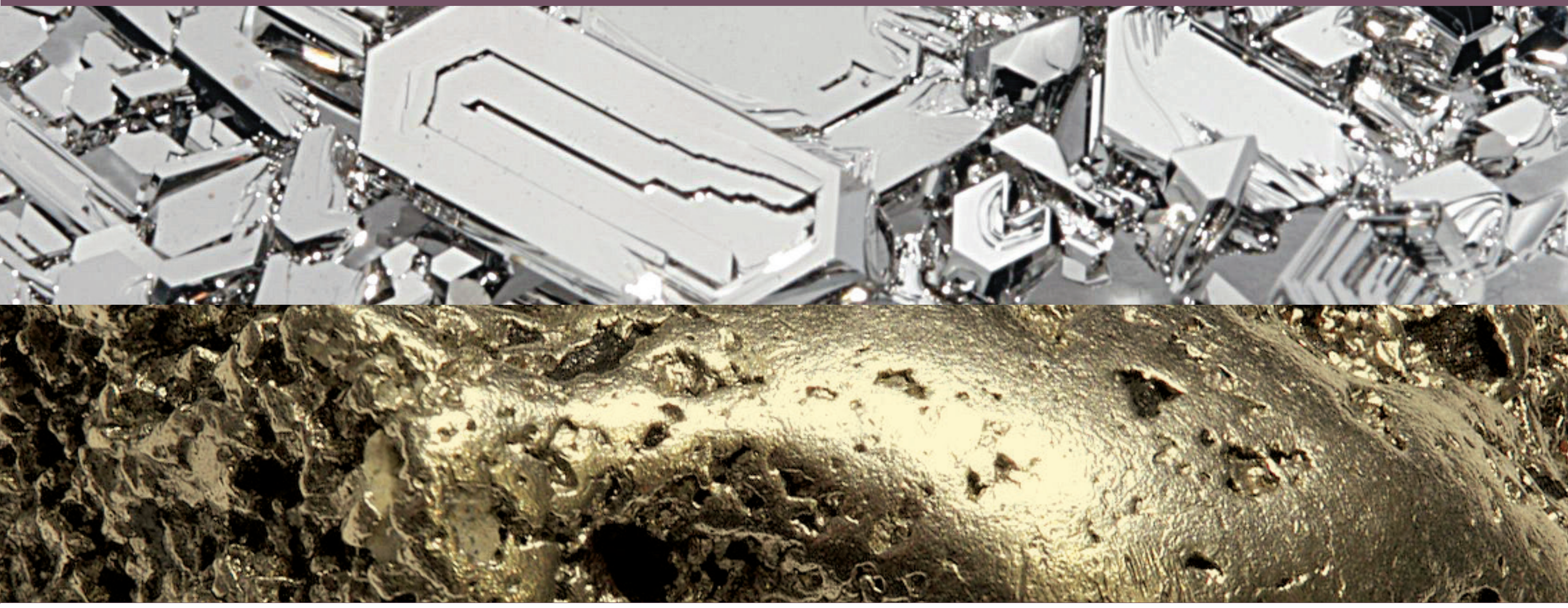
Thematic Research

May 2016



A view on Platinum and Palladium

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"The first great thing is to find yourself and for that you need solitude and contemplation, at least sometimes.
I can tell you deliverance will not come from the rushing noisy centers of civilization.
It will come from the lonely places."

Fridtjof Nansen
Norwegian explorer, Nobel Laureate

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Investment thesis

Platinum group metals (PGMs) are currently some of the rarest metals on earth. Platinum and palladium are the major representatives of the group, accounting for ~80% of total annual mining production; both metals display higher supply constraints than those of gold and silver, but unlike these two precious metals PGMs enjoy a much wider range of industrial applications and a higher visibility on volume-driven fundamental trends. We believe that a number of favourable fundamental and market conditions have materialized for platinum and palladium in the past 5 years such that today these two metals present a compelling long opportunity.

Supply – South African miners, the largest PGMs global producers, have seen their earnings gradually declining since 2000 to the lowest EBIT margin of 3.3% in 2015 and are losing money at current prices of US$995/ounce for platinum and US$553/ounce for palladium. Strikes, accidents, labor union fights, political intervention and power cuts added to the stress of falling metal grades and a depressed commodity market since 2012; the result is that mines with highest mining cost/ounce are being shut or sold, businesses are being substantially downsized and investments on growth are being postponed to an indefinite date. This situation has created a reduction in annual production from South Africa since 2004, which turned into a cut in production capacity since 2012, in a similar fashion to the oil industry in the 80s. Such trend at miners' level will further deepen the state of under-supply that platinum in particular has been witnessing since 2012. Forecasts are of another 5 years of supply deficit for both platinum and palladium, a prediction strongly corroborated by the correlation between drastically lower or zeroed expansion-oriented capital expenditure and mining output at 98% of world mines.

Demand – The automotive sector accounts for 50% and 65% of platinum and palladium demand, where PGMs are used in catalytic converters to reduce internal combustion engine pollution; the remainder of demand rests on jewelry, more for platinum than palladium. At the basis of the automotive industry there is the global regulation tightening on emission limits, a trend now common in all large countries. We observe how the evolution of the Chinese motor vehicle market will likely create a strong PGM demand increase due to compliance with tighter emission limits, a fact that authorities and market participants might have underestimated; our forecasts see China more than doubling the consensus deficit on palladium supply until 2021, as the country's vehicle fleet closes its density and PGM loading large gaps with its peers, Europe, the US and Japan.

We also observe that the continued regulatory drive towards lower emissions in both Western and emerging economies has probably pushed the internal combustion engine (gasoline and diesel) technologies to its limits in terms of fuel-, emission- and cost-efficiencies. This plateau in technology and various government regulations and incentives are giving momentum to the rise of the electric vehicle segment, especially in parts of Europe, the US, Japan and China; however, the market is still in its very early years both in terms of vehicles and filling stations, and in our view does not represent a threat to the dominance of internal combustion engines in the coming

5 to 10 years. This will open the way, perhaps unexpectedly after the Volkswagen “dieselgate”, for further PGM use in vehicles to comply with ever stringent regulations on major fleets.

Valuation – Platinum and palladium have followed different price paths in the past 40 years, due mainly to the mixed use the automotive industry has done of these metals. Today, we believe both metals have found a price support level albeit in different degrees of strength: palladium has maintained better its value if compared to platinum, which makes the estimate of the potential upside relatively more difficult, while platinum futures suggest that there has been a de-correlation between supply deficit and valuation in the past 4 years. In addition, we believe a psychologically important price support around US$750-800/ounce has been reached this January for platinum futures, the lowest level seen since 2008; while the origin of the upward price trend of the 90s and 2000s might have been sustained by the strong Chinese appetite for commodities, the 2007 peak and 2008 low could be reasonably attributed to the over- and under-shooting of a financial bubble.

The Fibonacci retracement levels signal in both metal futures that prices might have touched strong supports over a period of ~20 years of trading on the NYMEX. From here, we see platinum rising to US$1,250-1,300 in the next 24-36 months, which could open the way to US$1,500 once the previous 50% retracement level is reached. Palladium is instead in a trickier situation, where a downward trend has not been broken and the price fluctuates between 50% and 62% retracement levels since late 2015. We expect the price to remain within such channel until the real effect of the Chinese automotive effect on the PGM industry reveals itself, which we think could happen by the end of this year.

In our view, these conditions provide an interesting picture in which platinum and palladium will still be in great demand in the automotive industry in the next 5 to 10 years, especially thanks to the Chinese gasoline segment and to other, emerging fleets. Beyond this timeframe and depending on consumer appetite, state of the infrastructure and technologic advancements, we expect to see a wider mass adoption of an alternative way of transportation other than internal combustion engines, which are destined to be phased out after more than 100 years of dominance. At the same time, we do not think there are currently the elements to conclude whether the future of transportation will be in either batteries or hydrogen.

I. Supply side

a. PGM miners: signs of a production capacity crunch

60% of world reserves of PGMs, meaning platinum, palladium, ruthenium, rhodium, osmium and iridium, are found in South Africa and Zimbabwe, with the remainder mined out of the Russia and the US.

As in any industry, when prices increase miners make more profits; a positive trend in prices is often an encouragement to invest profits (plus debt) to increase output. As the mining activity intensifies, the extraction cost/ounce increases as metals have to be mined at higher depths, while the grade of metals extracted tends to decrease; eventually there comes a time when output exceeds demand and prices fall. The first miners to start losing money are those with higher break-even costs, and soon an industry-wide process of cost efficiency begins; the remaining miners decide to focus on mines with lower extraction cost/ounce, postpone expansion projects and investments on deeper, costlier reservoirs of PGMs. However, mining projects cost billions of dollars in building materials and human inputs and take many years to develop, with sometimes the uncertainty of success or precision in output estimation. Once the decision to drill is taken, the fixed costs underwritten, the employee salary plans agreed upon and the agreements with the local government signed, then production has to go on even in case of unfavorable prices. This is because it would be even costlier to dismiss those plans, with the politicians, contractors and employees waging their legal and monetary rights to be honored.

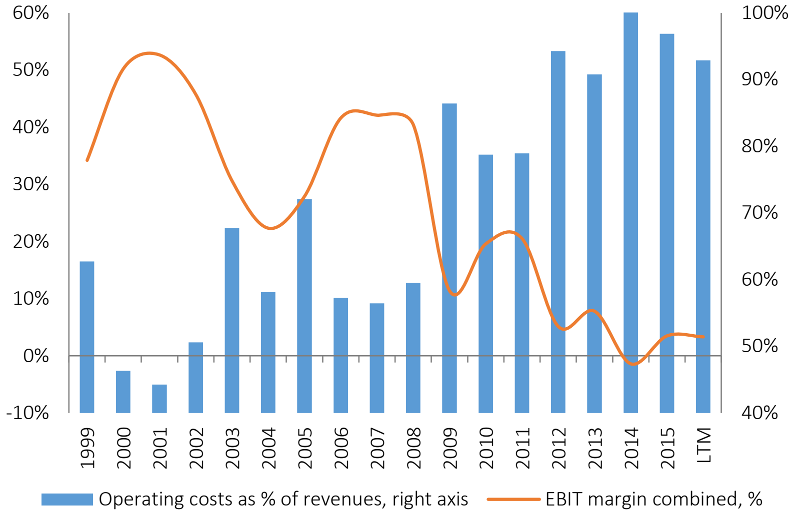
Once the decision to undergo cost efficiency plans is made, and in case demand does not dramatically rise or fall, usually two situations might develop: first, annual *production* decreases as miners concentrate their operations on lowest-cost mines; second, miners start either shutting down or selling higher-cost mines, thus cutting into *production capacity*, as it happened in the oil industry during the 80s. While the consequence of a decrease in production might only be a number of years of under-supply with no support for prices – as perhaps observed since 2012 in PGMs – the destruction of supply brought by reduction in production capacity usually creates the inability of the industry to satisfy a normal level of demand; in turn, prices should adjust to higher levels to reflect the scarcity of the commodity and a new growth cycle in both prices and mining activity starts, within three to five years depending on demand.

Currently, PGM miners in South Africa seem to be in the production capacity cut stage. The combined operating margin of the four largest South African miners was 3.3% in 2015, after more than 15 years of downward trend. For these players, the combined production cost/ounce has increased 11% a year since 2000, while it has been higher than the price of platinum since 2011 – which represents the largest share of the miners' production – and now stands at around US$1,700/ounce, considerably higher than the current platinum's and palladium's prices.

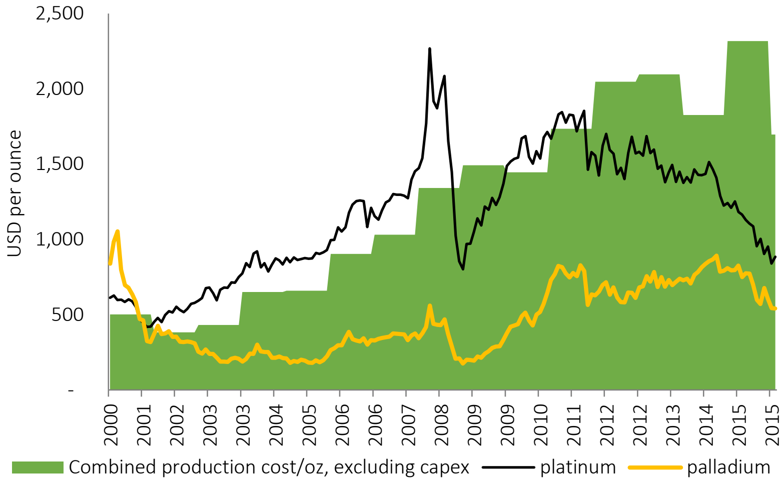
In terms of cost drivers, labour is definitely the highest at 60% of total costs; since 2012, employees' unrest started to mount over wage increase demands, which were met with settlements around 10-15% increases in 2014 and 2015. Miners in South Africa are also subject to and affected by increasing rhetoric and political pressure from the government to nationalize assets, increase taxes and community participation.

In addition, availability of electric power in the country continues to be precarious, directly affecting ~10% of operating costs for miners; blackouts are frequent and force miners to satisfy their energy needs through alternative, more expensive sources than the national grid.

Economics of the four largest South African miners



Market prices lower than costs since 2011



Source: Bloomberg, Index & Cie research

The national electricity supplier, Eskom, stated in the past years that blackouts were only avoided because of strikes at mines.

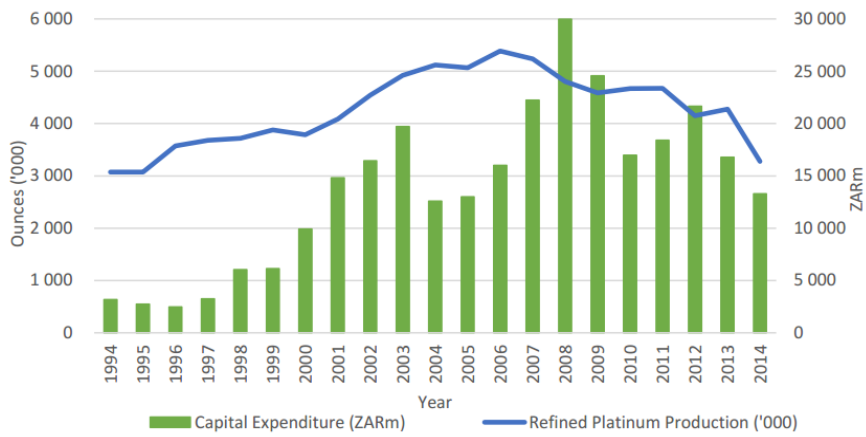
Since 2012, these issues have escalated to deeper, more impacting events at miner's level: union's demand for higher wages developed into strikes and protests, sometimes with deadly consequences. Find below a list of company-specific events at some of the largest PGM miners:

- *Anglo American Platinum*, the largest South African platinum miner and probably one of a handful cash-positive operators at current market prices, has gone through strikes, fires and revolts at its main mines that reduced its annual output by 26% in 2014, while it announced in its 2015 annual report that expansion capital expenditure has been postponed to 2017, the portfolio of mines is being refocused on the lowest cost/highest margin mines while loss-making mines are being sold (5 out of 13 mines);
- *Impala Platinum*, the second largest representing 22% of global supply, has been facing similar obstacles since 2012 in the shape of politicized and violent strikes led by the union AMCU (increasingly powerful in the platinum belt) which cost the company ZAR7.2bn (equivalent to US$666m at that time), 27% of annual production and 34% of revenues in 2014, rising costs, decreasing yields and margins and an increasingly stringent legislative environment;

- *Lonmin*, the third largest, also went through a horrible year in 2014, had to restructure the whole business and renegotiate its debt terms in late 2015 while battling labour issues (let go 5,077 of its 6,000 employees, with labour accounting for ~60% of total operating costs) and still remained cash-negative at current market prices.

While production at the largest PGM miners has been declining for some time now, our opinion that production capacity is destined to be cut is reinforced by the findings of a study commissioned by the World Platinum Investment Council (WPIC) in August 2015. The capital expenditure at 98% mines in South Africa since 1994 has shown to produce an effect on refined production with a lag of two to five years; as time went by, it also appears that capital expenditure had a diminished impact on production, such that a higher capital expenditure produces a lower spike (or no spike at all) of refined production if compared with the past.

