words of a recently retired chairman, "the square root of diddly squat".

Iridium & Ruthenium

Q3 2022
Market Report



Price risk of small PGMs

How are rising recession risks in the major economies impacting consumer demand?

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- Supply-demand balances
- Price outlook to 2026
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- Supply risk and mine economics

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THE PGM MARKETS IN 2022



The PGM markets in 2022

Dr. Ralph Grimble, SFA (Oxford)

The palladium market

The palladium market has been subjected to another year of turbulence in 2022. For the second year in a row, Russia was the cause of the palladium price hitting record levels, as the Russian invasion of Ukraine in late February caused the price to surge to over \$3,400/oz intra-day. A deteriorating demand outlook amid economic headwinds has seen the price fall back, but it could average over \$2,000/oz for a third successive year.

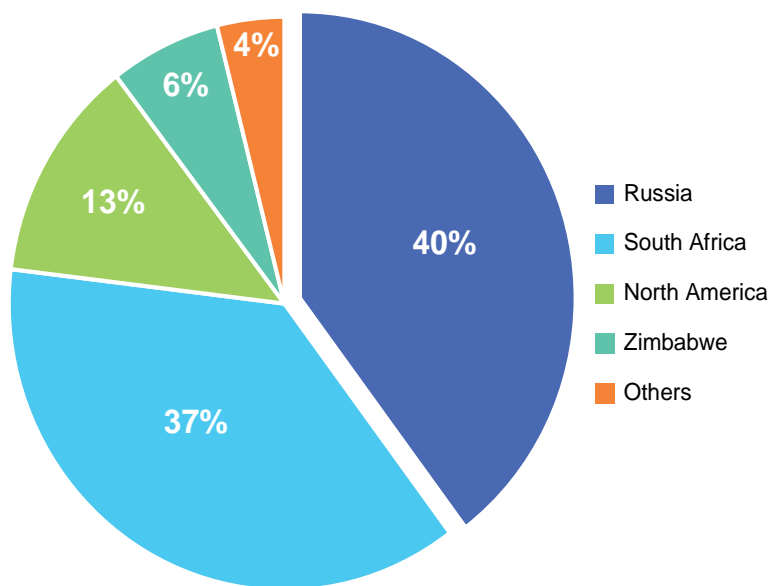
Global demand was expected to continue to recover this year as the shortage of semiconductor chips that had held back light-vehicle production last year was overcome. However, light-vehicle output has been hindered by the slow resolution of the chip shortage and various other supply chain issues, resulting in demand growth of just 2%.

The market is estimated to be close to balance (30 koz surplus) as supply has also underperformed expectations in South Africa and North America. Recycling is being held back as the lack of new cars has resulted in second-hand cars being kept on the road for longer. However, Nornickel has maintained its production guidance for the year as the company has not been directly targeted by sanctions.

Supply and demand underperforming initial expectations in 2022

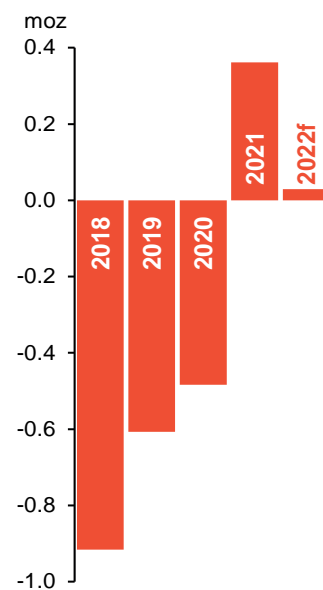
Palladium market close to balance

Palladium supply by region, 2022



Source: SFA (Oxford)

Pd supply-demand balance



Source: SFA (Oxford)

Mine supply

Refined palladium output is forecast to shrink by 2% to 6.76 moz, partly owing to the boost 2021 production received from the processing of stockpiled material and partly to operational difficulties in South Africa and North America. Lower productivity, load-shedding and heavy rains have hampered South African production in the first half of the year, while operational constraints and a flooding incident negatively impacted output in the US. However, production in Zimbabwe is forecast to rise by 13% to 445 koz as the ramp-up at Zimplats' Mupani and Bimha mines continues and Unki's throughput improves following debottlenecking of the concentrator.

Mine supply slips 2% in 2022

Meanwhile, Nornickel has maintained its production guidance of 2.45-2.71 moz for this year. Neither Nornickel nor PGMs have been targeted by sanctions, but the sanctions do make it more difficult for the company to operate, which means that there is a risk that productivity could decline.

Recycling

Secondary palladium supply is predicted to rise by 2% to 2.90 moz in 2022, mostly owing to modest growth in autocatalyst recycling in China and the RoW. However, that is lower than projected at the start of the year and there are ongoing challenges for the recycling industry. The lack of semiconductor chips that has constrained new car production has meant that second-hand cars have been more sought after and so sent prices sharply higher. This has had the effect of keeping cars on the road for longer than would normally be the case, reducing the scrappage rate in North America and Europe, in particular.

Palladium demand up modestly in 2022

Demand

Global palladium demand is projected to increase by 2% to 9.63 moz this year. Automotive demand is improving modestly from 2021, even while being impacted by the war in Ukraine, the ongoing semiconductor chip shortage, and the rapid gains in market share by BEVs. Palladium's industrial usage is forecast to dip slightly this year as demand contracts modestly in the chemical, electrical and dental sectors.

Demand growth held back by constrained light-vehicle production

Automotive demand

Automotive palladium demand is predicted to climb by 3% to 7.81 moz in 2022, despite downward revisions to light-vehicle production forecasts. The automotive industry has had to cope with disruptions to production from wire harnesses made in Ukraine, the shutdown of production in Russia, and Covid lockdowns in China. On top of which, semiconductor chip supply has continued to be a constraint on light-vehicle output, although that finally appears to be improving in the second half of the year. Overall though, light-vehicle production is expected to be around 4.5 million units higher than last year.