Capital expenditure vs refined production in South Africa*



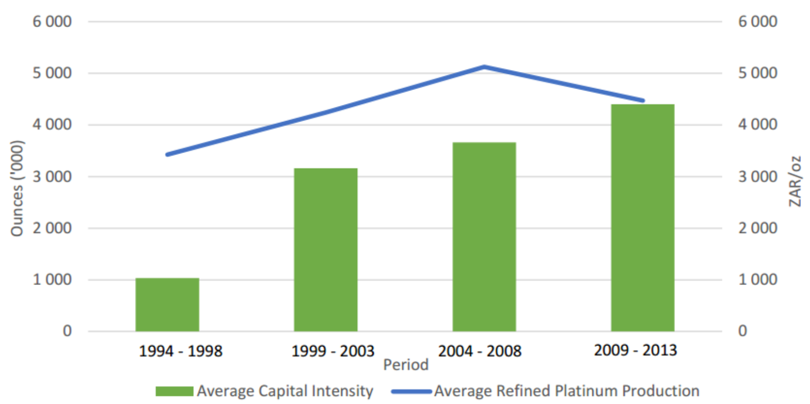
* In 2015 South African Rand terms Source: Venmyn Deloitte

The graph aside shows exactly the evolution of the relationship, where the two/five years lag is observed. If this is true for the past 20 years, one could reasonably expect that the 2014 and 2015 reduced levels of expenditure will be felt in 2017-2020 in terms of reduced production.

These levels will also be lower than what they were in 2014 – already as low as those of 2004 – unless the capital expenditure of 2016 and 2017 will be high enough to counter a contraction in mining, which does not seem to be the case.

A second aspect to consider is the increased cost of mining per ounce, as shown in the graph aside. It was 76%, 28% and 17% more expensive to mine an extra ounce in 2013 than it was 20, 15, and 10 years ago. It is evident the capital intensity in South Africa has sensibly increased.

Capital intensity curve in South African mines*

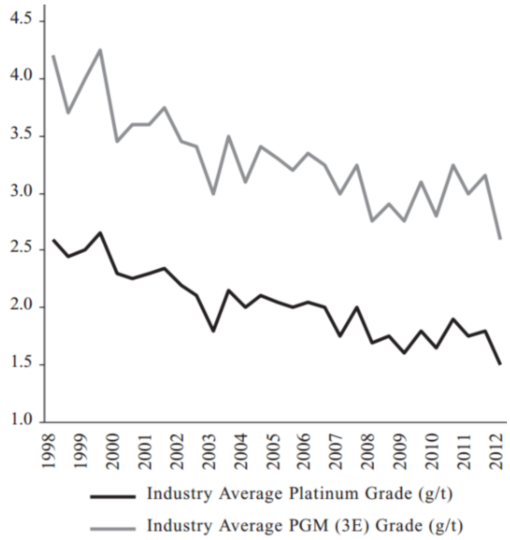


* In 2015 South African Rand terms Source: Venmyn Deloitte

Both the effect of capital expenditure on refined production and the increasing extraction cost/ounce can be explained by the challenge the industry has faced in mining at greater depths and with falling grades in recent years.

The current state of affairs suggests that miners will continue to experience margins contraction, which will also continue to affect their production capacity in the coming years, which in turn will contribute to deepen the state of under-supply of the past four years (see chapter III Forecasts).

Intensive mining, declining ore grades

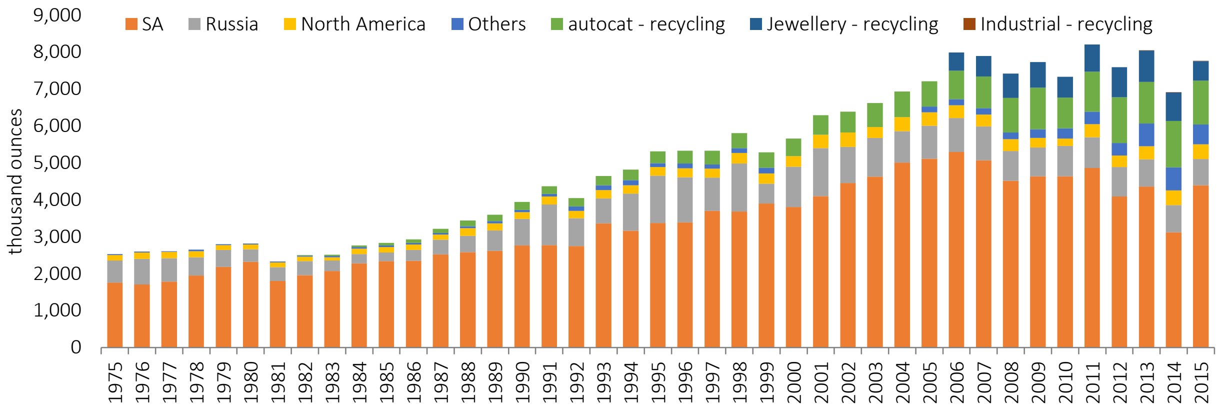


Source: CIBC Research

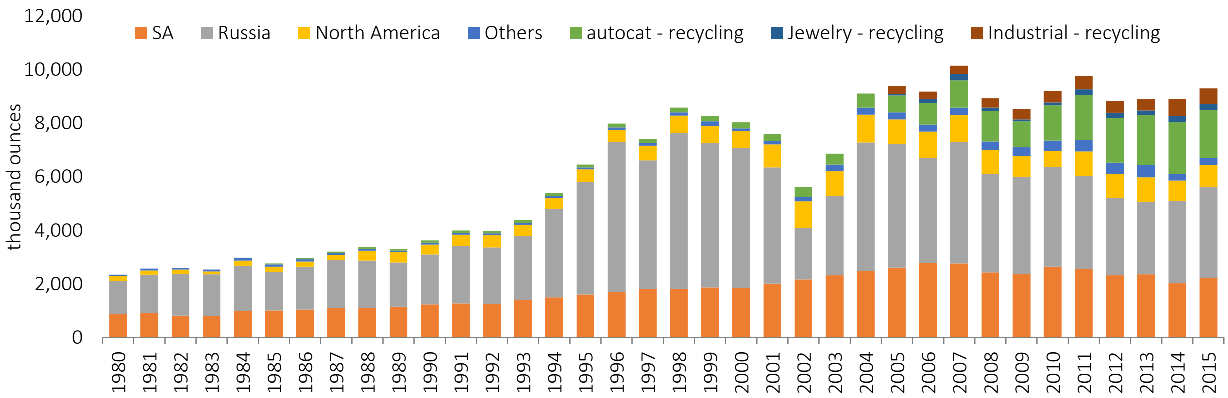
b. Plateauing supply: diminishing mining output, increasing recycling stock

As mentioned earlier South Africa provides some 60% of world production of PGMs, a role played for over 30 years. From a fundamental perspective, we chose to focus on platinum and palladium, which represent the largest portion of PGMs in terms of mining output.

Platinum



Palladium

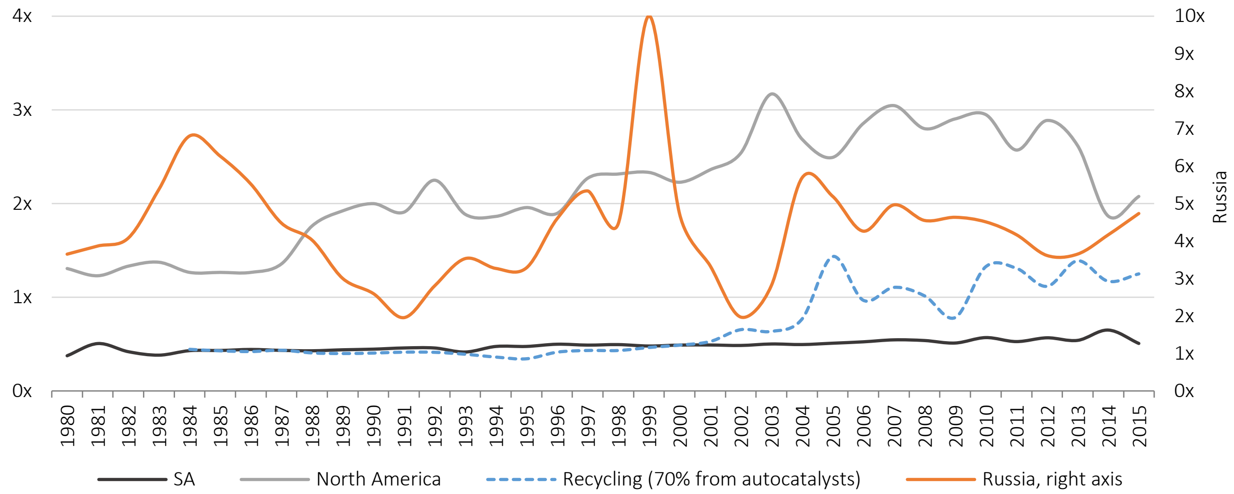


Source: World Platinum Investment Council (WPIC), Index & Cie research

As seen in both graphs, recycling is becoming increasingly relevant in comparison to the mining output of South Africa, Russia and North America; this trend is logical since a great deal of PGMs has been already unearthed in the past 45 years, and the recycling volumes are primarily coming from the autocatalyst sector for both metals. As mining output diminishes and recycling rises, the above-ground stock is re-utilized for various purposes with the end result being overall supply plateauing since 2004/2006 – above-ground stocks will be discuss further on more in detail.

The two metals are usually found together in nature at a rather stable rate depending on the geographic area of the deposits, as shown in the next graph. Annual production in South Africa provides a stable palladium yield of 0.5 ounce per ounce of platinum mined over the past 45 years, an essential data point for us to formulate supply forecasts into the future; these deposits have the highest concentration of PGMs, which reaches a maximum level of 500 parts per million (ppm, or milligrams per ton). In the US the palladium/platinum ratio is instead 2-3x, meaning the deposits are proportionally much richer of palladium than platinum. The Urals deposits in Russia are also some of the richest in PGMs (~10-20 ppm), but the historical yields have been affected by the above-ground stocks the country accumulated since the Soviet times, which it sold at varying quantities throughout the 80s, 90s and 2000s. Today, such reservoir of supply is believed to be exhausted, as more widely discussed in the following paragraph, hence the highly volatile history in Russian yields, especially during 1999-2004.

Palladium/platinum yield ratios

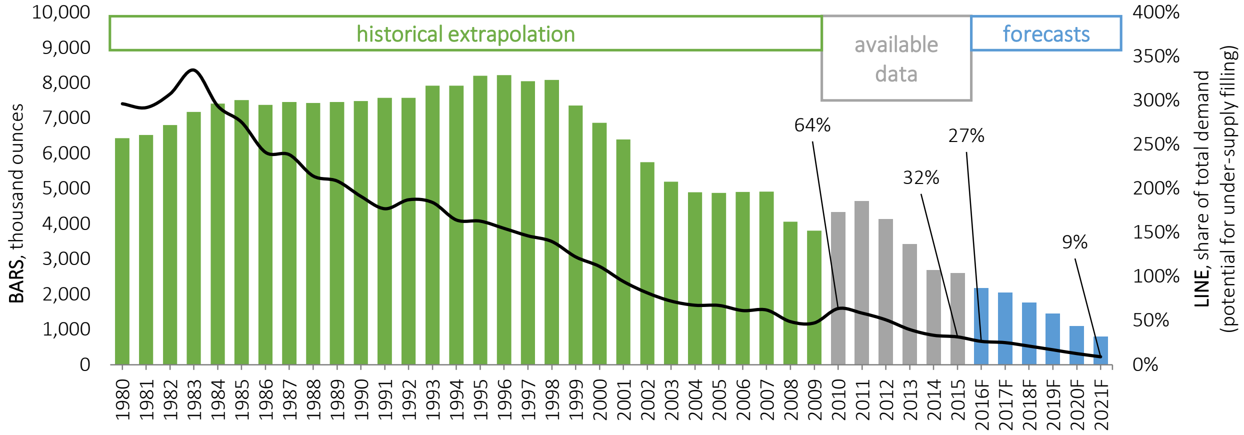


Source: WPIC, Index & Cie research

c. Risk of unexpected supply surplus: above-ground stocks and new deposit discoveries

We feel above-ground stocks are definitely **the major wildcard when forecasting the future of PGM prices**. The problem lies in the quantification of stocks held around the world, a highly difficult task because these are usually private holdings. Various institutions and specialists do quantify the stock, but none reliably and with high discrepancy in figures; this fact generates doubt in the investment community, which reacts to headlines rather than facts. For instance, the WPIC defines the platinum stock as "*the year-end estimate of the cumulative platinum holdings not associated with exchange-traded funds, metal held by exchanges or working inventories of mining producers, refiners, fabricators or end-users. Typically, unpublished vaulted metal holdings from which a supply-demand shortfall can be readily supplied or to which a supply-demand surplus can readily flow.*" If this is true, then the long-term profile of platinum stock should look like the graph below.

An attempt at sizing platinum above-ground stock from WPIC



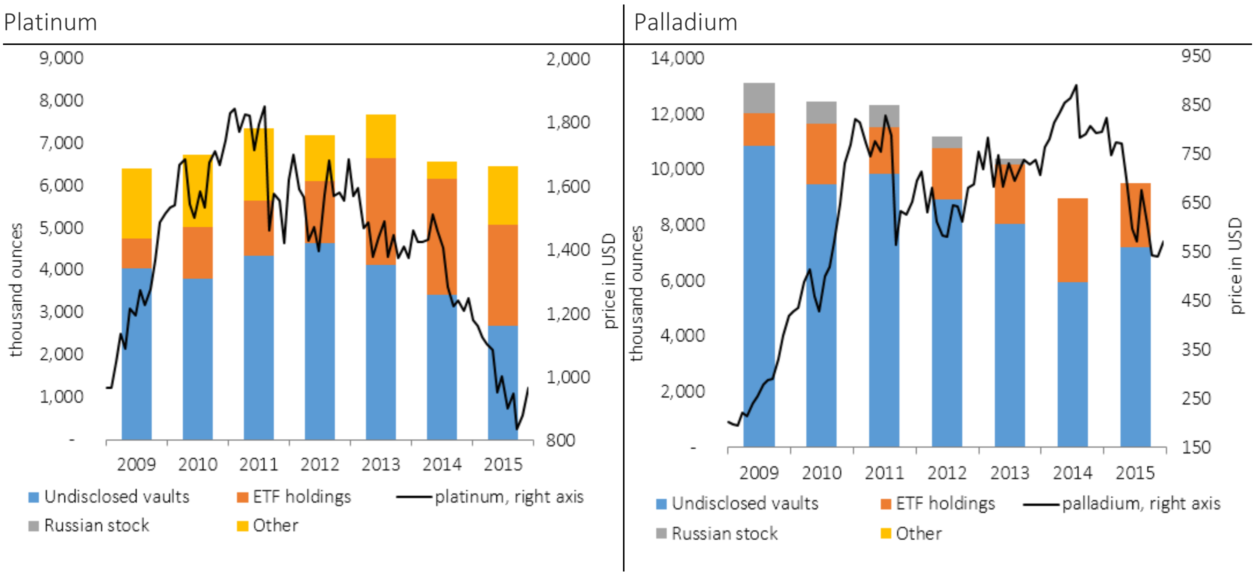
Source: WPIC, Index & Cie research

The WPIC has estimated that the stock of platinum significantly reduced starting from 1997 to reach 32% of total demand in 2015; this equates to a buffer of 9% of forecasted demand coverage in 2021, which is still about 2.6 times the forecasted supply shortage. So, there is still plenty of "rescue" metal around should demand spike well beyond forecasts. The WPIC does not provide any palladium stock figures, and since these figures do not include ETF holdings, Russian and Swiss stocks and other inventories that could cover supply shortages every year, we tried to examine each part to size their respective magnitudes a make sense of them, if any, as follows:

- *ETF holdings* amount to 2.3 and 2.2 million ounces for platinum and palladium respectively in 2015;
- *Russia* has been the largest producer and exporter of palladium, with South Africa right behind. The ore grade at active mines in the Norilsk region of Russia has been declining since 2010, which could be a sign that production levels have peaked – in a similar fashion to what has been going on from the 90s at South African PGM mines. The country has been a net exporter since the 80s, typically selling out of its state inventories – Gokhran, the Russian state's official gem and precious metal deposit. These flows seem to have stopped in 2005 for platinum, and are about to stop for palladium (198,000 ounces shipped in 2013) after years of gradual fall;
- *Switzerland* has also been a major net exporter of palladium since 2007, but in 2015 this trend reverted and it seems the country added to its inventory after many years of dispersing metal to manufacturers and probably to other metal trading hubs. Analysts at JP Morgan believe the country has been receiving palladium from Russian state inventories for years, which have now fallen to negligible levels for the PGM market.

These components are hard to quantify accurately given the nature of the major contributor (private vaults), but we can definitely add up the estimates for both metals, as per below:

Above-ground stock estimates



Source: Johnson Matthey, GFMS Thomson Reuters, New York Mercantile Exchange, Index & Cie research

At this point, the challenge the investor faces is to understand how current prices are related to increases and decreases in the amount held. The graphs above show that platinum price has *decreased* since 2011 in a moment when undisclosed vaults were selling metal, but overall above-ground stocks saw a negligible decrease; palladium price has instead *increased* substantially in an overall decreasing stock trend. Since these two sets of 7-year evidence do not seem to suggest any conclusive relationship between stocks and prices, we can only hope authorities will eventually come up with a more comprehensive set of data and evidence for investors to understand the real contribution of above-ground stocks in the PGM price determination. With the surge in investment demand for these two metals, there is reasonable hope something will eventually also happen on the data transparency/disclosure front.

The risk of a **new deposit discovery** in South Africa and Zimbabwe is ever present, the two countries being the richest in PGMs. While Zimbabwe is a small producer of platinum and palladium, it is one of the few countries that has the potential to expand production in a significant manner. However, industry plans for production increases in Zimbabwe have suffered setbacks in the last five years due to increasing political tensions and threats over security of tenure. In 2012 the government advanced increasingly forceful demands for the assignment of a 51% stake in existing operations to indigenous Zimbabweans with a deadline of April 1st, 2016 and a ban on the export of raw platinum metals. The situation in Zimbabwe is far from transparent and intelligible, there is the continued threat of nationalization, corruption, insufficient power and transport infrastructure, social and political turmoil and the rather worrying prospect of conflict concerning the struggle to succeed the aging Robert Mugabe, in power since 1987.

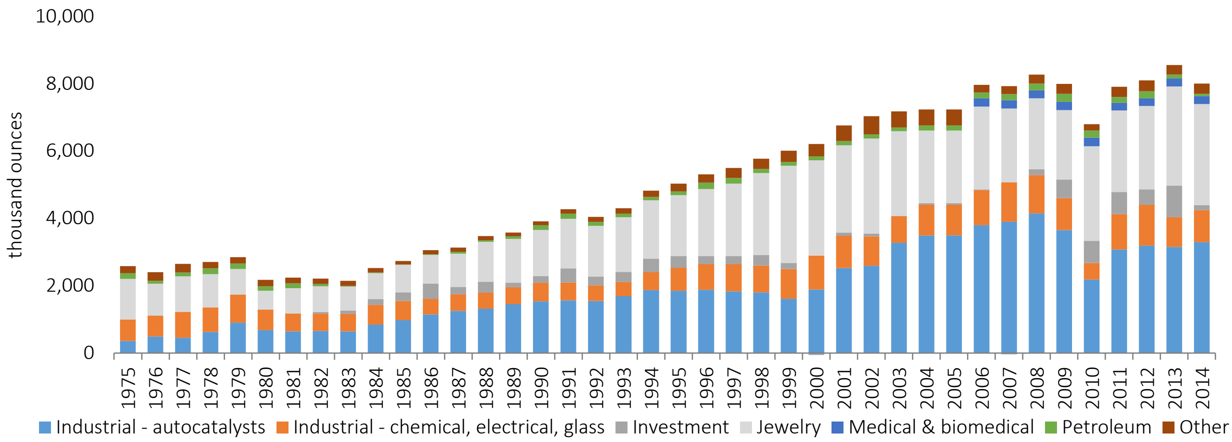
If the political turmoil in Zimbabwe offers comfort against the sudden discovery of large PGM deposits, cost remains the major obstacle to extraction at large deposits found in South Africa, a country that shares some of Zimbabwe's typical business impediments. This March, Canadian explorer Platinum Group Metals (PTM) has found five large mining blocks of PGMs and gold in the Waterberg district of South Africa. Drilling has been going on since 2011 and the estimation of reserves has been updated several times to the current 12-61 million ounces of platinum, palladium, gold and miscellaneous metals. The company is planning to apply for a mining license by the end of 2016 while a bankable feasibility study will be ready probably by 2017. The cost of extraction have not been mentioned so far, but we previously calculated the estimated cost of production excluding capex to range between US$1,700 and 2,000/ounce, which is still substantially higher than the current market prices of both platinum and palladium. So, **the question is not how many estimated reserves have been found in South Africa or anywhere else in the world, but whether it is economically viable to extract such resources**. Knowing that today there is only a handful of mining companies generating little positive cash flows, we anticipate this new discovery will take 3 to 5 years to commence extraction, and it will happen only when PGM prices will be substantially higher than what they are today.

II. Demand side

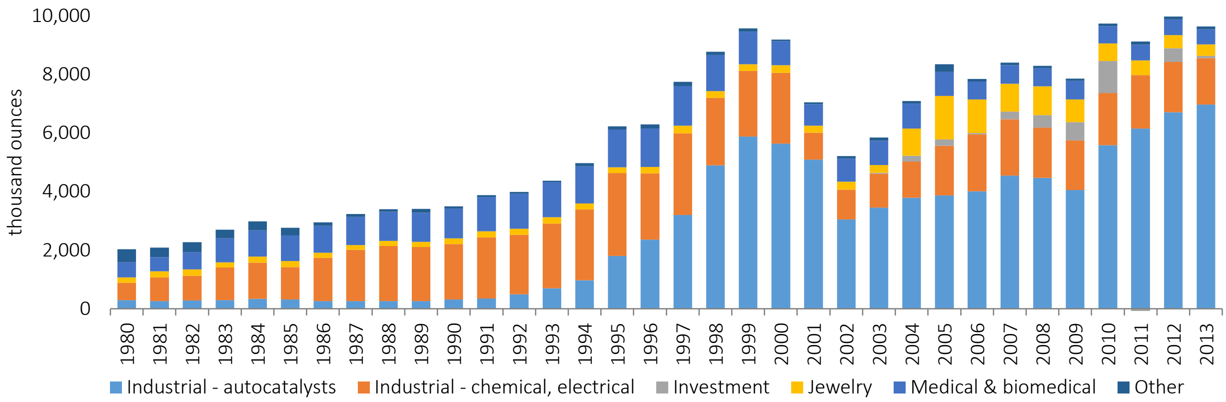
a. Automotive: the dominant driver

The past 40 years of demand history can be explained essentially through the intensive use of PGMs in the automotive industry in the US and Europe following the US Clean Air Act of 1970, and through the Chinese enormous appetite for natural resources in the 90s and 2000s. A relatively smaller part is played by jewelry, much more so for platinum than palladium.

Platinum



Palladium



Source: World Platinum Investment Council (WPIC), Index & Cie research

Nowadays the autocatalyst application takes ~50% of platinum's and over 65% of palladium's demand globally. In addition, while platinum's use has been more diversified and more steadily growing in comparison with that of palladium, this other metal has seen a dramatic surge in utilization in the 90s due to the massive consumption from the automotive industry; interestingly, autocatalyst consumption halved from 1999 to 2002 but since then, palladium consumption saw a strong increase primarily driven by ever stricter environmental regulations in Europe and the US, much more so than what platinum experienced during the same timeframe.

Today's main use of PGMs in the automotive industry is in the form of metal coating inside ceramic or metallic honeycomb structures, the so-called **catalytic converters**; these are directly connected to any internal combustion engine and reduce to up to 90% of poisonous emissions, in compliance with environmental regulations in Western countries. Platinum and palladium have slightly different chemical properties that make them better catalysts in either diesel or gasoline engines.

In particular, catalytic converters act through two processes, the *reduction process* and the *oxidation process*; these processes happen in different ways in diesel and gasoline engines, so converters are designed differently and with different PGM loadings and mixes. The main objective is the same: to convert nitrogen oxides (NOx, which is the main constituent of particulate matter, PM), carbon oxides (CO) and unburned hydrocarbons (HC) into harmless nitrogen, oxygen, CO_2 and water. It is essential to understand each engine technology to grasp the difference in catalytic properties and mutual enrichment of the two metals, as follows:

- Diesel engine: the first catalytic converter goes through the *oxidation process* in which CO and HC are oxidized into CO_2 and water. The main technology here is the Diesel Oxidation Catalyst (DOC). Before 2000 the *reduction process* happened without the help of a catalytic converter because PM, in this case NOx, was not a regulated pollutant; the gas would be re-circulated inside the combustion chamber multiple times, a process known as exhaust gas re-circulation (EGR); the process decreases the overall temperature (lower than that of gasoline engines) and allows the nitrogen-rich gas to bond multiple times and in a stronger way to oxygen from the air, ultimately releasing less nitrogen into the atmosphere after the oxygen burns out in the combustion. The bond between oxygen and nitrogen is stronger at lower temperatures, hence the re-circulation and optimization of nitrogen emissions. Since 2009, more advanced technologies began to be adopted and homologated for the reduction process, namely: the platinum-rich Lean NOx Trap (LNT) and the no-PGM Diesel Particulate Filter (DPF) and Selective Catalytic Reduction (SCR), which are discussed more in detail in the *potential threats to internal combustion engines demand* paragraph (iii.4.). In particular, the DPF captures most of NOx and periodically re-generates by increasing its temperature so that the unburned HC and NOx are re-oxidized in the PGM-rich oxidation catalyst. Platinum's primary advantage in diesel oxidation relates to the fact that the diesel exhaust stream is a highly oxidizing environment in which palladium is readily oxidized to a less catalytically active palladium oxide (thus losing in catalytic performance), whereas platinum resists oxidation and remains active in its metallic form. Differently from palladium, platinum is effective in the reduction process; the metal is also more resistant to sulphur poisoning than palladium, therefore it fits better the diesel engine where de-sulphation does not occur spontaneously.
- Gasoline engine: the catalytic converter, especially thanks to is rhodium component, needs to first strip the NOx of its oxygen molecule as a way of *reduction*, thus leaving the nitrogen free to bond with other nitrogen molecules to form N_2. The second process is to *oxide* by adding the remaining oxygen to the CO and unburned HC, which transforms them into CO_2 and water. These converters are technically known as Three-Way Catalysts (TWC) because they break down NOx, CO and HC as opposed to only CO and HC as they did prior to 1979. Similarly to the DPF in diesel engines, a Gasoline Particulate Filter (GPF) is coupled with the TWC to further reduce NOx emissions. Due to its catalytic properties at high temperatures, palladium is the predominant metal used in gasoline engines, augmented with small amounts of platinum and rhodium where necessary to add to thermal stability, resistance to sulphur poisoning and to make the reduction process effective, since palladium is mainly used as an oxidation catalyst. At the higher temperatures reached in a gasoline engine compared to a

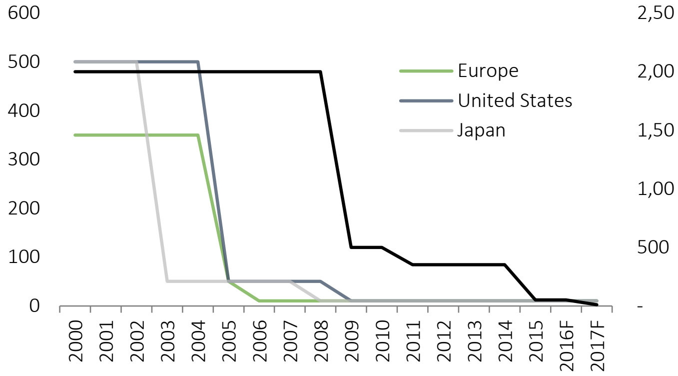
diesel one, the palladium catalyst spontaneously de-sulphates, meaning that sulphur gases resulting from fuel combustion desorb and cease to impair the performance of the metal – a sort of self-cleaning feature.

Given these slight differences in catalytic properties, **are platinum and palladium perfect substitutes**? This point is important in order to understand the business motivations underlying the car manufacturers' decisions, since PGMs are costs to them. The answer is that **the two metals are not perfect alternatives**, but they do enrich each other's performance in terms of (1) *thermal stability*[1], since the addition of palladium to platinum decreases sensibly the tendency of platinum molecules to merge into larger molecules when heated (sintering), a phenomenon associated with loss of catalytic efficiency, (2) *sulphur poisoning resistance*, whereby platinum is more resistant to sulphur poisoning than palladium, a problem that has been greatly reduced since the legalized level of sulphurs in on-road fuels – which stands for the level of purity of the fuel – is currently the lowest ever at 10 ppm across the world, see graph below, (3) *oxidation capabilities*, platinum is relatively more effective on HC whereas palladium on CO in large quantities and both functions are needed at the same time in both engines, albeit in different proportions, and (4) *cost*, meaning that the difference in market pricing provides cost averaging of raw metals, which are ultimately included in the basket of total OEM manufacturing costs.

This complementing relationship means the two metals are found in DOCs with a ~2:1 platinum/palladium ratio, while there is 90% palladium in TWCs. Recent research developments point in the direction of a feasible 1:1 ratio in diesel catalysts, which could have a mixed impact on platinum need in diesel engines depending on its price differential with palladium.

But it was not always this way.

Sulphur legal limits in on-road diesel fuels, in part per million



Source: EEA (EU), EPA (US), AECEN (Japan), MEP (China)

Platinum was identified as essential to curb emissions right at the inception of the Clean Air Act in 1970 in the US; the metal has been used massively in all engine autocatalysts ever since, to a point when Ford Motor Company concluded in the 80s that there would not be enough of the metal to cover new vehicle production in conjunction with increasingly stricter environmental regulations. Therefore, in 1989 scientists from Ford began researching the catalytic properties of metals close to platinum to increase the amount of catalytic metals available, hence the rise in interest for palladium as a valid addition to its senior metal for the chemical reasons discussed above. Prior to this technologic discovery, palladium was substantially less expensive than platinum, so

[1] In a catalytic converter, the metal is in the form of nanoparticles, which are dispersed over the entire surface of a highly porous support material. As the temperature of the catalyst rises, the particles start to become mobile and can coalesce – this is called *sintering*, and becomes particularly noticeable as the metal approaches its Tammann temperature, at which bulk mobility of the metal particles becomes measurable. This temperature is often taken to be half the material's melting point on the absolute temperature scale. Unlike gold and silver, platinum and palladium have a Tammann temperature (Pt: 750ºC, Pd 640ºC) that is above the average exhaust-gas temperature (600–700ºC) for a gasoline car in motion and so this makes possible their use in three-way catalysts (Source: Stan Golunski, Johnson Matthey Technology Centre).

automotive demand was redirected towards the former and prices started sky-rocketing; these technologic advancements gradually pushed towards a 2:1 ratio between the two metals, which is the norm today. As mentioned a further 1:1 ratio in diesel engines seems achievable – no such risk exists on gasoline engines due to palladium's better performance under heat – but in our view will depend more on the price differential than on a large-scale redirection of demand as observed in the 90s, mainly due to the fact that the potential marginal technologic advancements are much smaller than those achieved back then.

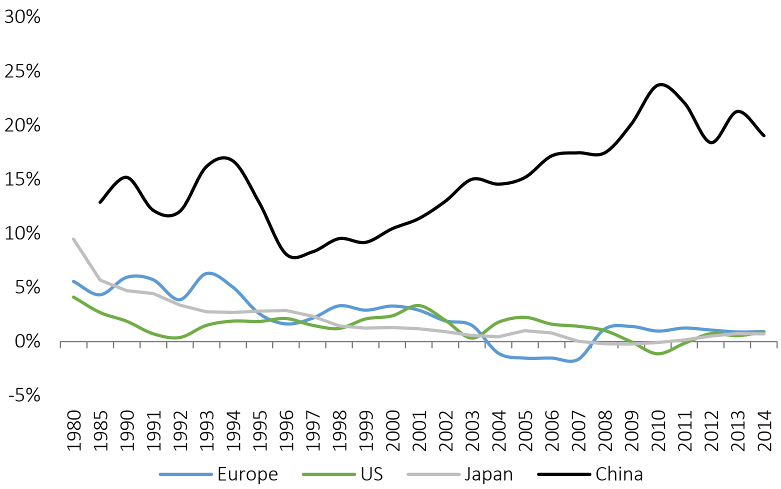
So **how will the use of platinum and palladium develop in this industry in the next five years**? To answer this question we focused our attention on the effect China and its vehicle fleet will have in the future; we modelled the Chinese evolution after that of the four largest motor vehicle fleets in use and after annual production in Europe, the US and Japan. China is central to the PGM investment thesis, but while we are under no illusion of fully comprehending or confidently forecasting the future development of the soon-to-be largest vehicle fleet on the planet, we nevertheless suspect the market might not be correctly appreciating the disruptive potential China has on the PGM markets.

After modeling China, we proceeded with gauging the direction of the remaining large fleets that together account for ~80% of total automotive consumption of PGMs. While doing so, we also calculated the potential impact of the electric revolution on the whole automotive industry and on the PGM consumption levels; this effort includes understanding which of the new technologies represents what kind of threat to the future of internal combustion engines.

i. China and applicable analogies

Fleet size and annual production – To start with, the Chinese fleet has overtaken the Japanese one in just 20 years and is now about half the one in the US, the European being the largest vehicle fleet in the world (see chart 1 in the Appendix). In terms of growth, the Chinese curve looks rather detached from its peers, as shown below.