High palladium price is hampering industrial demand

Industrial demand

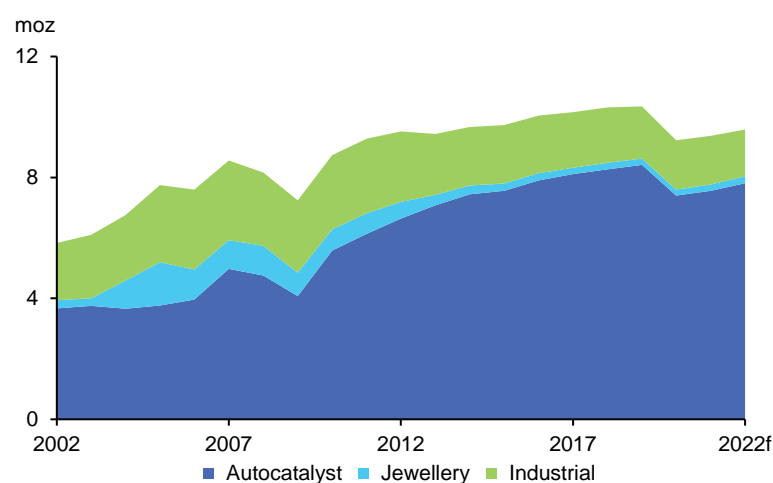
Palladium's industrial usage is expected to dip by 5% to 1.61 moz this year, as the three major sectors all see lower demand. Chemical sector demand is likely to be held back by a slower rate of capacity expansion in China after robust growth in 2021. The electrical sector continues to suffer from price-induced demand destruction and the dental market shrinks again owing to the high price and use of cosmetically more appealing materials.

Palladium ETF holdings are still declining

Investment

Palladium ETF holdings have shrunk by 86 koz to 464 koz at the end of August. The US, UK, Swiss and South African holdings all declined. Global holdings had gained 50 koz following Russia's invasion of Ukraine but, as the price retreated, investors took profits and the selling has been consistent since April. Speculative futures positions on NYMEX have been net short for the last year and even the record price in March was not enough to change the overall position to net long. The non-commercial traders' short and long positions are both relatively small at 301 koz and 112 koz, respectively.

Long term palladium demand by sector



Source: SFA (Oxford)

The platinum market

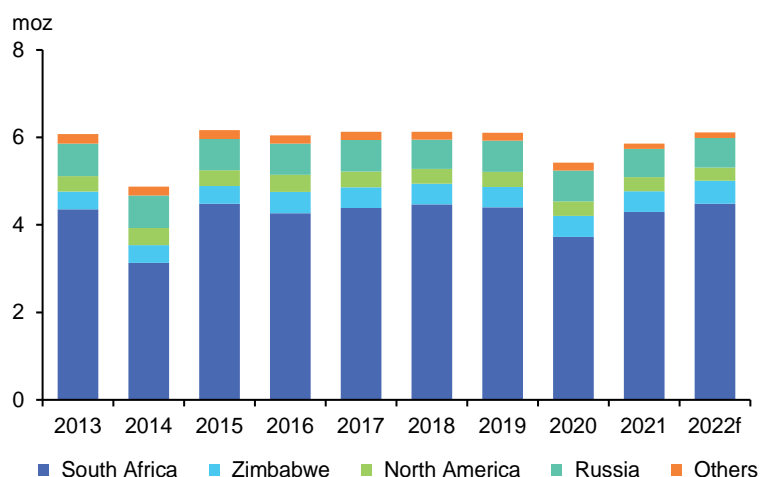
The platinum market is once again forecast to have a significant surplus (excluding investment) of 745 koz in 2022. The surplus has shrunk compared to last year as demand has improved while supply drops back after being boosted by the processing of stockpiled material in South Africa. Unfortunately, although bar and coin demand has been positive, investors have reduced their ETF holdings by 452 koz in the first eight months of the year, so investment is making more metal available and not reducing the surplus. Platinum is fundamentally the weakest market and, apart from the rally induced by the Russian invasion of Ukraine, the price has generally reflected that.

Platinum market is in surplus and investors are selling their ETF holdings

Automotive demand is estimated to climb by 13% to 2.86 moz in 2022. Despite the downward revisions to light-vehicle forecasts this year, light-vehicle production is expected to be around 4.5 million units higher than last year. Platinum demand also benefits from substitution into gasoline three-way catalysts, which are being used more widely. Demand from heavy-duty vehicles is also increasing in China, with China VI emission standards applying for the full year.

Automotive demand benefits from platinum substitution into gasoline autocatalysts

Primary platinum supply



Source: SFA (Oxford)

Global platinum jewellery demand is forecast to drop by 7% to 1.67 moz this year, mostly owing to a further decline in China which more than offsets gains elsewhere. In China, platinum jewellery demand is predicted to fall to 735 koz. The difficult economic situation and Covid restrictions are not supportive of consumer spending and the decline in marriages is working against bridal demand. Modestly higher jewellery demand is expected in North America, as strong momentum from last year carried into the first half of this year, but then eased as inflation rose and consumer sentiment fell. The economic recovery from Covid continues in India and platinum jewellery is benefitting from the more positive economic environment.

China's difficulties mean jewellery demand is falling

The Palladium Standard

Industrial platinum demand is projected to rise by 6% to 2.31 moz in 2022, mostly as a result of growth in the glass industry and a rebound in petroleum catalyst requirements. Expansions of glass fabrication capacity in China are lifting demand. Net requirements for petroleum refining are set to recover in North America, Europe and the RoW after several plant closures in the last two years. Platinum use in the hydrogen economy continues to rise from a low base, with increases in both fuel cell vehicle production and electrolyser installations expected this year.

Industrial use is climbing

Refined platinum supply is estimated to shrink by 4% to 5.99 moz this year. Output in South Africa was boosted by the processing of stockpiled material last year, and bad weather and operational difficulties have reduced productivity in the first half of this year. Secondary supply is predicted to slip 2% to 1.82 moz. Autocatalyst recycling has been constrained by the chip shortage that has reduced new car availability and hence kept second-hand cars on the road for longer. In addition, although some companies have taken steps to deal with silicon carbide diesel particulate filters, they remain problematic to process. Jewellery recycling is anticipated to be slightly higher than last year, at 420 koz.

Secondary supply slips on lower vehicle scrappage rates

The rhodium market

The rhodium market is predicted to have a small surplus (20 koz) in 2022. Automotive demand is up this year despite downgrades to light-vehicle forecasts, and with no boost from processing stockpiled material, refined supply is down, tightening the market. The price received a boost when Russia invaded Ukraine amid concerns about supply, rallying above \$20,000/oz, but unlike palladium it did not come close to new record highs. The deteriorating economic outlook and downward revisions to light-vehicle production have resulted in the price retreating below \$14,000/oz.

Automotive demand for rhodium is projected to expand by 16% to 975 koz. Light-vehicle production forecasts have been downgraded owing to a combination of the ongoing semiconductor chip shortage, other supply chain issues, Covid restrictions in China and the impact of the Russia-Ukraine conflict. However, even following the downgrades, light-vehicle production is projected to be up 4.5 million units from last year's depressed level.

Automotive demand rises on greater light-vehicle production

Refined rhodium production is forecast to drop by 7% to 760 koz. Last year, supply was boosted by stockpiled material being processed in South Africa. Excluding the impact of the processed stock, rhodium supply is likely to dip slightly this year owing to operational challenges in South Africa, as bad weather, community unrest, power constraints and difficult ground conditions reduced productivity in the first half of the year. Russian production is expected to continue to reach the market. Secondary rhodium supply is anticipated to be flat with the risk that it could be lower year-on-year, as the lack of new cars has resulted in second-hand cars being kept on the road for longer than would typically be the case.

Rhodium supply drops 7% without stock boost

Industrial rhodium demand is estimated to rebound by 10% to 130 koz this year owing to improving demand in the glass and chemical sectors. After thrifting the amount of rhodium in glass fabrication equipment, the expansion of glass manufacturing capacity is predicted to increase demand in China and the RoW. Similarly, USge in the chemical sector is expected to recover somewhat after some price-induced substitution to palladium in nitric acid gauzes.

Industrial demand recovers

The price outlook for the next six months

Palladium: \$1,750/oz

Earlier this year, the palladium price hit record highs for the second year in a row on concerns about supply from Russia. After Russia invaded Ukraine and Western countries started to impose sanctions, the worry was that Russian PGM supply could be cut off. However, while Western countries applied sanctions to many businesses and individuals, Nornickel and PGMs have not been sanctioned (so far).

Russian palladium is yet to be sanctioned

The automotive industry has suffered from the impact of the Russian invasion of Ukraine, Covid restrictions in China and supply chain issues beyond the ongoing semiconductor chip shortage, and this has resulted in significantly lower light-vehicle production being forecast than anticipated at the start of the year. Despite this, demand is rising this year as light-vehicle production is still expected to be higher than 2021's very depressed level. The market is close to balance, which could be helping to support the price. However, amid high inflation and a worsening economic situation, the demand outlook is deteriorating and the price is forecast to average \$1,750/oz over the next six months.

Grim economic outlook could soften the price

Platinum: \$890/oz

The platinum market is predicted to have a substantial surplus (ex. investment) once again, though with lower supply and rising demand the surplus has shrunk to an estimated 745 koz. Primary supply is projected to be lower than last year when it was boosted by the processing of stockpiled material in South Africa. Overall, demand is increasing, despite the difficulties in China's jewellery market, as automotive demand is lifted by platinum substitution into gasoline autocatalysts and higher loadings on commercial vehicles in China, where China VI emission standards now apply. Industrial demand is also improving, aided by expanding glass and petroleum requirements.

The price received a boost when Russia invaded Ukraine, but platinum has not held on to those gains. Increasing economic uncertainty amid surging inflation has not helped and investors have been reducing their ETF holdings in an already oversupplied market. If dollar strength subsides then the platinum price could receive some support from an appreciating rand, but while the Fed is still rapidly raising rates that seems unlikely. The price is expected to remain weak, averaging \$890/oz over the next six months.

Large surplus remains for the platinum market

Rhodium: \$12,500/oz

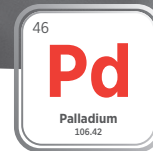
Rhodium demand is forecast to increase this year, despite all the automotive supply chain difficulties, as light-vehicle production rises from last year's extremely low level. Industrial demand is also predicted to expand this year, with modest growth in chemical and glass applications. As for platinum and palladium, primary rhodium supply is lower this year, lacking last year's large boost from processing stockpiled material, and recycling is not growing, so overall the market is expected to have a small surplus.

Rhodium demand still below 2019 levels

The rhodium price is still trying to find an equilibrium level after hitting record highs last year. The Russian invasion of Ukraine provided a boost to the price earlier in the year, but downward revisions to light-vehicle production forecasts and the deteriorating economic outlook are weighing on the price, which is predicted to average \$12,500/oz during the next six months.