Motor vehicle fleet growth – the effect of higher annual production

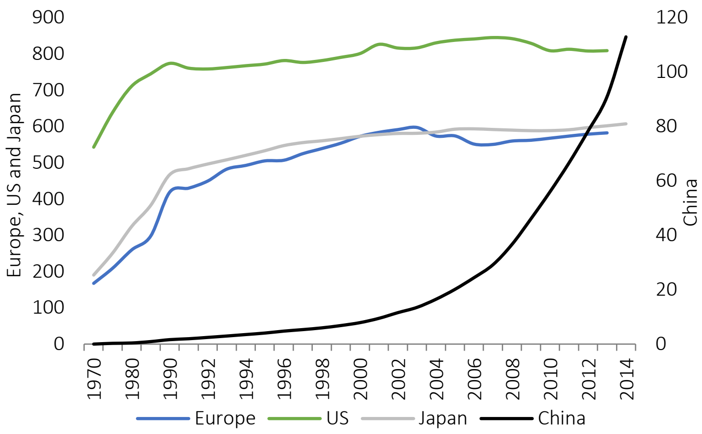


Source: OICA, ACEA, RITA, JAMA, Index & Cie research

In addition, the country's vehicle production output surpassed the US' in 2008, Japan's in 2009 and Europe's in 2011. Today, China is the largest manufacturer of motor vehicles in the world. This fact is only natural, as other large countries' fleets behaved in a similar way in their respective heydays and China has more than three times the population of the next largest region, Europe.

Another way of comparison that analysts commonly use is the vehicle density per inhabitant. The comparison is rather telling: China is today where Japan and Europe were in 1970, and where the US were in the early 1920s. Such comparison should be taken with a pinch of skepticism, because a direct comparison of these countries/regions is based on different economic, social and political cycles.

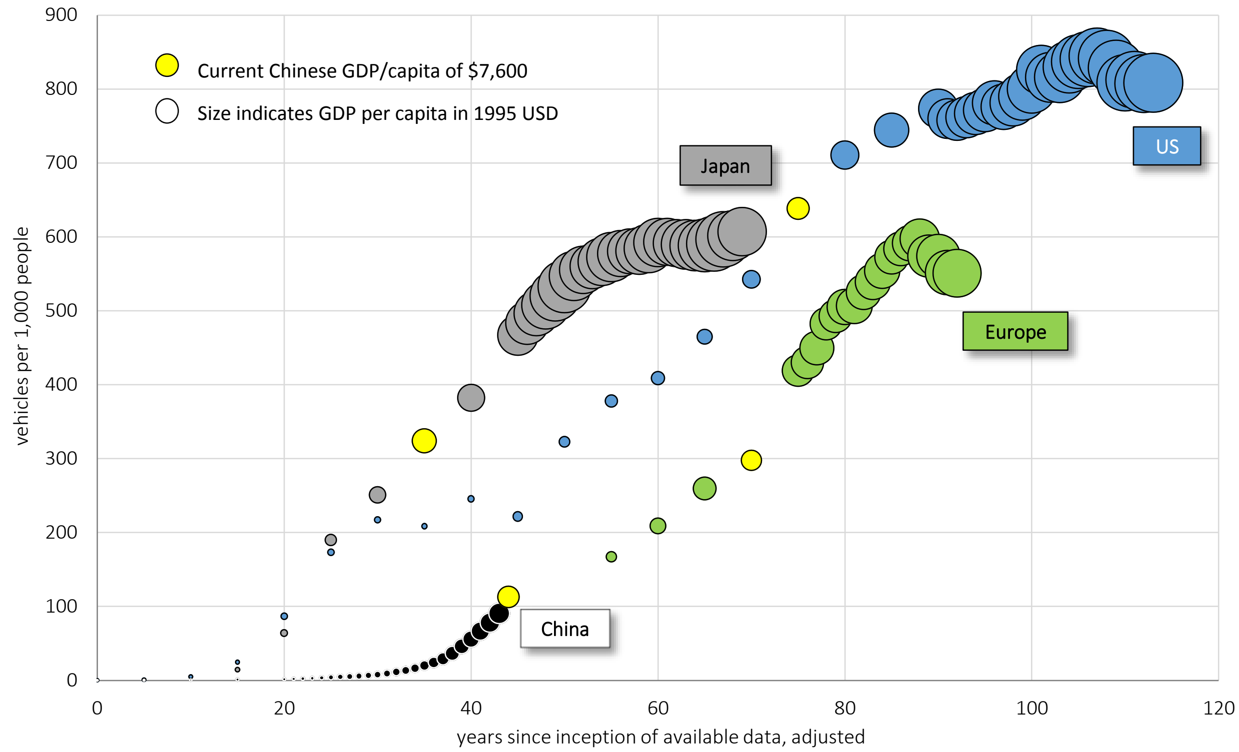
Vehicles per 1,000 people – China has 15% of US cars



Source: OICA, ACEA, RITA, JAMA, Index & Cie research

In other words it is only relatively helpful to compare China today with the US in 1923, or Europe and Japan in 1970, because social and economic conditions of consumers were at a much earlier stage of sophistication then than they are today. Chinese consumer spending dictated by social standing has triggered a renaissance-like time of growth for the Western-based luxury and automotive industries, just to mention a few. Since 20 years, the rapidly expanding Chinese middle class has been the single and most disruptive growth driver of whole industries which were in fact experiencing a secular decline in consumption in the West. Nevertheless, we believe analogies provide the strongest instrument of prediction, as our past experience of the Russian and European motor vehicle markets' comparison demonstrated. Therefore, we plotted vehicle density and spending power on a relative time scale from inception of the automotive industry starting from 1900, to see how these four countries/regions developed, as shown below.

Historical evolution of GDP per capita and vehicle density, by country/region



Source: OICA, ACEA, RITA, JAMA, Index & Cie research

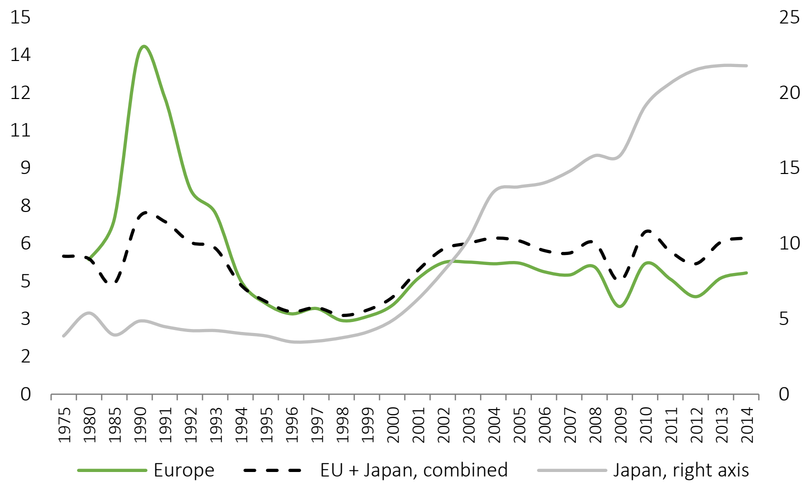
It is important to understand a couple of points about this graph:

1. The motor vehicle fleets of Europe, the US, Japan and China are depicted starting from the date from which data is available, which have then been adjusted to better reflect the most recent growth cycle in the automotive industry. We chose to represent the US since 1900 and Europe since 1915 – a time that coincides approximately with the moment when motorization became a mass phenomenon in the West – Japan since 1945 because of the reconstruction after World War II (only 114,000 registered vehicles in 1945) and China since 1970 because the Cultural Revolution initiated by Chairman Mao had the evident effect to depress and postpone Chinese economic and industrial development compared to its Asian peers (Japan and South Korea, mainly);
2. The dimension of the circles refers to GDP per capita in USD while the yellow circle indicates the current GDP per capita of China, which is then represented inside each country/region's curve to facilitate a comparison.

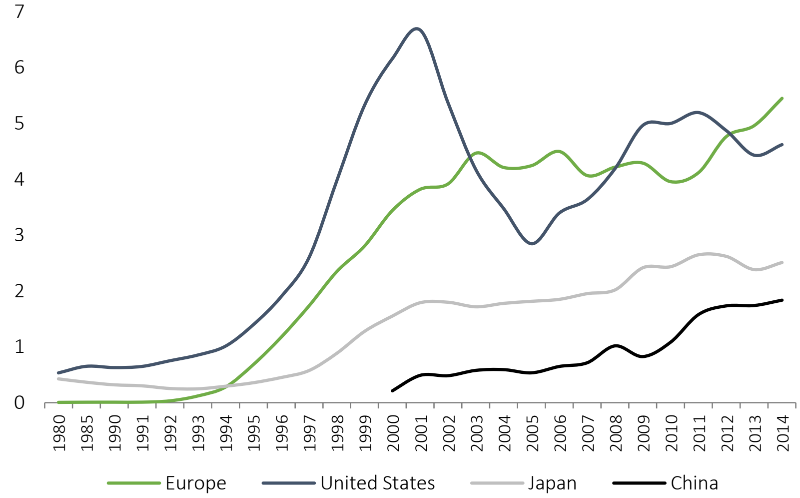
Without going too deep into the details of the historical evolution of each fleet, the graph above shows two very interesting facts: **first, the Chinese vehicle fleet is approximately in the same trajectory of those of all other countries/regions, and second, today's vehicle density in China is substantially lower than those of its peers if considered in relation to its GDP per capita level – to be precise it is half of Europe's and Japan's (113 vs ~300) and 1/7th or 14% of the US' (113 vs 808)**. It is not our intention to understand exactly why this is so (it might have to do with the enormous size of the Chinese population, well beyond 3 times that of any of its peers here considered), but the existence of such gap suggests that there might be room for a natural, strong upside in vehicle production and sales in the coming years, a fact strongly backed by the wide difference in car production and population growth rates between China and its peers. It also suggests that the Chinese growth rate might be slightly lower if compared with its peers, whereby it takes the country a longer time to reach similar levels of the metrics considered.

Diesel versus gasoline – We then looked at the composition of each single vehicle fleet in order to gauge the split between diesel- and gasoline-fueled vehicles. Diesel engines are used only in 16-18% of the global vehicle fleet today, 90% of which is found in Europe. The European vehicle fleet is almost evenly split between diesel- and gasoline-fueled vehicles; Japan and the US have also intensively used diesel engines in the past, but today they both tend to limit this technology to heavy-duty, industrial-purpose or public transportation vehicles due to the higher torque (hence the higher loading per vehicle seen in the first graph below). The North American and Chinese fleet are instead dominated by gasoline-fueled vehicles. To sum it up, the vast majority of vehicles on earth run on gasoline (i.e. ~75%, ~15% on diesel and the remainder on alternative fuels, hybrids and electric vehicles). As a ballpark figure, Europe and Japan account for 60% of platinum consumption, while the country split on palladium is more balanced around 20-25% for Europe, the US, China and rest of the world each (Japan accounting for ~10%, see chart 3 and 4 in the Appendix). In order to establish what is the different use at each country's or region's level, we analyzed in detail the amount of grams of platinum and palladium mounted on vehicles produced each year, as shown in the graphs below.

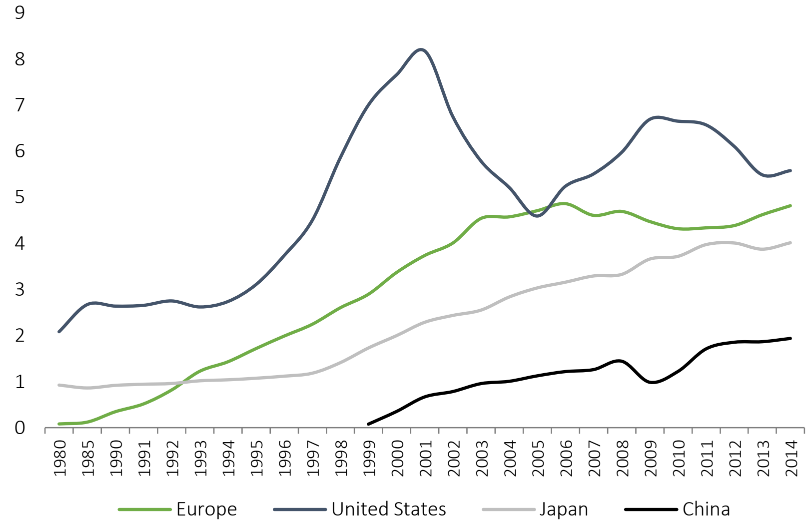
Platinum loadings, grams per vehicle



Palladium loadings, grams per vehicle



PGM combined loadings (platinum & palladium), grams per vehicle



Source: Index & Cie research

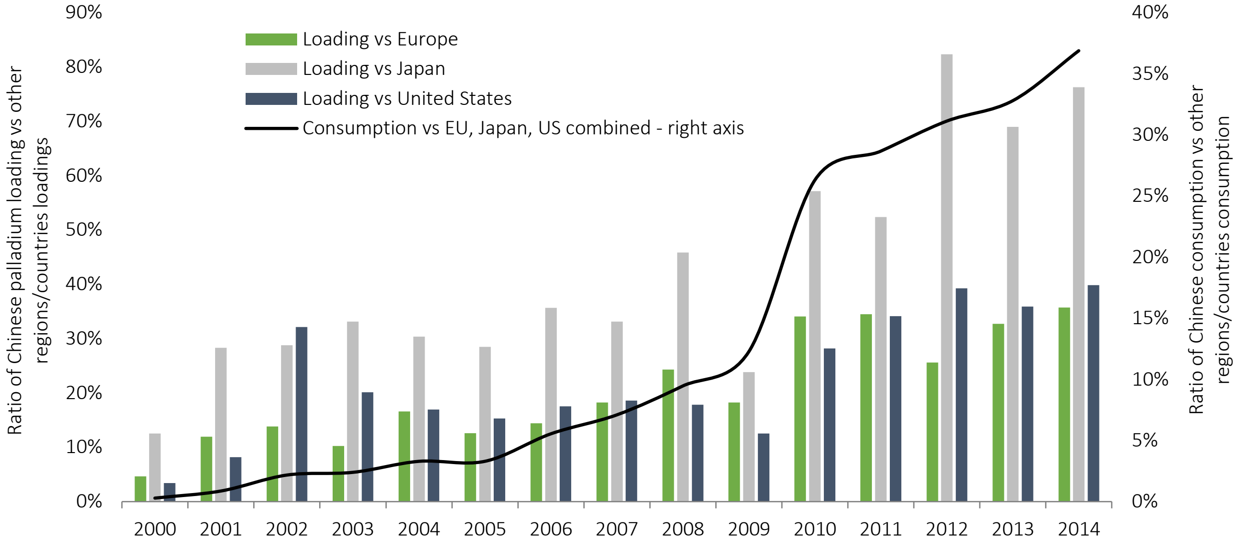
The trend observed in the platinum loading evolution in Europe, an initial spike in late 80s and a consequent normalization around 5-6 grams per vehicle starting from the 2000s, is the result of research advancements in the substitution of platinum with palladium in diesel engines. As mentioned, platinum was the sole catalytic option until the 80s since scientists identified the metal as the only available metal with such features.

In 1989 research showed palladium could complement platinum in reducing emissions, a discovery that triggered the sharp decrease in platinum loadings and the steep increase in palladium loadings. Currently, the ~5gr/vh of platinum value seems to represent a long-term average in the European mature diesel market, which will probably stay that way in the foreseeable future.

The situation on palladium is instead one of generalized growth across all major countries and regions. In particular, China is substantially behind its peers in terms of palladium loadings.

To better represent the substantial gaps China has against its peers, find the loading ratios coupled with the Chinese consumption of palladium against the sum of Europe's, the US' and Japan's consumption.