PGM autocatalyst recycling report

Unrivalled insights and analysis

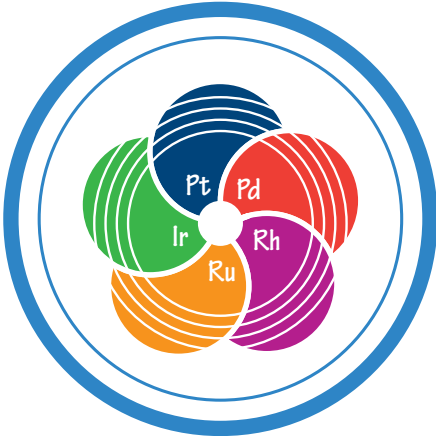


This new 2022 edition updates the team's previous ground-breaking work with further analysis and market commentary on:

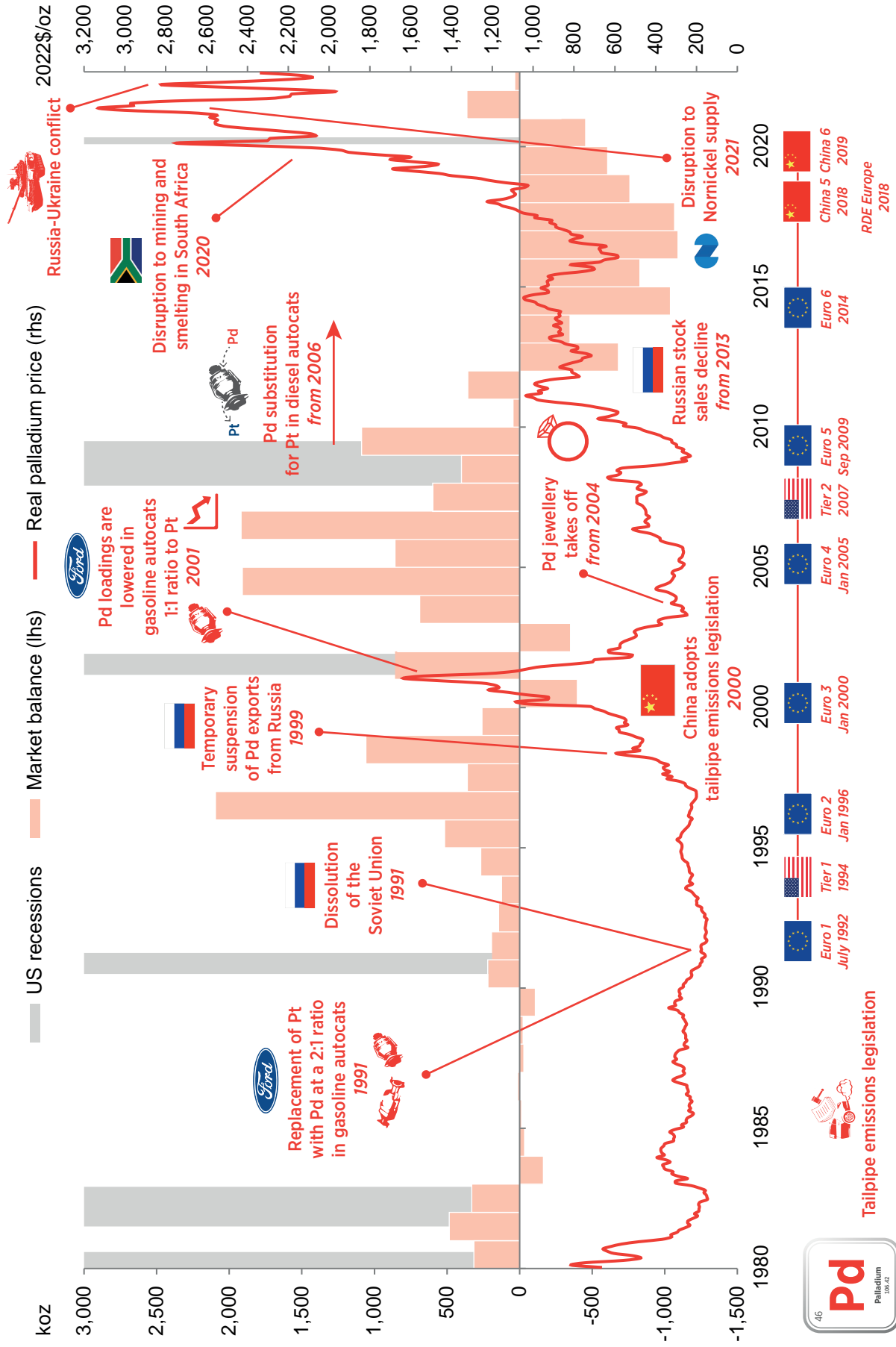
Robust regional PGM modelling

- Current market situation
- Indicative splits of costs and margins
- Latest forecasts of global and regional autocatalyst recycling out to 2040
- End-of-life vehicle projections to 2040 by region, split by light- and heavy-duty and gasoline/diesel
- Scrapped autocatalyst loading projection to 2040
- More detailed examination of autocatalyst configurations as emissions legislation has tightened
- Projections of global SiC catalyst volumes fitted to vehicles and Western European collection volumes
- China's recycling potential and details of refiners in China
- Examination of US autocatalyst imports by company and source of autocatalysts (region)

PGM PRICE HISTORY

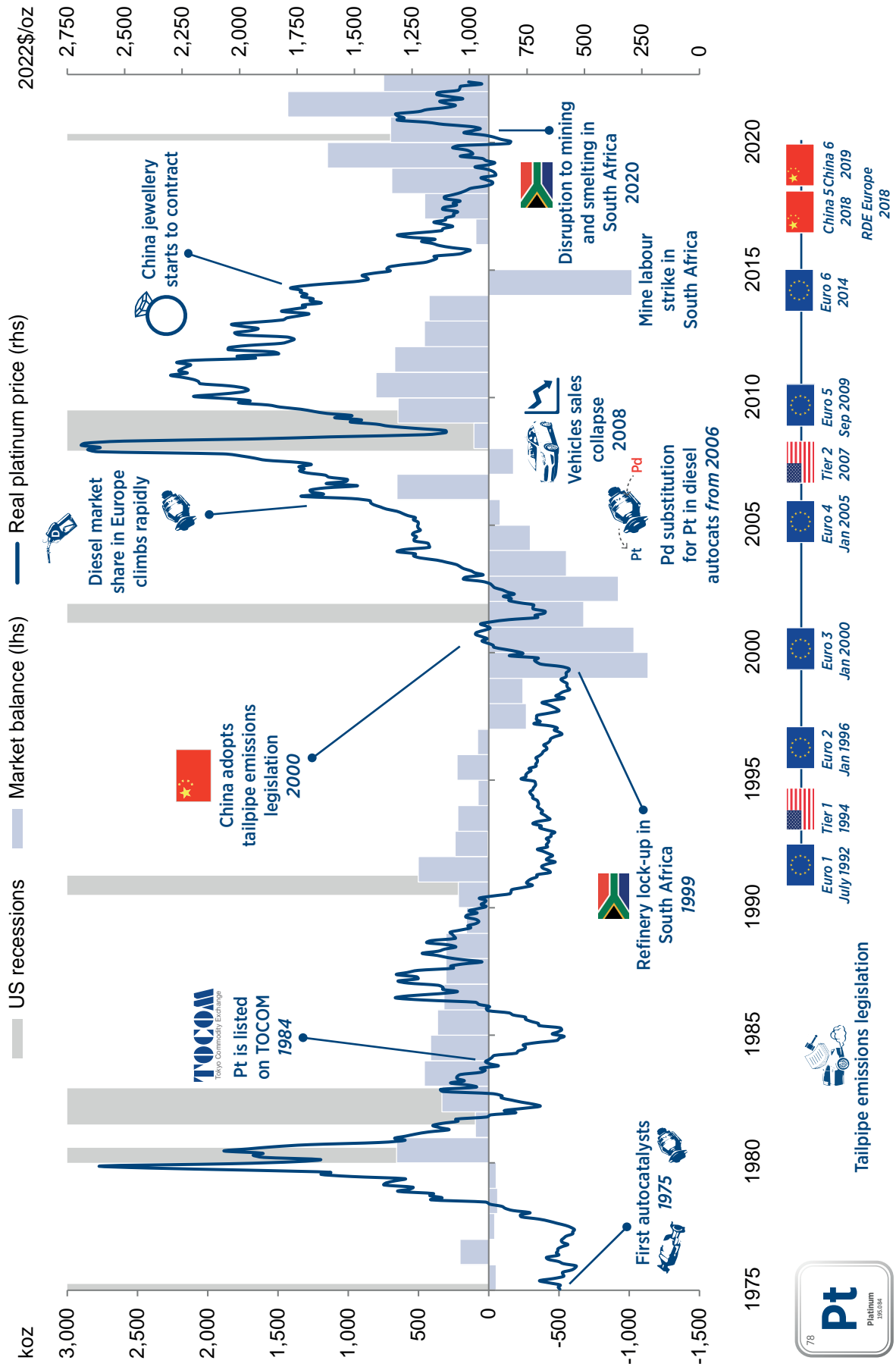


Palladium



Source: SFA (Oxford), Bloomberg

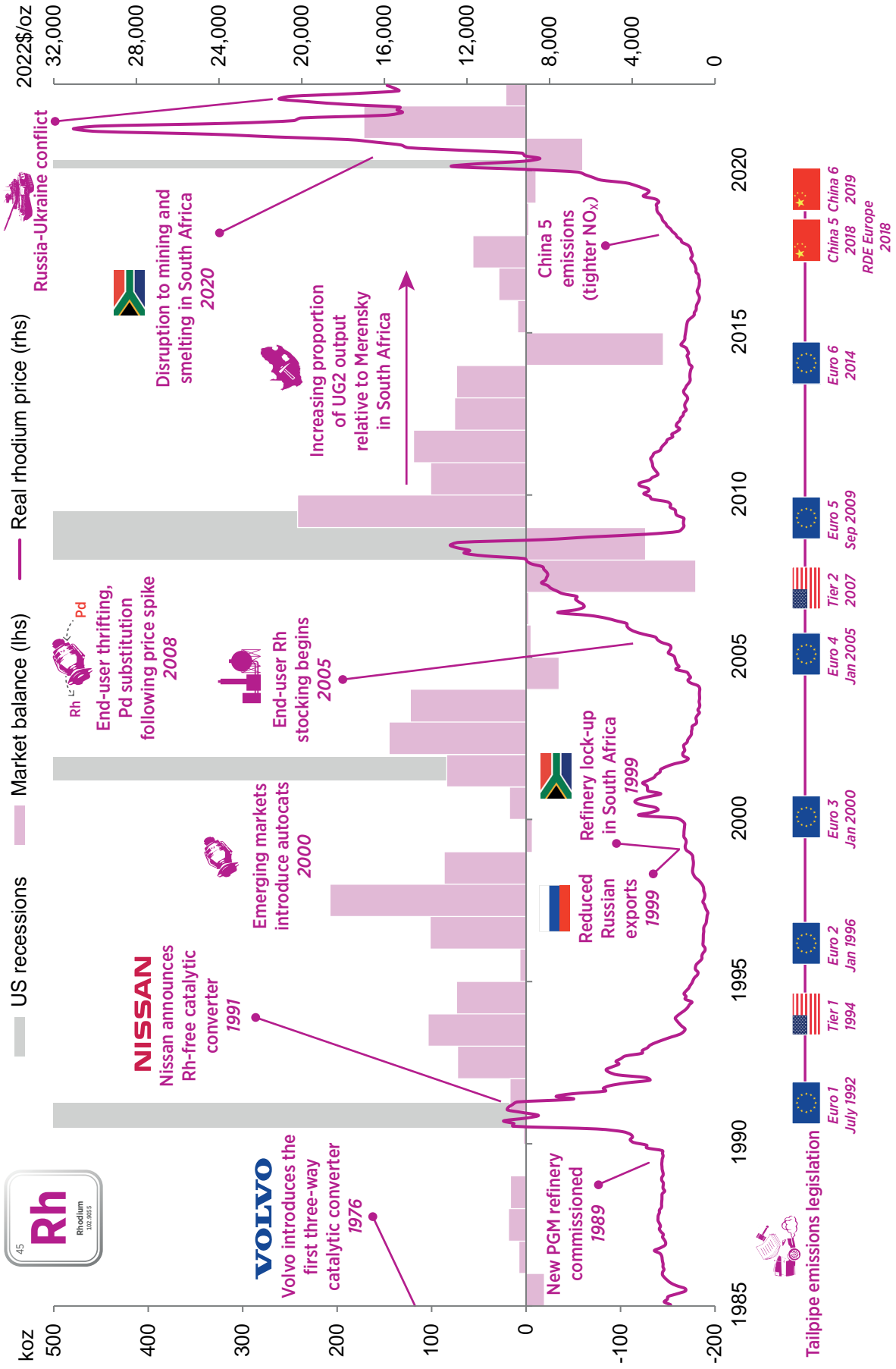
Platinum



Source: SFA (Oxford), Bloomberg



Rhodium



Source: SFA (Oxford), Bloomberg

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Forensically evaluating evolving influences on lithium, nickel and cobalt markets and prices over the next five years.

3

Li

Lithium
6.941

27

Co

Cobalt
58.933195

28

Ni

Nickel
58.6934

APPENDIX



Palladium supply-demand balance

koz	2014	2015	2016	2017	2018	2019	2020	2021	2022f
Primary supply									
Regional									
South Africa	1,870	2,560	2,375	2,530	2,500	2,555	1,845	2,750	2,475
Russia	2,690	2,605	2,555	2,740	2,670	2,870	2,810	2,585	2,710
Zimbabwe	330	325	395	395	380	385	405	395	445
North America	1,055	995	1,065	985	1,035	975	950	925	860
Other	460	455	420	415	395	395	385	265	270
Total	6,405	6,940	6,810	7,065	6,975	7,180	6,395	6,925	6,760
Demand & recycling									
Autocatalyst									
Gross demand	7,480	7,590	7,935	8,145	8,305	8,455	7,440	7,595	7,850
Recycling	1,720	1,605	1,710	1,920	2,035	2,175	2,010	2,380	2,465
Net demand	5,760	5,985	6,220	6,225	6,270	6,280	5,430	5,215	5,385
Jewellery									
Gross demand	290	245	240	215	215	215	200	215	225
Recycling	120	80	80	60	60	60	55	60	65
Net demand	170	165	165	155	155	155	145	155	160
Industrial demand	1,935	1,930	1,900	1,840	1,840	1,715	1,635	1,610	1,550
Other recycling	430	430	390	380	370	365	335	415	365
Gross demand	9,705	9,765	10,075	10,200	10,360	10,385	9,275	9,420	9,630
Recycling	2,265	2,115	2,180	2,360	2,465	2,600	2,395	2,855	2,900
Net demand	7,440	7,650	7,895	7,840	7,895	7,785	6,875	6,565	6,730
Market balance									
Balance (before ETFs)	-1,035	-715	-1,090	-780	-915	-605	-485	360	30
ETFs (stock allocation)	930	-665	-640	-375	-560	-90	-115	50	
Balance after ETFs	-1,965	-45	-450	-400	-355	-520	-370	310	

Source: SFA (Oxford)



Palladium demand and recycling summary

koz	2014	2015	2016	2017	2018	2019	2020	2021	2022f
Gross demand									
Autocatalyst									
North America	1,930	1,855	1,935	1,850	1,860	1,815	1,460	1,475	1,555
Western Europe	1,665	1,790	1,685	1,705	1,725	1,675	1,260	1,195	1,240
Japan	740	745	775	800	840	870	760	725	720