Palladium loadings and consumption compared

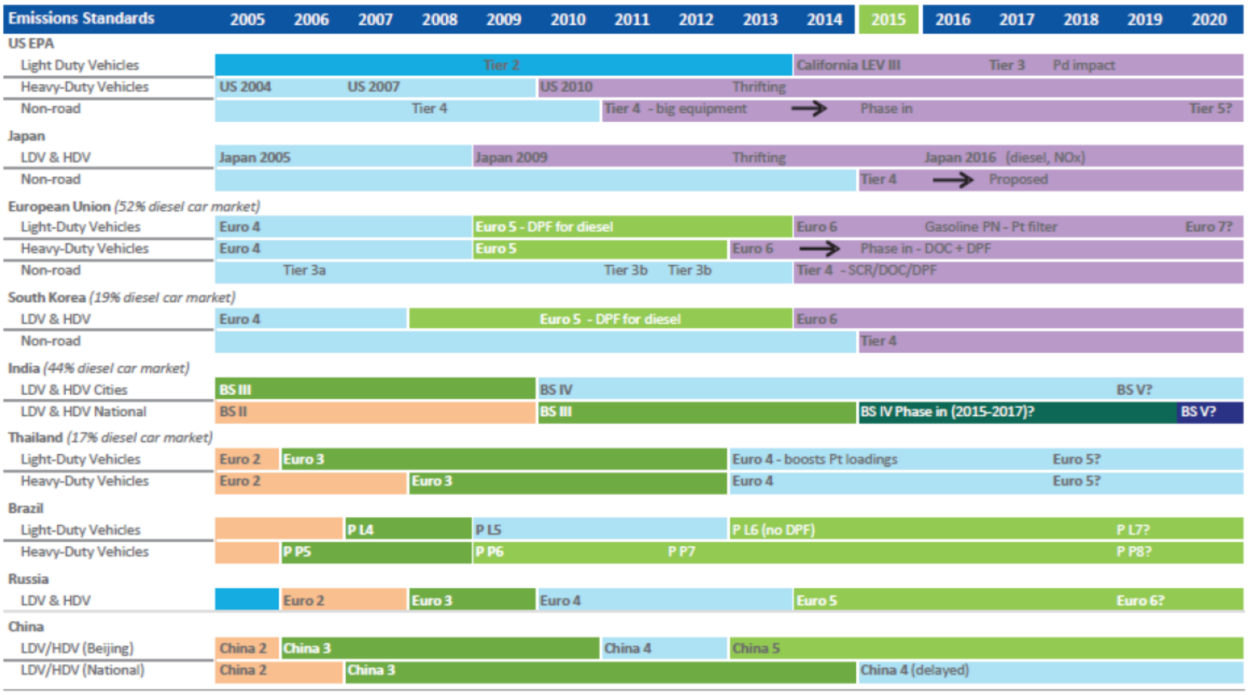


Source: Index & Cie Research

The graph above is rather telling in that China is rapidly overcoming its peers' consumption levels, which in turn means the country is increasing the palladium loading on its growing vehicle fleet. This is true for the past 15 years and it is dominating the overall PGM application in the Chinese automotive industry. In particular, stages of normalization against peers are present: the first one is with Japan, whereby Chinese palladium loading is only ~80% of the Japanese one; the further ones to be reached are probably the American (Chinese consumption is only 40% of it) and the European ones (Chinese consumption is less than 40% of that).

Regulation – So what is driving such a dramatic increase in PGM consumption from the automotive industry in China? The first thought is definitely the general increased awareness of the climate change forces in action, which were the central subject of the Climate Change Conference held in Paris last November. While we do not ascribe a solid economically and industrially binding power to this event, we nevertheless observed that it had a lot of headline power in giving responsibility to each participating country on their emissions; countries like India and China were in fact among the major targets in that they are much less regulated from an environmental point of view in comparison to Europe, the US and Japan. To put things in perspective, here is a table of the historical evolution of country regulations, which in turn are at the basis of the increased use of PGMs for their cost-effective anti-pollutant properties in the automotive industry.

Global emission standards tightening



Source: SFA Oxford

In the case of China, the implementation dates and reference of their various regulation stages is shown in the table below. In order to provide a potential picture of the future for Chinese regulation, the current Euro 6 regulation has imposed pollutant emission reduction of 50% in comparison with Euro 5 – see chart 5 in the Appendix for more details.

Chinese implementation dates of emission standards for light-duty vehicles

Stage	Implementation date (type approval)	Implementation Date (all vehicle sales and registrations)	Region	Reference
China 1	1 Jan 2000 (Type 1[3]) 1 Jan 2001 (Type 2[3])	1 Jul 2000 (Type 1) 1 Oct 2001 (Type 2)	Nationwide (production conformity Aug 2000 onward)	Euro 1
China 2	1 Jul 2004 (Type 1) 1 Jul 2005 (Type 2)	1 Jul 2005 (Type 1) 1 Jul 2006 (Type 2)	Beijing (2002), Shanghai (2003), nationwide (Aug 2004 onward)	Euro 2
China 3	1 Jul 2007 (no EOBD[4] req.) 1 Jul 2008 (EOBD req. for Type 1) 1 Jul 2010 (EOBD req. for all others)	1 Jul 2008 (no EOBD req.) 1 Jul 2009 (EOBD req. for Type 1) 1 Jul 2011 (EOBD req. for all others)	Beijing (2005), Guangzhou (2006), Shanghai (2007), nationwide (Aug 2007 onward)	Euro 3
China 4	1 Jul 2010	1 July 2011 (gasoline) 1 Jul 2013 (diesel)[1]	Beijing (2008), Shanghai (2009), nationwide (gasoline & nat gas Aug 2011, diesel Jan 2015 onward)	Euro 4
China 5	1 Jan 2016 (gasoline) 1 Jan 2017 (diesel)	1 Jan 2017 (gasoline)[2] 1 Jan 2018 (diesel)[2]	Beijing (2013), Shanghai (2014), nationwide (Jan 2018 onward)	Euro 5
China 6	n/a	n/a	Beijing (gasoline & nat gas Dec 2017)	US Tier 3

Source: Ministry of Environmental Protection of the People's Republic of China, March 2016

Notes:

1. This date represents a two-year delay from the date specified in the original standard.
2. The implementation timeline of China 5 light-duty gasoline vehicle and light-duty diesel bus in the eastern 11 provinces (Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan) is 1st April 2016.
3. Light-duty vehicle categories are based on the EU classification with some deviation: type 1 vehicles: M1 vehicles for no more than 6 passengers including driver, and GVWR ≤ 2.5 tons; type 2 vehicles: Other light-duty vehicles (including N1 light commercial vehicles) further divided into three classes based on the reference mass.
4. European On Board Diagnostics, instruments equipment required under certain regulations.

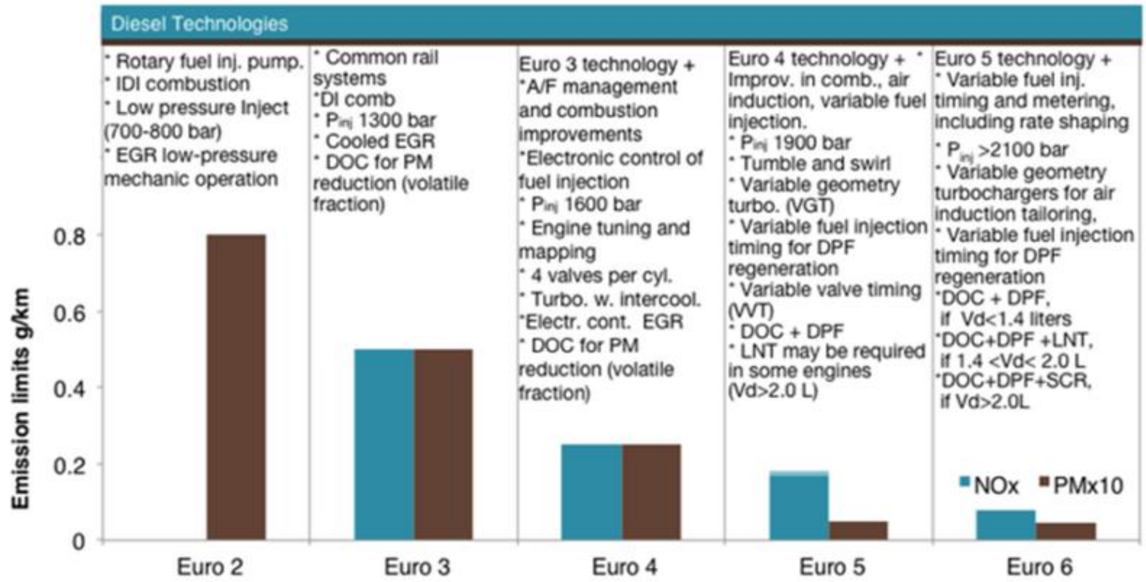
The increasingly stringent requirements against pollution has been recently coupled with the sales tax halving to 5% on 1.6 litre engines and below from October 1st, 2015 to the end of 2016, this segment accounting for 70% of new car sales in China. While such tax incentives should not be relied upon for future investment decisions, they do signal the intention of the Chinese government to act upon pollution curbing through various channels. Being there no other cost-effective alternative to PGMs in matter of emission reductions on internal combustion engines, it seems reasonable to expect that China will eventually mirror the European and American loading standards, after it surpasses the Japanese levels. In fact, the highest emission standard target would be relatively inexpensive for manufacturers to achieve and clients to afford, since currently it only costs US$90-100 to provide a vehicle with the quantity of palladium necessary to comply with European and American regulations (~US$150 worth of platinum). This considerations would have to be made by the Chinese authorities and manufacturers together with the current push on electric vehicles in order to comply with achieve emission targets for 2020 and 2025 (see next paragraph).

ii. Europe, the US and Japan

Unlike China, these countries and regions have the most stable and oldest fleets in the world, whereby vehicles density, sales growth, and average age are similar and typical of mature markets. In particular, the ~10 years average age of European, American and Japanese cars suggests that the introduction of new technologies and the subsequent changes in sales and PGM consumption will not happen abruptly, as it is happening now in the electric segment. As we discuss more in detail in the following paragraph, **we believe the threat to internal combustion engines – and in particular to diesel and platinum – coming from secular shifts and other specific events within the industry will likely start to show an impact on these large fleets in 5 to 10 years from now**; beyond this timeframe, we think the diesel segment is more exposed than the gasoline one to any such changes since 90% of the current diesel market is in mature and technologically plateauing Europe. In other words, while the gasoline segment will quite likely witness high growth from China and other emerging markets, the diesel segment's long-term evolution will depend almost entirely on a region that has reached a peak of both diesel penetration and emissions reduction levels. However, we do not expect a substantial decrease in global platinum consumption to materialize in the next 5 years because in Europe the diesel engine is still less polluting than gasoline thanks to Euro 6 regulation, the region's dependence on this technology is still very high and India is displaying strong growth in this segment due to fuel cost efficiency against gasoline.

Focus on diesel – Regulation in Europe is among the toughest globally, and often taken as a reference as seen in China. Today, the Euro 6 regulation on diesel is imposing a platinum-rich DOC on all vehicles since 2014, plus an also platinum-rich LNT in vehicles with engines between 1.4 and 2 litre (see chart below). The level of NOx allowed is 50% lower than that of Euro 5, a trend that has almost reached the zero limit in emissions allowance. The question becomes how further can regulation go to curb emissions, hence the technological plateau we believe Europe is reaching.

Difference in CO2 emissions in registered passenger vehicles in Europe

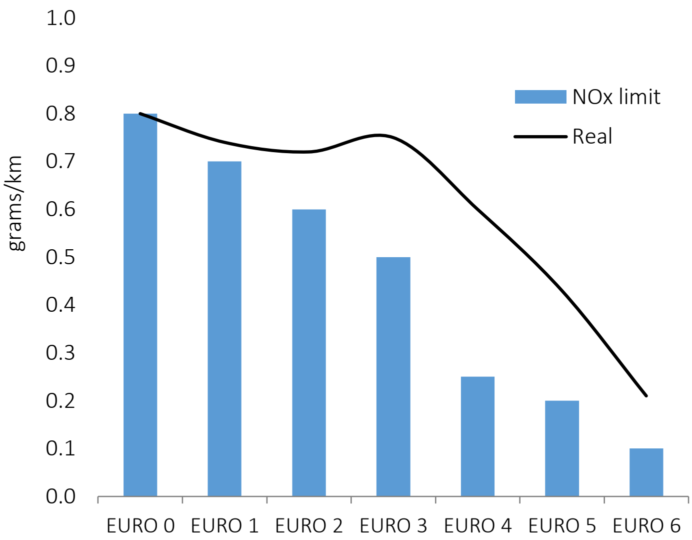


Source: European Commission Directives and Regulations

Past experience shows that any regulation tends to last 4 to 5 years; Euro 7 regulation is now expected to come by 2020 with a more stringent set of rules on emissions, if possible.

In late 2015 we observed how the Volkswagen "dieselgate" had the effect of pushing manufacturers to improve emissions even before Euro 7 was discussed; all OEMs began an internal review of all true emissions on diesel engines and major players began introducing smaller, more fuel efficient and less polluting diesel engines in previously gasoline-fueled vehicles. This is what emerges from the sales growth observed since 2015 in segment B and C vehicles in Europe from BMW, Mercedes Benz and FCA.

Regulation versus real NOx emissions in European diesel



Source: European Environment Agency (EEA)

As of today, the diesel engine remains about 10% less polluting that the gasoline one, as seen in the table below.

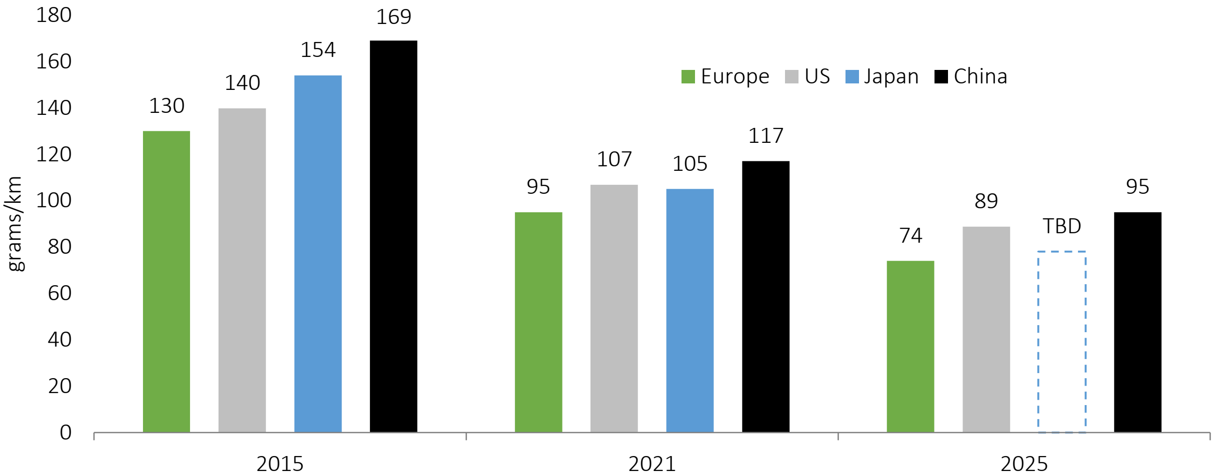
Difference in CO_2 emissions in registered passenger vehicles in Europe

Vehicle segments	Definition	Engine size (cm³)	Diesel, gr/km 2010	2011	2012	2013	2014	Difference with gasoline, % 2010	2011	2012	2013	2014
A	mini	0-1,000	95	93	90	93	105	-15%	-12%	-14%	-12%	-2%
B	small	1,000-1,500	121	117	113	110	107	-12%	-14%	-16%	-16%	-17%
C	medium	1,500-2,000	149	143	138	133	130	-12%	-14%	-14%	-13%	-13%
		2,000-2,500	186	175	167	162	154	-10%	-15%	-17%	-13%	-11%
D	large	2,500-3,000	206	191	180	176	170	-5%	-9%	-10%	-9%	-13%
E	executive	3,000-3,500	224	214	210	217	215	1%	7%	11%	17%	16%
F & S	luxury & sport	3,500-4,000	289	298	273	234	224	10%	18%	8%	-4%	-6%
		4,000+	249	233	228	227	223	-19%	-20%	-19%	-18%	-16%
		all	**160**	**151**	**145**	**138**	**134**	**-5%**	**-5%**	**-9%**	**-7%**	**-9%**

Source: European Environment Agency (EEA)

Because of lower emissions and better fuel efficiency, OEMs in Europe have relied on diesel for many years to comply with past and future (target) CO_2 emission limits imposed by regulations. This is still the case today and we believe that the below targets will be achieved in the long-term by a combination of gasoline engines for small vehicles, diesel engines for upper segments and a slow, gradual introduction of electric cars after a transitional stage of hybrid technology.

Average CO_2 emission regulatory targets for light-duty vehicle fleet, by country/region

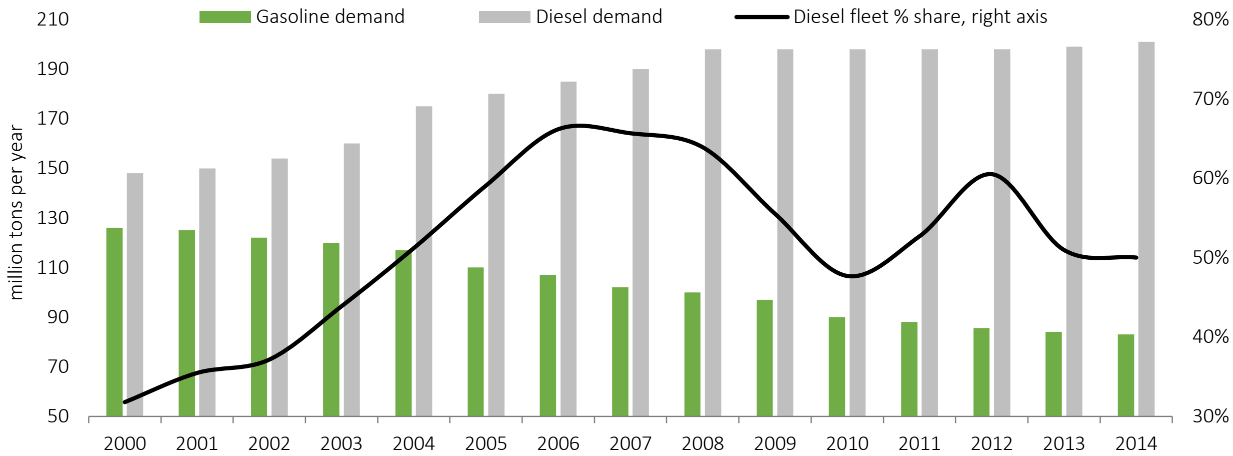


Source: Delphi, European Commission, EPA, Center for Climate and Energy Solutions

Other states and countries have preferred to tap into the electric vehicle solution without using the diesel technology; in 2014, six Tier 1 cities in China have adapted the same framework California has had since 1990 and heavily incentivized pure electric vehicles, while penalizing internal combustion engines. However, as further discussed in sub-paragraph iv further below, these initiatives are far from being country-wide realities in both the US and China, so the question remains on how to curb the existing mass of pollution created by the current fleet. A first answer could be found in the general view we obtained from OEMs and automotive specialists that resources and technologic advancements will be gradually focused on gasoline engines instead of diesel for small vehicles, while diesel will retain its dominance in the upper segments (D, E, F & S in Europe). This will be mainly due to the higher cost that diesel engines impose, which is then transferred on to the consumers as a higher retail price. The SCR technology is one example.