China	1,705	1,725	1,985	2,055	2,035	2,255	2,445	2,565	2,610
India	170	185	225	245	265	240	205	280	335
RoW	1,270	1,295	1,325	1,490	1,580	1,595	1,310	1,355	1,395
Total	7,480	7,590	7,935	8,145	8,305	8,455	7,440	7,595	7,850
Jewellery									
North America	35	35	35	35	35	35	35	35	40
Western Europe	60	55	55	55	55	55	50	50	55
Japan	55	50	50	50	50	50	45	45	50
China	120	75	75	50	50	50	50	55	60
RoW	25	25	25	25	25	25	25	25	25
Total	290	245	240	215	215	215	200	215	225
Industrial									
North America	390	385	370	340	305	295	245	250	245
Western Europe	290	320	325	310	295	290	260	260	260
Japan	425	420	400	360	335	300	255	245	230
China	395	375	375	415	485	415	480	495	455
RoW	435	435	430	410	420	415	395	360	360
Total	1,935	1,930	1,900	1,840	1,840	1,715	1,635	1,610	1,550
Total gross demand									
North America	2,355	2,275	2,345	2,225	2,200	2,150	1,740	1,765	1,840
Western Europe	2,015	2,160	2,065	2,070	2,070	2,020	1,570	1,505	1,550
Japan	1,220	1,220	1,225	1,215	1,225	1,220	1,060	1,015	995
China	2,215	2,175	2,435	2,520	2,570	2,720	2,975	3,115	3,125
RoW	1,905	1,935	2,005	2,170	2,290	2,275	1,930	2,020	2,115
Total	9,705	9,765	10,075	10,200	10,360	10,385	9,275	9,420	9,630
Recycling									
Autocatalyst									
North America	975	895	960	1,060	1,135	1,190	1,130	1,300	1,285
Western Europe	365	270	260	305	330	335	300	380	375
Japan	135	125	125	145	180	200	185	205	205
China	60	115	160	165	155	165	150	180	245
RoW	185	205	205	245	240	290	240	315	350
Total	1,720	1,605	1,710	1,920	2,035	2,175	2,010	2,380	2,465
Jewellery									
Japan	20	20	20	20	20	20	15	15	20
China	100	60	60	40	40	40	40	45	45
Total	120	80	80	60	60	60	55	60	65
WEEE									
North America	75	85	80	75	70	70	60	70	60
Western Europe	95	80	75	80	80	75	70	75	70
Japan	150	170	135	130	125	120	110	120	110
China	30	25	35	35	40	45	45	60	55
RoW	75	65	60	60	60	60	55	90	70
Total	430	430	390	380	370	365	335	415	365
Total recycling									
North America	1,050	980	1,040	1,130	1,205	1,255	1,190	1,370	1,350
Western Europe	460	350	335	385	410	410	370	455	445
Japan	305	315	280	295	325	335	310	345	335
China	190	195	255	240	235	250	235	285	350
RoW	260	270	265	305	295	345	295	405	425
Total	2,265	2,115	2,180	2,360	2,465	2,600	2,395	2,855	2,900



Platinum supply-demand balance

koz	2014	2015	2016	2017	2018	2019	2020	2021	2022f
Primary supply									
Regional									
South Africa	3,135	4,480	4,265	4,385	4,470	4,405	3,255	4,705	4,370
Russia	740	710	715	720	665	710	705	645	670
Zimbabwe	405	405	490	480	465	460	480	470	525
North America	395	365	390	360	345	350	330	325	300
Other	200	200	185	185	180	185	175	125	125
Total	4,870	6,165	6,045	6,125	6,130	6,105	4,950	6,270	5,990
Demand & recycling									
Autocatalyst									
Gross demand	3,240	3,245	3,350	3,295	3,100	2,825	2,390	2,695	3,025
Recycling	1,255	1,185	1,210	1,325	1,420	1,495	1,300	1,415	1,365
Net demand	1,985	2,065	2,140	1,970	1,680	1,335	1,090	1,280	1,660
Jewellery									
Gross demand	3,000	2,835	2,510	2,450	2,245	2,090	1,560	1,780	1,665
Recycling	775	515	625	560	505	500	410	400	420
Net demand	2,225	2,325	1,885	1,890	1,740	1,595	1,150	1,380	1,245
Industrial demand	1,675	1,780	1,910	1,790	1,980	2,020	2,005	2,175	2,310
Fuel cells	25	25	45	50	70	45	45	50	70
Other recycling	25	25	25	30	30	30	30	45	40
Gross demand	7,940	7,885	7,820	7,590	7,395	6,985	6,000	6,700	7,065
Recycling	2,055	1,720	1,860	1,915	1,955	2,020	1,745	1,860	1,820
Net demand	5,890	6,165	5,955	5,675	5,445	4,965	4,255	4,840	5,245
Market balance									
Balance (before ETFs)-1,015	0	85	450	685	1,145	700	1,430	745	
ETFs (stock allocation)210	-240	-10	100	-240	995	505	-265		
Balance after ETFs	-1,225	240	95	355	930	150	195	1,690	

Source: SFA (Oxford)



Platinum demand and recycling summary

koz	2014	2015	2016	2017	2018	2019	2020	2021	2022f
Gross demand									
Autocatalyst									
North America	465	480	410	390	390	380	285	375	500
Western Europe	1,395	1,450	1,630	1,550	1,340	1,145	805	745	795
Japan	585	510	450	435	425	395	305	280	275
China	125	145	195	230	220	245	485	695	780
India	170	180	170	175	195	155	115	175	205
RoW	500	485	495	515	535	510	395	430	470
Total	3,240	3,245	3,350	3,295	3,100	2,825	2,390	2,695	3,025

Source: SFA (Oxford)

Platinum demand and recycling summary (continued)