Despite this future outlook, the current relevance of diesel in Europe can hardly be underestimated when one looks at the way fuel consumption has evolved over the past 15 years, as shown in the graph below. In addition to the high average age of vehicles in Europe, the fuel demand trend testifies in favor of a higher stickiness of demand to diesel relative to other geographies; therefore, we expect the diesel segment in Europe to be more resilient than expected by the markets to negative headlines from the Volkswagen case and a gradual descent of diesel share.

Road fuel demand in Europe

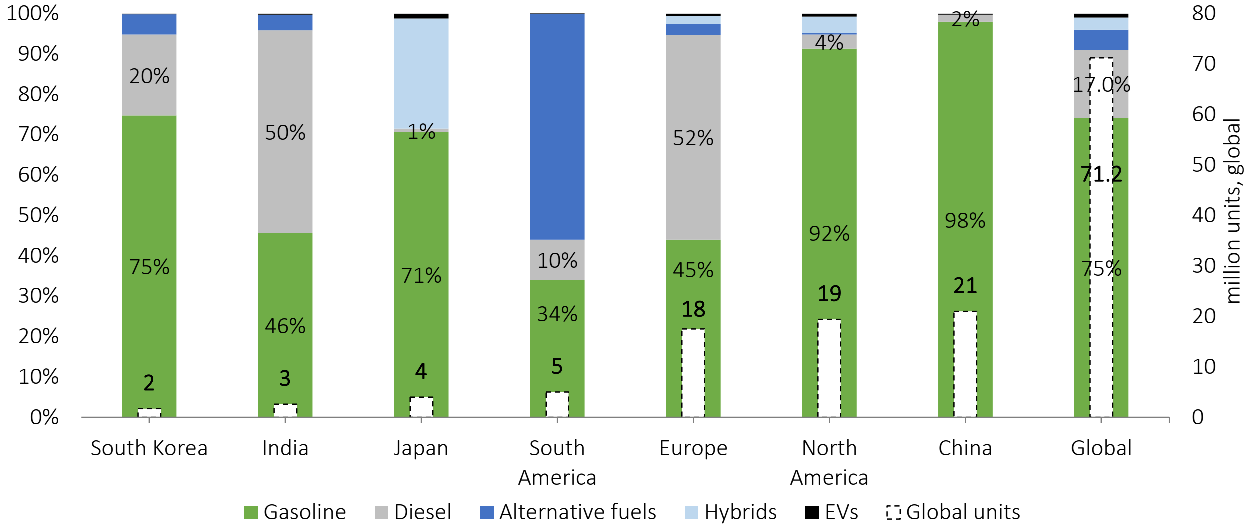


Source: Wood Mackenzie, FuelsEurope 2015 statistical report

The evolution of fuel demand is the reflection of the tax incentives promoted by EU governments since the early 80s; today, diesel demand in Europe is more than double that of gasoline. On one hand, our research and conversations with market specialists suggest that demand for diesel has reached a peak of penetration at ~50% of the European fleet, decreasing from ~60%; on the other, sale and production volumes have remained stable recently as the fleet has slightly increased overall along with other mature fleets. In terms of platinum consumption, the effect on demand would then be effectively small if not increasing in the coming 4 to 5 years, because each new vehicle will need to be equipped with DOC and LNT whereas before Euro 6 the LNTs were not required; this introduction could counter-balance the reduction in platinum consumption coming from a reduction in sales, essentially neutralizing any decline in the overall number of vehicles sold.

Lastly, powertrain shipments for 2015 give further comfort on the resilience of global diesel demand, especially when considering that the positive trend in India might also contribute to counter-balance the potential decline in European diesel share and hence in platinum consumption, as shown in the graph below. In terms of emerging diesel markets, it seems India is poised to grow considerably with its 50% diesel share because diesel fuel has a price advantage over gasoline even without subsidies. This figure was 55% of 4.1m vehicles in 2014, i.e. 2.3m vehicles. Besides, the graph shows only light-duty vehicle shipments, thus disregarding the strong diesel presence in the heavy-duty segment of the Japanese and European markets.

Light-duty vehicle powertrain shipments, 2015



Source: Frost & Sullivan, LMC Automotive

iii. Potential threats to internal combustion engines demand

Investment banking analysts and a variety of precious metal specialists seem mainly concerned about the languishing/lacklustre demand from both automotive and jewelry, the level of above-ground stock which stands ready to cover any demand surplus and the unpredictable effects of the Volkswagen scandal on diesel-fueled cars (with the recent news of a US$18bn fine pending). Our conversations with automotive specialists and OEM engineers provided grounds for a long-term view of the automotive industry and its challenges, which we chose to separate into internal combustion engines and electric motion, the latter discussed in the next chapter. We identified a number of long-term trends that support a continued use of PGMs, as follows:

1. **Internal combustion engines have been around for more than 100 years now** and technology has reached a plateau in terms of improving emission-, cost- and fuel-efficiency. In addition, environmental regulation is making ever stricter emission limits compulsory in the largest automotive markets (see Chart 5 in the Appendix). By coupling these two facts it seems only reasonable that the new social and environmental needs will be met through a revolution in the automotive industry embodied in hybrid and electric powertrains, in this order of adoption to ease the passage to full electric motion. Such passage is happening fast, but will not materialize overnight since the electric phenomenon is still negligible in terms of penetration in the most advanced markets and it is facing some serious challenges; this leave another 5 to 10 years of continued predominance of internal combustion engines in the industry;
2. The **Volkswagen scandal** is simply seen as part of such trend. While the investment community is focused on the scandal's short-term impact on the diesel segment, our findings suggest it worked as an accelerator towards an already existing strong push to improve diesel efficiency in the short-term in Europe and develop emission-, cost- and fuel-efficient hybrid and electric powertrains in the long-term globally. The real, long-term questions are (1) how much more can technology advancements reduce emissions from internal combustion engines to comply with ever stringent emission limits imposed by regulations and (2) how fast

will this change happen beyond Euro 7, which is perceived as being at the end of emission allowance range;

3. The risk of decrease in PGM use coming from **new technologies** is as follows:
   a. Starting from 2014, the diesel *Selective Catalytic Reduction* (SCR) technology is homologated in Europe for all new vehicles over 2 litre engine size, which applies to all heavy-duty vehicles and some light-duty vehicles. The SCR does not need PGM-based catalysts. However, this technology is not exactly brand new, depending on the OEM using it (Mercedes Benz has been using it for the past 15 years); before becoming a requirement, it was used in V6s and V8s and heavy-duty vehicles due to its torque and cost. Since it has been around for quite a while now, we believe the impact on sales is limited and does not pose a surprise risk in the coming 5 years to the volume of diesel cars sold in Europe;
   b. Under the Euro 6 regulation, new light-duty diesel vehicles have been homologated since 2014 with the *Diesel Oxidation Catalyst* (DOC) and the *Diesel Particulate Filter* (DPF) for engines below 1.4 litre, while with DOC and the *Lean NOx Trap* (LNT) for engines between 1.4 and 2 litre. As seen before, the DOC still contains an oxidizing PGM-rich catalyst, which is also the case for the LNT, but the DPF is a simple filter for the NOx reduction process and does not need any PGM. The DOC is also homologated for heavy-duty vehicles since 2013. Overall, we expect the introduction of LNTs to counter-balance the adoption of SCR in larger engines, because 1.4-2 litre vehicles constitute the large majority of the European fleet and of consumer demand;
   c. In the gasoline domain, PGMs will still be used massively to comply with Euro 6 and 7 (Europe) and Tier 3 (US) regulations and there seems to be no threat of substitution with other materials or technologies;
   d. It is worth repeating that **any revolutionizing, brand new technology in the internal combustion engine domain will take around 9-10 years to reach ~70% penetration rate** in the vehicle fleet, this length being the average age of a European car today, which compares to the American average of 11.5 years.

We therefore see no particularly large and close threats to PGM demand coming from further technological refinements on internal combustion engines. A much more significant threat is instead posed by the strong push towards electric motion, discussed and sized in the following paragraph.

iv. Electric motion: still in its infancy

It is beyond the purpose of this research to deep-dive into the electrification trend in the automotive industry; however, we feel it is important to provide a context and size to this phenomenon to understand how near, or far, is the threat to traditional ways.

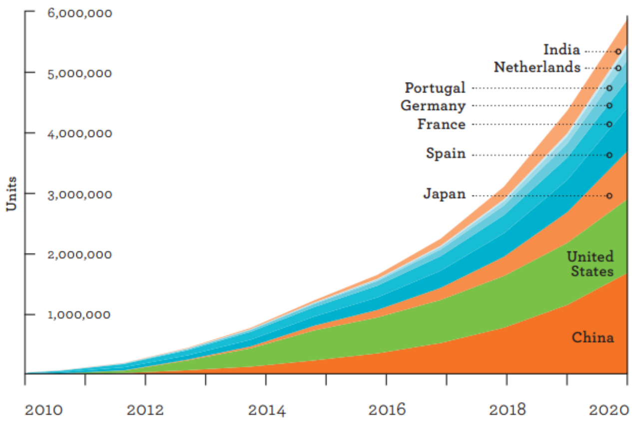
While the internal combustion engines have been dominating the automotive industry since its inception and currently power the almost entirety of the vehicles that exist on earth, it is evident nowadays that the environmental and human health impacts of burning fossil fuels became valid reasons for all participants – consumers, governments and manufacturers – to find ways to reduce or nullify polluting emissions from cars. It is hard to establish whether consumer demand, or regulation, or manufacturers' offer initiated the trend; most often it starts with demand from consumers, which needs to be met by manufacturers within a matter of years of technological advancements; this is where government interventions come in and provide a subsidy to both consumers and manufacturers to sustain and speed up the change. This seems to be the current situation on pure electric and fuel cell vehicles, because the passage through the intermediate point, i.e. hybrid vehicles, is already an everyday reality. Demand for hybrid and electric vehicles was already present in late 90s in the US and Europe, so General Motors began its electric vehicle production in 1996 with the EV1, while in 1997 Toyota – the largest car manufacturer in the world – became the first OEM to mass-produce a hybrid electric vehicle, the Prius. In 2003 Tesla was founded and in 2011 Toyota announced a concept fuel cell vehicle, the Mirai (meaning "future") which was developed into a commercial product in 2014 when it launched in Japan and in late 2015 in Europe. Last October, Toyota announced its goal of eliminating gasoline and diesel engines from its fleet by 2050.

For the purpose of simplicity, we refer to "electric vehicles" to address hybrids, plug-in hybrids, pure electric and hydrogen-based fuel cell vehicles, unless otherwise stated. The electric vehicle (EV) phenomenon began shaping markedly in 2010 from a sales perspective; today it is still in its infancy and it is growing fast through the intermediate step of hybrid vehicles due to two major bottlenecks, i.e. the battery technology and the power station networks, which both contribute in making the achievable range much lower than that of internal combustion engines (150km max against >500km for internal combustion engines).

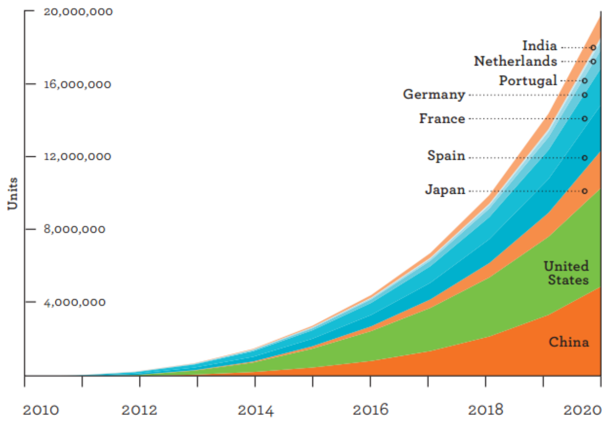
How fast is the EV market growing? It turns out that there is no objective, fact-based answer to this question, since there seems to be no consistency in historical sales and countries' fleet size across reporting authorities. This could be due to a lack of data typical of small and fast-growing markets, which have not yet attracted the attention of the public. For instance, the Energy Information Administration of the US (EIA), the Electric Drive Transportation Association also in the US (EDTA) and the Clean Energy Ministerial (CEM) effort report all different sales and fleet sizes for the US and other countries; the only source for Chinese numbers is the Ministry of Transportation, which can only be counter-checked via an account of EVs sold by each single manufacturer (not all manufacturers disclose this number, such as Tesla); the European Automobile Manufacturers' Association (ACEA) started reporting registrations in Europe since 2013 while the European Association for Battery, Hybrid & Fuel Cell Electric Vehicles (AVERE) has reported figures up until 2012; and finally we do not seem to find any reliable public source on the Japanese market. However, we found the most comprehensive set of data through the Clean Energy Ministerial, a joint-effort of various nations and institutions, which we cross-checked with other sources and ultimately deemed worthy of mention.

What authorities think - #1

Historic and forecast annual sales



Historic and forecast vehicle fleet



Source: Clean Energy Ministerial, EVI, International Energy Agency

According to the authors, in 2010 the market accounted to not meaningful percentages of the global annual *vehicle production*, while in 2015 EV production accounted for 2.6%; the Street expects it to account for 10-20% of total vehicle production by 2020. This forecast will be mainly driven by the hybrid vehicle segment expansion, which will continue to largely dominate the transition towards pure electric, which in turn is expected to account for ~2% by 2020. In terms of fleet, the EV vehicles in 2015 accounted for ~0.1% of the global fleet, forecasted to account for ~3% of the global car fleet in 2020. We then combined a number of datasets from various providers to arrive to a 3-year evolution of fleets and filling/charging stations by country.

What authorities think - #2

Thousands	Pure electric		All hybrids		Gasoline & Diesel	
US & Canada	**2012**	**2015**	**2012**	**2015**	**2012**	**2015**
Vehicle fleet	71	420	56	439	253,639	255,877
Filling stations	15	25	←can use both→		134	126
% of total fleet	*0.03%*	*0.16%*	*0.02%*	*0.17%*		
% of stations	*11%*	*20%*				
Europe						
Vehicle fleet	48	132	10	68	292,488	295,113
Filling stations	12	42	←can use both→		116	120
% of total fleet	*0.02%*	*0.04%*	*0.00%*	*0.02%*		
% of stations	*10%*	*35%*				
India						
Vehicle fleet	1.4	2.7	n/a	n/a	22,622	25,011
Filling stations	1	0.328	←can use both→		45	52
% of total fleet	*0.01%*	*0.01%*				
% of stations	*2%*	*1%*				
Japan						
Vehicle fleet	45	128	19	94	76,126	77,188
Filling stations	5	12	←can use both→		38	34
% of total fleet	*0.06%*	*0.17%*	*0.02%*	*0.12%*		
% of stations	*13%*	*34%*				
China						
Vehicle fleet	18	294	4	116	109,331	154,410
Filling stations	8	30	←can use both→		96	99
% of total fleet	*0.02%*	*0.19%*	*0.00%*	*0.08%*		
% of stations	*8%*	*30%*				

The picture is that of an almost parity of pure electric and hybrid fleets across countries. The US dominate the scene with ~50% overall share; once again available data are somewhat confusing, since the EIA has published their own forecasts where the pure electric vehicle fleet has historically amounted to 10-16% of the hybrid one, a fact also confirmed by our primary research with leading EV global manufacturers. It seems the vast majority of vehicles sold since 2010 and now in circulation are hybrid vehicles that use the battery pack as an auxiliary device to the internal combustion engine – the typical distance range achieved uniquely with the battery is 30-50km (only exception is the Chevrolet Volt at 85km).