koz	2014	2015	2016	2017	2018	2019	2020	2021	2022f
Gross demand									
Jewellery									
North America	230	250	265	280	280	275	210	255	260
Western Europe	220	235	240	250	255	260	175	190	175
Japan	335	340	335	340	345	330	245	260	280
China	1,975	1,765	1,450	1,340	1,095	945	755	875	735
India	175	180	145	175	195	210	120	135	160
RoW	65	70	70	75	75	75	55	60	50
Total	3,000	2,835	2,510	2,450	2,245	2,090	1,560	1,780	1,665
Industrial									
North America	330	260	400	350	350	300	240	275	330
Western Europe	250	275	285	280	315	300	270	265	280
Japan	35	95	85	65	100	105	120	95	100
China	500	585	650	590	550	620	820	1,015	975
RoW	560	560	490	505	665	695	555	525	620
Total	1,675	1,780	1,910	1,790	1,980	2,020	2,005	2,175	2,310
Hydrogen									
North America	10	5	10	10	15	10	10	10	10
Western Europe	0	0	5	0	0	0	0	0	10
Japan	5	15	25	30	35	15	20	25	30
China	0	0	0	0	0	0	0	0	10
RoW	10	5	5	5	20	15	10	10	10
Total	25	25	45	50	70	45	45	50	70
Total gross demand									
North America	1,035	995	1,090	1,030	1,035	965	745	915	1,105
Western Europe	1,865	1,960	2,165	2,085	1,910	1,705	1,250	1,205	1,260
Japan	960	955	890	870	900	845	695	660	690
China	2,605	2,500	2,300	2,160	1,870	1,810	2,060	2,585	2,500
RoW	1,475	1,475	1,380	1,450	1,680	1,660	1,250	1,335	1,515
Total	7,940	7,885	7,820	7,590	7,395	6,985	6,000	6,700	7,065
Recycling									
Autocatalyst									
North America	560	505	535	585	640	645	575	580	510
Western Europe	465	370	400	440	465	505	425	500	500
Japan	105	95	95	100	110	110	100	115	120
China	30	55	40	40	35	40	30	35	40
RoW	90	155	150	160	170	190	170	185	190
Total	1,255	1,185	1,210	1,325	1,420	1,495	1,300	1,415	1,365
Jewellery									
North America	0	5	5	5	5	5	5	5	5
Western Europe	5	5	5	5	5	5	5	5	5
Japan	235	160	150	160	145	140	110	115	130
China	530	335	460	385	340	340	285	265	270
RoW	5	5	5	5	5	10	10	10	10
Total	775	515	625	560	505	500	410	400	420
WEEE	25	25	25	30	30	30	30	45	40
Total recycling									
North America	570	520	545	600	650	660	585	595	525
Western Europe	480	380	410	450	480	520	440	515	515
Japan	340	255	245	265	260	255	210	235	255
China	565	395	500	425	380	385	320	305	315
RoW	100	165	165	175	185	205	190	210	210
Total	2,055	1,720	1,860	1,915	1,955	2,020	1,745	1,860	1,820



Rhodium supply-demand balance

koz	2014	2015	2016	2017	2018	2019	2020	2021	2022f
Primary supply									
Regional									
South Africa	425	620	615	620	625	640	475	670	610
Russia	75	70	70	75	75	80	80	75	75
Zimbabwe	35	35	45	45	40	40	45	40	45
North America	30	30	25	25	20	20	20	20	20
Other	10	10	10	10	10	10	10	5	5
Total	580	765	765	775	770	790	630	815	760
Demand & recycling									
Autocatalyst									
Gross demand	840	865	835	870	900	985	885	890	975
Recycling	280	260	280	305	335	355	330	365	365
Net demand	565	605	555	565	565	635	555	525	610
Industrial demand	160	155	180	155	210	170	135	120	130
Other recycling	2	2	2	2	2	2	2	3	3
Gross demand	1,005	1,020	1,015	1,025	1,110	1,160	1,020	1,010	1,105
Recycling	280	265	280	305	340	355	335	370	370
Net demand	725	755	735	720	775	800	690	640	740
Market balance									
Balance (before ETFs)-145	10	30	55	-5	-10	-60	170	20	
ETFs (stock allocation)	5	-5	5	-20	-50	-15	-10	-5	
Balance after ETFs	-150	15	25	75	50	5	-50	175	

Source: SFA (Oxford)



Rhodium demand and recycling summary

koz	2014	2015	2016	2017	2018	2019	2020	2021	2022f
Gross demand									
Autocatalyst									
North America	240	240	235	230	225	220	175	170	190
Western Europe	225	250	210	215	230	290	225	215	235
Japan	140	125	125	125	130	130	110	100	100
China	110	110	130	150	155	180	235	255	290
India	15	15	20	20	20	20	15	20	25
RoW	115	120	115	130	145	150	125	125	130
Total	840	865	835	870	900	985	885	890	975
Industrial									
North America	20	15	20	20	20	20	15	15	15
Western Europe	15	10	15	15	25	15	10	5	10
Japan	5	10	10	10	10	10	10	10	10
China	75	70	85	70	90	70	65	65	70
RoW	50	45	50	45	70	50	30	25	30
Total	160	155	180	155	210	170	135	120	130
Total gross demand									
North America	260	255	260	245	245	235	190	185	205
Western Europe	240	265	225	225	250	305	235	220	245
Japan	145	135	135	135	140	140	120	115	110
China	180	185	215	220	245	255	300	320	360
RoW	180	180	185	195	235	220	170	170	185
Total	1,005	1,020	1,015	1,025	1,110	1,160	1,020	1,010	1,105
Recycling									
Autocatalyst									
North America	160	150	160	165	180	190	180	200	195
Western Europe	60	45	50	55	60	65	60	70	70
Japan	30	30	35	35	45	45	40	45	45
China	5	10	5	5	5	5	5	10	15
RoW	20	25	30	35	45	50	45	45	45
Total	280	260	280	305	335	355	330	365	365

Source: SFA (Oxford)



GLOSSARY OF TERMS

BEV

Battery electric vehicle.

Covid-19

An infectious disease caused by a Coronavirus.

ETF

Exchange-traded fund.

GDP

Gross domestic product.

Gross demand

A measure of intensity of use.

ICE

Internal combustion engine.

IRA

The Inflation Reduction Act.

koz

A thousand troy ounces.

Load-shedding

The action of switching off parts of South Africa's electric grid in a planned and controlled manner due to insufficient capacity or to avoid a countrywide blackout.

moz

A million troy ounces.

MSRP

Manufacturer's suggested retail price.

Net demand

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

NYMEX

New York Mercantile Exchange.

OEM

Original equipment manufacturer.

oz

Troy ounce.

PGM

Platinum-group metals.

PHEV

Plug-in hybrid electric vehicle.

Primary supply

Mine production.

Seasonally adjusted annual rate (SAAR)

A rate adjustment used to account for changes in data due to seasonal variations.

Secondary supply

Recycling output.

Thriftling

Using less metal in order to reduce costs.

TOCOM

Tokyo Commodity Exchange.

USGS

United States Geological Survey.

WEEE

Waste electrical and electronic equipment.

Currency symbols

\$ 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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