Total						
Vehicle fleet	183	977	89	717	754,206	807,599
Filling stations	41	109				
% of total fleet	*0.05%*	*0.24%*	*0.01%*	*0.09%*		
% of stations	*19%*	*50%*				

Source: CEM, EVI, EIA, EDTA, ACEA, MoT, Index & Cie

The shape and dimension of the EV market might become clearer in 2020-2025, when the number of cars around is expected to reach ~1-3% of the global fleet; even from a *shipment* perspective (number of vehicles delivered to end markets) EVs, including hybrids, account for only 3 to 4% of global shipments in 2015. For the moment the hybrid solution seems to be the intermediate step between internal combustion and pure electric motion, a vehicle powered by both an electric motor and an internal combustion engine. The car can be equipped with a plug-in device, which allows to charge the battery from external sources (such as a filling/charging station along the road, or a socket installed in a solar-powered house) in addition to the energy coming from fossil fuels. Whether plug-in or simple hybrid, the average vehicle today offers an electric range of up to 85 km, which is acceptable for city driving, combined with a downsized combustion engine to achieve a global autonomy of more than 500km, in line with most pure gasoline models. **The key to the PGM use in these vehicles is that the almost totality of hybrids have a gasoline-fueled engine inside, which our research shows to be within the 1.2-3 litre range across the offered models. These are exactly the same internal combustion engines used in non-electric vehicles, and will therefore have similar PGM loadings to what we have observed in the past 45 years of automotive history**. **For this reason, we see no potentially meaningful changes in PGM use for the coming 4 to 5 years**. Beyond this threshold, we expect to start seeing material changes in the habit of consumers as the infrastructure expands and becomes more reliable, as vehicle prices decrease and as technology improves.

What the future will look like – We can already appreciate such changes at a very local level, namely in California, Norway, Beijing and Shanghai. In these areas, the major push towards a more widespread consumer adoption is currently happening through strong governmental intervention (i.e. incentives, licensing and parking perks to EV users). As it usually happens, large cities lead the change, since they represent a sort of controlled playground for regulators. California initiated this virtuous trend with purchase incentives to consumers buying EVs, lower parking fees, government-led establishment of filling stations in the territory and Zero Emissions Vehicles (ZEVs) quotas first conceived in the 90s; these quotas are imposed on OEMs, meaning they need to sell a mandatory percentage of electric cars if they want to keep selling internal combustion engine vehicles in the State, below which a fine is issued on the manufacturer. Quotas have created a situation whereby some OEMs are willing to incur a loss in EVs to avoid the fine and access the market, as stated by Sergio Marchionne in 2014 (he declared FCA was selling the 500e model at a US$14,000 loss just to comply with regulations).

California's regulations set in 2012 required that 2.7% of new cars sold in the state had to be ZEVs; these are defined as plug-in hybrids, pure electric and fuel-cell vehicles. In 2015 the quota was 14%, while it will rise every year starting in 2018 to reach 22% in 2025. Such quotas have effectively pushed OEMs to manufacture and sell more ZEVs even at a loss instead of facing fines and closure of the Californian market; incidentally, technologic advancement might happen more in the fuel cell segment than in the rest since the quotas can be met with a smaller number of such cars compared to hybrids and pure electric vehicles.

Such quotas, together with other interventions the Californian government has been applying for some 20 years now, have attracted the attention of China which since 2014 is running pilot tests in Beijing, Shanghai and other 5 major cities. The Chinese market presents some of the best characteristics to introduce EVs to the masses; the country has an immense population which is vastly under-penetrated in terms of vehicles per capita, has a high GDP per capita growth rate, has an enormous number of first-time car owners which do not have high expectations on range as Western consumers do and are more open to new technologies than the mature Western consumers. On top of these already very favourable conditions, the government grants purchase incentives of about 25% for EVs, the car license is automatically assigned for free – as opposed to undergoing a lottery and paying US$10,000 for an internal combustion engine vehicle – and access to all areas at all times is granted while any other vehicle is restricted to certain days (alternate plate numbers). What is the result? EV sales quadrupled in China from 2014 to 2015.

Beyond the investment horizon here discussed, and in the case where the automotive industry will eventually see a phase-out of the internal combustion engine, it is not clear today whether the end solution will be battery-led vehicles or fuel cell cars. Toyota and other manufacturers are in fact working on the improvement of the fuel cell vehicle, which is powered through the energy-producing reaction between hydrogen and oxygen, whereby PGMs (especially platinum and ruthenium) are used as a catalytic surface upon which the reaction happens. Fuel cells are becoming increasingly commercialized in stationary power generation and niche vehicles such as forklifts, as well as for light-duty vehicles in the long-term. The introduction to the passenger vehicle mass market depends on the cost reduction achievable on building materials, as the packaging of liquid hydrogen is still an expensive process and **the PGM quantity used in the car is 4 to 5 times higher than in internal combustion engines**. However, technical advancements seem to point in the right direction, as the quantity of PGM from the technology inception until today has reduced by 80% and will likely mirror the current loadings in conventional vehicles in the long-term. This evolution could present again in the future the current unbalances found in PGMs use in the automotive industry, as the fuel cell technology increases its impact on the mass markets.

The **cost of manufacturing** is another aspect to consider when appraising the feasibility of the EV mass adoption, and indeed it is the main aspect OEMs consider when embarking in such projects. Product development at OEMs' level takes on average 2 to 4 years, depending on the amount of innovation the project requires. If it is 100% new, then it will take 4 full years from design to availability on the market. We are now at a moment in the automotive industry where a large amount of resources are dedicated to innovation and improvements in the electric segment, and the situation is evolving very fast – as seen in the fuel cell PGM loading evolution. From an OEM perspective, innovation means cost of manufacturing; in other words, does it cost more to increase fuel-, cost- and emission-efficiency (the latter meaning PGM loading) in gasoline- and diesel-fueled vehicles to comply with ever more stringent regulations or to manufacture hybrid and electric vehicles? This is an incredibly difficult question to answer, since (1) there are many different OEMs that entered the electric segment at different times, (2) they have different development and production cost bases, (3) the range of vehicles offered and the economies of scale reached are widely different, and (4) production cost is the closest kept secret in the automotive industry. However, through our research we calculated the below ballpark figures for different technologies and different levels of PGM loading, as per below.

Estimate of OEM average cost by technology, in developed markets

Engine type	internal combustion	pure electric	plug-in hybrid/hybrid	fuel cell (hydrogen)
Average selling price, US$	11,000-13,000	35,000-48,000	33,000-54,000	50,000-63,000
OEM average cost, US$	10,000-12,000	40,500-46,500	30,000-49,000	42,000-47,000
OEM profit	max 1,000	Loss* - max 2,000	3,000-5,000	max 6,000
PGM need	yes	no	yes	yes
PGM cost** per vehicle, US$	100-155	0	100-155	700-850
PGM loading per vehicle, grams	4-5	0	4-5	~25
PGM % of OEM cost	1%	0%	negligible	2%
PGM % of OEM profit	10-13%	0%	3%	13%

* As a consequence of sale quotas in California, Beijing and Shanghai ** Cost as of March 2016

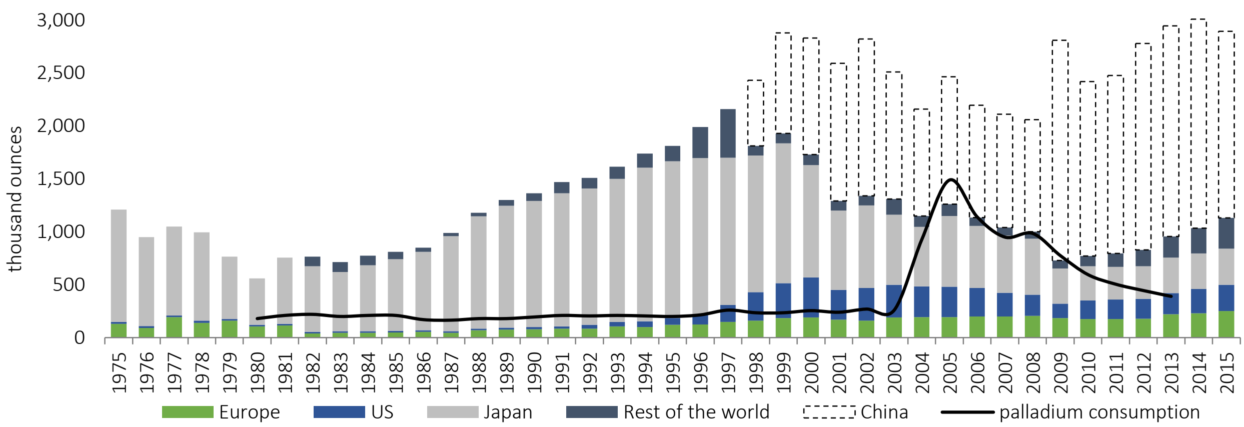
Source: Johnson Matthey, NHK, Frost & Sullivan, Fiat-Chrysler Automobiles, General Motors, Ford, Nissan, Toyota, BMW, Mercedes Benz, Audi, Porsche, Volkswagen, Tesla, Index & Cie research

These numbers should be looked at only as a reference and without the impression they represent the exact reality. However, we are sure of the fact that the first element consumer will consider when choosing between a traditional car or an EV will be price; the table shows the average difference there still exists among the various categories, which are in other terms the reflection of higher costs at manufacturers' level; the latest news of Tesla selling its Model E for a base price of US$35,000 not only falls into the price range stated for pure electric, but it also does not bode well for what we think is a quick mass adoption of EVs.

b. Jewelry: a platinum story

Platinum has a reasonably long history of use in traditional jewelry and watch making and it has received more recognition by consumers than palladium, which in turn represents less than 20% the quantity of platinum used in jewelry. Platinum is currently used in higher-end products, such as top-of-the-range watches and exclusive edition rings and necklaces. High-volume jewelry makers like Louis Vuitton are scarcely using palladium, usually confined to coating of steel-based accessories for men.

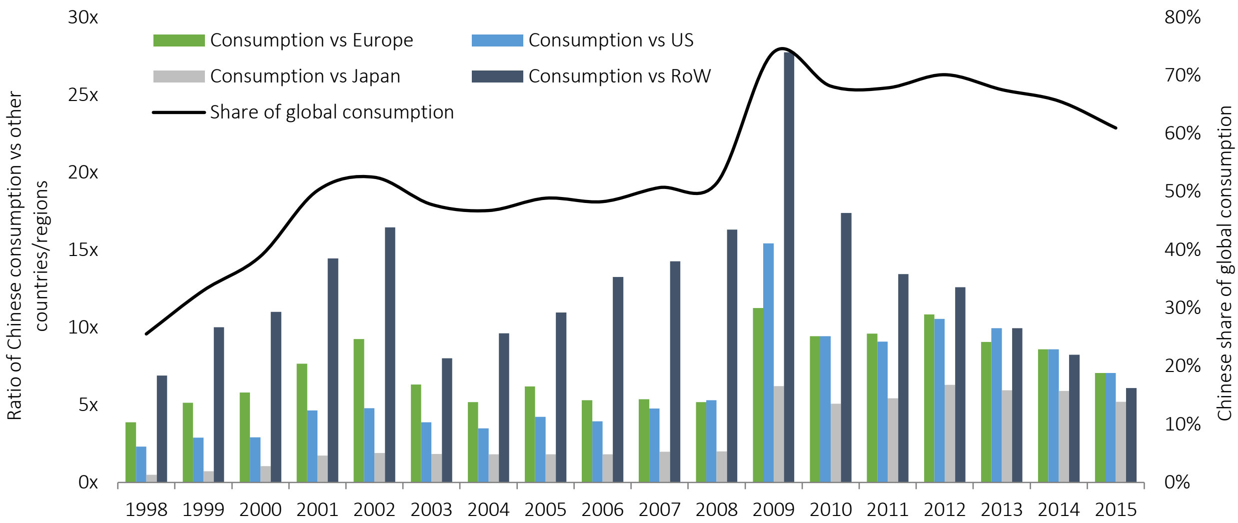
Jewelry: global platinum and palladium consumption by country



Source: WPIC

Once again, if compared with its peers, China is definitely the largest consumer of platinum since 2001; it has overtaken and surpassed Japan in absolute terms in 2001. Notably, after about 20 years of predominance in luxury consumption, Japan has been gradually reducing its consumption to the lowest levels ever since 1975. In relative terms, China has been quickly gaining ground against its peers to account for ~60% of total platinum luxury demand in 2015.

Chinese platinum consumption compared to peers



Source: WPIC, Index & Cie research

However, the Chinese global share of demand has been reducing mildly since 2009, and in 2012 the anti-corruption campaign by President Xi Jinping furthered the decline; as of 2015 China is still on a rather stable term versus Europe, the US and Japan, while it reduced by more than half of the rest of the world share due to the 20%+ yearly increase in the Indian market since 2009.

In Eastern Asia, we have been closely monitoring the evolution of major regional luxury companies, which mostly operate from Hong Kong. The likes of Chow Tai Fook, Luk Fook and Chow Sang Sang seem to have rather successfully dominated for some years now a trend in affordable luxury that appears to substitute the sudden disappearance of high volumes generated by the heavy gifting of Chinese government and army officials. The Chinese anti-graft campaign had the effect to kill a large chunk of demand for both Western and Asian jewelers in 2012-2013, but we believe the revenue loss at the companies' level, while still sizable and sorely felt, was limited to top-of-the-range products. While we haven't put a number to it, we feel future growth in Asian demand for jewelry might come from the rise of the middle class, which usually buys lower priced items, rather than from the ultra-high net worth people. And platinum will have a part in this organic growth in expenditure by the largest middle income class there exists in the world. This is true for global Western brands as well as for regional names, focused on Southeast Asian markets.

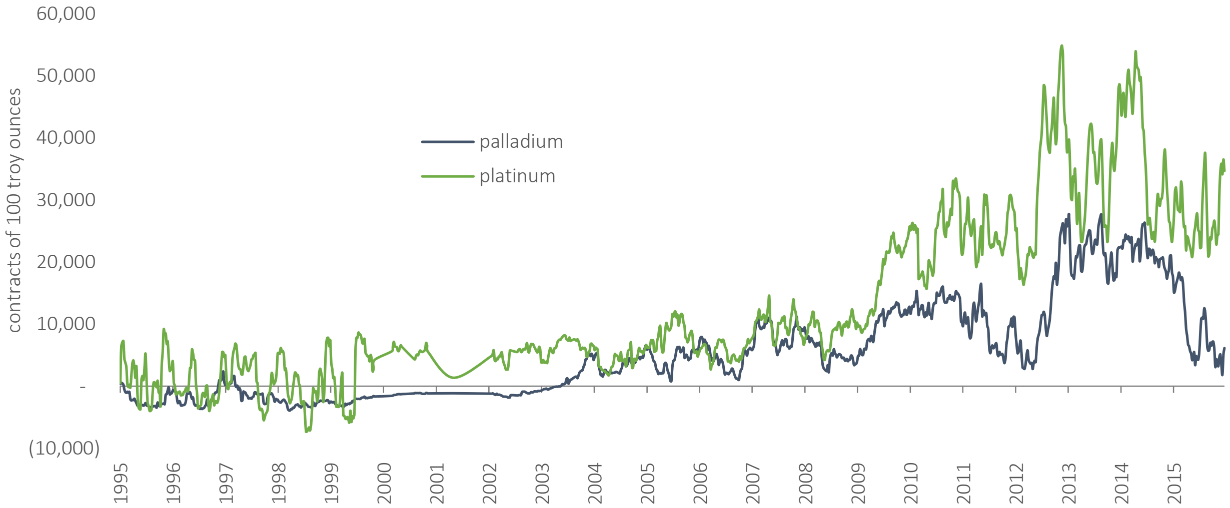
We see the 2008 global crisis and the 2012 anti-corruption campaign as serious tests to the global luxury consumption of platinum, which in a way are instrumental to understand the elasticity of demand for this metal during tough times. We observe the 2008 global crisis indeed had a big negative impact in global platinum consumption, which was expected since luxury is one of the most exposed industries to economic cycles; at the same time, Chinese consumption increased by 2% in 2013 and only saw a limited reduction of about 11% of consumption in 2015, which is three years in to the anti-corruption campaign. Such past experience provides some reasonable comfort to us to think that platinum demand could be more resilient to future major shocks than expected by the markets.

c. Investment: an increasingly relevant source of demand

Another interesting evolution in the PGM market is found in the increased trading volumes at some of the largest commodity futures exchanges; in particular, the New York Mercantile Exchange (NYMEX) accounts for the majority of palladium trading volume and has seen increased levels of activity over the past five years. The exchange reports the commitments of traders (COT) every week, essentially a count of the number of long and short contracts of 20 or more traders above specific limits set by the Commodity Futures Trading Commission (CFTC). Operators in the market are divided into commercials, non-commercials and small speculators; commercials are usually producers, refiners, merchants, processors and users of the physical metals, while non-commercials are typically money managers such as ETF or other pooled capital managers which are only using the futures for financial investment reasons.

The graph below shows how long and short positions of non-commercial, speculative traders have netted out over time for both metals; it seems activity gradually picked up from 2008 and took an upward direction until today. Positions on palladium are close to zero, meaning that speculative traders have a neutral view on palladium, while longs on platinum are substantially higher than shorts.

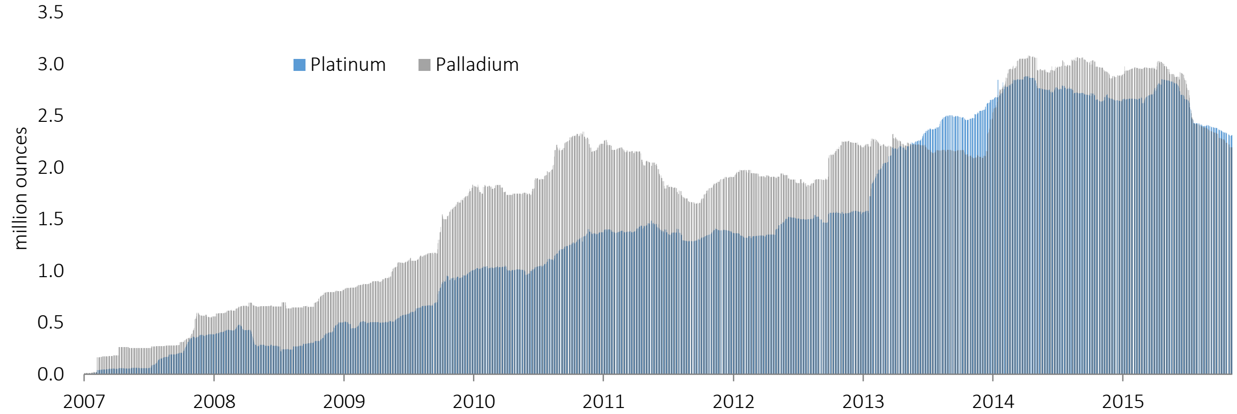
What traders are doing: NYMEX net non-commercial futures positions



Source: New York Mercantile Exchange

What does this mean? This metric is a sum of market views by participants, therefore we can deduce that views on palladium are generally pessimistic and seem to have bottom out exactly at the beginning of 2016 – there is an almost equal amount of long and short contracts. We see the graph above as a thermometer for increased participation of investment-driven players, as the combined holdings of all known ETFs displayed below also seem to suggest. The sudden decline in mid 2015 could be attributed to the Volkswagen scandal, which the Street thinks will have a great and negative impact on PGMs used in diesel engines.

Combined holdings of known ETFs



Source: Bloomberg, New York Mercantile Exchange

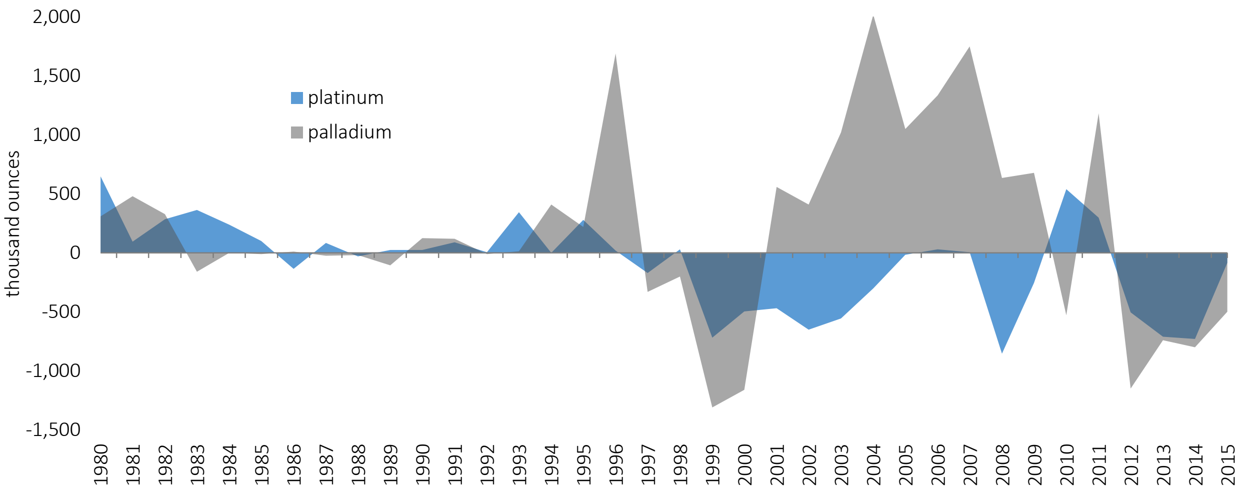
The interest on PGMs since 2007 has given rise to an array of physically-backed ETFs that provide investors with exposure on these metals. These instruments were introduced in Europe in 2007 and in South Africa in 2013, which effectively meant a growing amount of demand in terms of ounces has been generated through this non-fundamental demand driver in the future – which has ranged from 2% to 11% of total demand in the past ten years. While it is hard to gauge the overall effect of investments on the total demand for PGMs – let us remember that shorts could be higher than longs, which means investments could also increase supply – we expect markets to become increasingly volatile as more players participate with their different investment objectives, views and holding periods.

III. Forecasts on fundamentals

Higher-than-expected palladium demand from the Chinese automotive industry

Putting supply and demand together for both platinum and palladium reveals that both metals are considerably undersupplied since 2012.

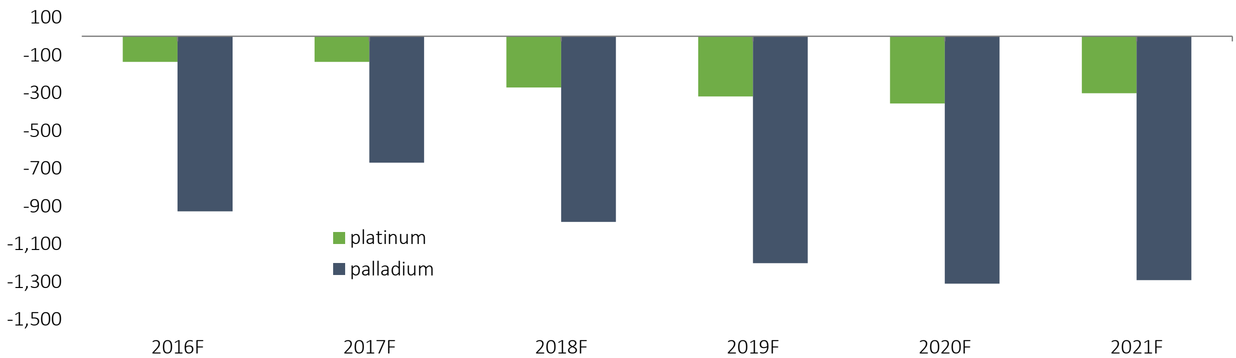
35 years of history of balance in platinum and palladium



Source: WPIC, March 2016

What is more interesting is that one of the major authorities in these matters, the World Platinum Investment Council (WPIC) set up in 2014, has commissioned a precious metal specialist, Dr. David Jollie at Glaux Metal, to forecast the future supply-demand balance for platinum. We started from these consensus figures to derive forecasts for palladium, which is not provided by the mentioned authorities. As previously shown, there are rather stable ratios between the two metals at both the supply and demand levels by country, even though the ones from the demand side are more volatile that the supply side ones (especially in jewelry demand). The results are shown below.

Under-supply ahead: WPIC-derived balance forecasts for platinum and palladium



Source: WPIC, Index & Cie research

Our **forecasts for platinum** are broadly in line with those of the WPIC. They basically take into account the fact that diesel annual production and sales in Europe and Japan, which together account for ~61% of total automotive demand in diesel, will start gradually declining both in absolute and relative value. We projected a 0.3% annual increase in Europe and a 2.2% annual decline in Japan in platinum consumption, until 2021. The under-supply situation is therefore confirmed on our side.

From a **palladium perspective**, our view is radically different from that of WPIC. If we were to apply the historical ratios observed in the past 40 years, the under-supply in palladium would be quite deep and would amount to 10-15% of total supply by 2021. While in principle we agree there must be some kind of un-balance ahead, we decided to test it by projecting the potential Chinese automotive demand increase in the next 5 to 10 years. Before focusing on China, we kept Europe, the US and Japan growth in palladium consumption at half the growth rate exhibited in the past five years, so as to position ourselves in a conservative way. Our numbers on these stable markets came out already higher than those derived from WPIC, and by 2020 we already have an under-supply situation without even including China, which seems a bit odd.

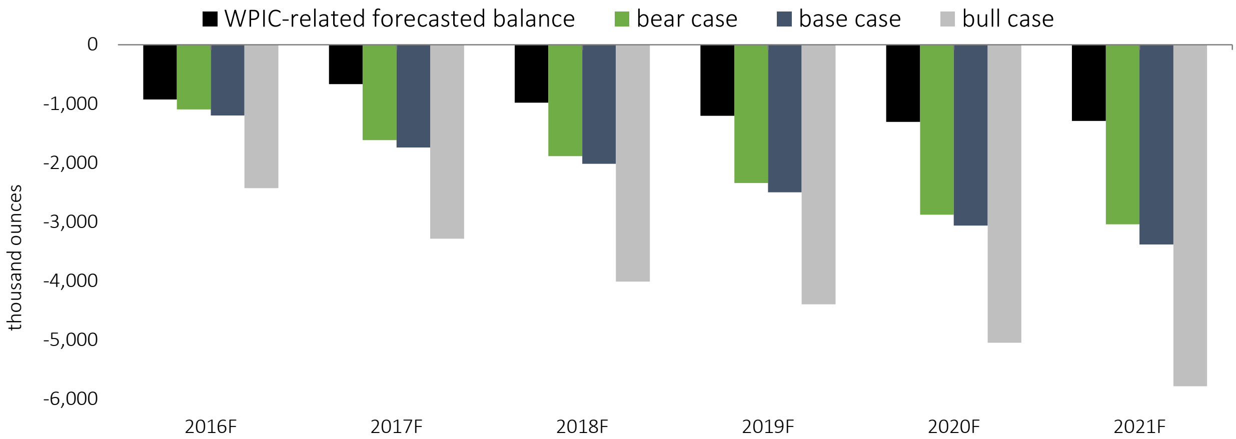
We then moved on to model China; a number of assumptions had to be made, as Table 1 and 2 in the Appendix show. We used the population forecasts from the United Nations, as well as the past growth trends in vehicle fleets of Japan, Europe and the US to simulate the Chinese fleet evolution and finally arrived to three scenarios of potential PGM and palladium demand. We believe these scenarios are very conservative in that they see the Chinese fleet grow to 141 (pessimistic case), 158 (base case) and 231 (optimistic case) vehicles every 1,000 people in 2021, which does not even reach the 300 value shown by Japan and Europe at similar GDP per capita levels – note that by 2020 the GDP per capita figures for China would also substantially improve. The base case scenario, which we think has the highest probability of happening, has the following underlying assumptions:

- the Chinese population will grow at 0.8% yearly until 2021 instead of the 0.5% posted annually in the last 10 years, which we believe is not wildly impossible since the one-child policy has been abandoned last October – these are figures published by the United Nations;
- the vehicle fleet will grow at 5.7% mimicking the European fleet growth of 1970-1980, against the average 16% China posted annually since 1995 (last readings at 26% in 2013-2014 and 12% in 2014-2015);
- palladium loadings per vehicle will behave in a similar manner to the Japanese evolution of 2000s going from 2.24 grams per vehicle to 3.72 in 2021 (1.84 gr/vh in 2014 for China), which will effectively make China account for 19% of global palladium demand for automotive purpose by then (while it accounted for 22% in 2014);
- the number of new vehicles entering the fleet will stay at around 20 million pieces until 2021, which is a conservative figure if compared with the growing trend in annual vehicle production of 19, 22, 24 and 24.5 million cars in 2012, 2013, 2014 and 2015 respectively. In other words, we left a lot of space for electric vehicles growth, as the difference between the threshold of ~20 and whatever is higher than that is basically considered to be a pure electric vehicle. However, we believe these are very optimistic figures for the EV market, as do managers at Nissan and other manufacturers we spoke with;
- the vehicle density will eventually reach 158 per 1,000 people by 2021, which is still about 33% below those of its peers at similar GDP per capita levels in 2015 and massively below the observed growth of this metric for Europe, the US and Japan. Note that by 2021 the Chinese

GDP per capita will most probably be higher than today's, which means that the peer comparison will still see the Chinese ratio well below all others'.

The graph below shows that under the base case scenario discussed the supply deficit would be twice as big as that extrapolated from WPIC forecasts from 2017 onwards, suggesting that there is a chance authorities and probably commodity market participants might be underestimating the disruptive potential of Chinese automotive demand in the PGM market.

The Chinese automotive effect on palladium: a potentially much larger deficit than forecasted



Source: WPIC, Index & Cie research

Finally, we projected the EV market growth in China to develop from 1.6% of annual sales in 2015 to 6.3% in 2020, corresponding to 1.5 million vehicles sold in 2020 (5 million since 2015). If we had to quantify the impact of such EV market growth on the Chinese demand for palladium in the coming 5 years, we believe it would look like this:

EV market growth impact on Chinese palladium demand

thousand ounces	2015	2016	2017	2018	2019	2020
Original Chinese demand scenarios:						
- bear case	1,037	979	1,193	1,115	1,232	1,306
- base case	1,115	1,083	1,316	1,248	1,389	1,486
- bull case	2,472	2,309	2,863	3,242	3,285	3,471
EV-revised scenarios:						
- bear case	1,019	947	1,148	1,060	1,163	1,206
difference in thousand ounces	*-18*	*-32*	*-44*	*-55*	*-69*	*-100*
- base case	1,097	1,052	1,271	1,193	1,320	1,386
difference in thousand ounces	*-18*	*-32*	*-44*	*-55*	*-69*	*-100*
- bull case	2,431	2,242	2,766	3,100	3,121	3,238
difference in thousand ounces	*-40*	*-67*	*-97*	*-142*	*-163*	*-234*

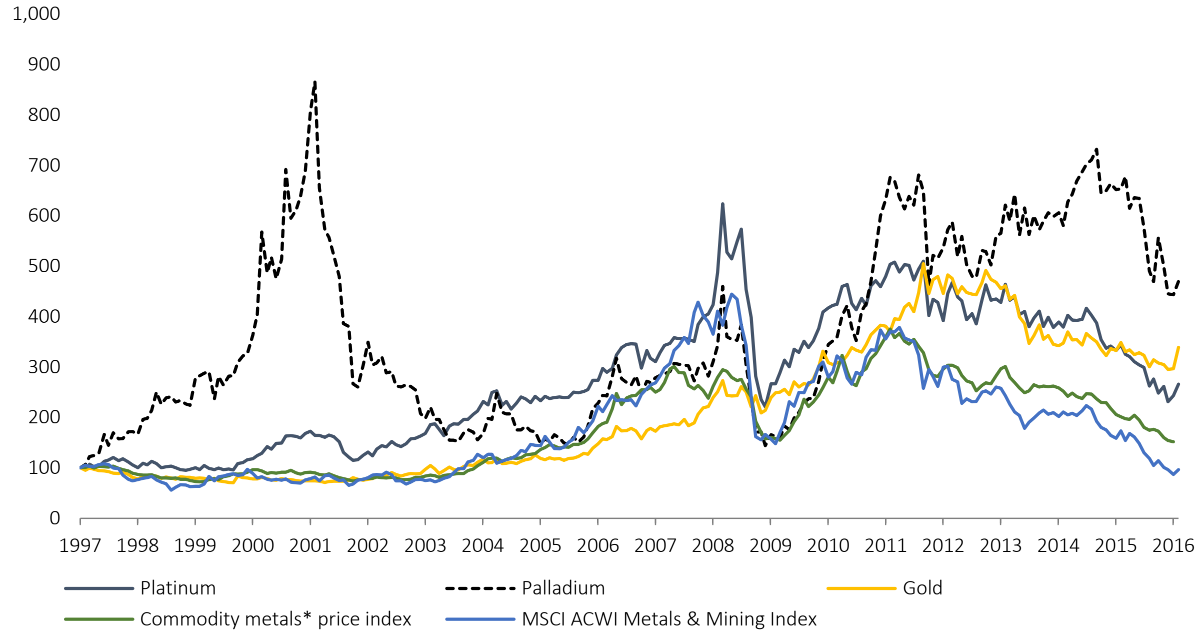
Source: EDTA, EEA, ACEA, Index & Cie research

IV. Market valuation

A sensible entry point

Platinum has behaved in line with the valuation of industrial metals in the past 20 years, which can be explained partly by the commodities growth cycle fueled by China (in majority driven by automotive and jewelry applications for PGMs), and by the amplification the hedge fund industry provided prior to the 2008 credit crunch. We believe this latter event was a U-shaped interruption of a ~12-year long (2003-2015) growth cycle in these commodities.

Platinum & palladium vs gold, commodity metals and MSCI metals & mining indices rebased at 1986

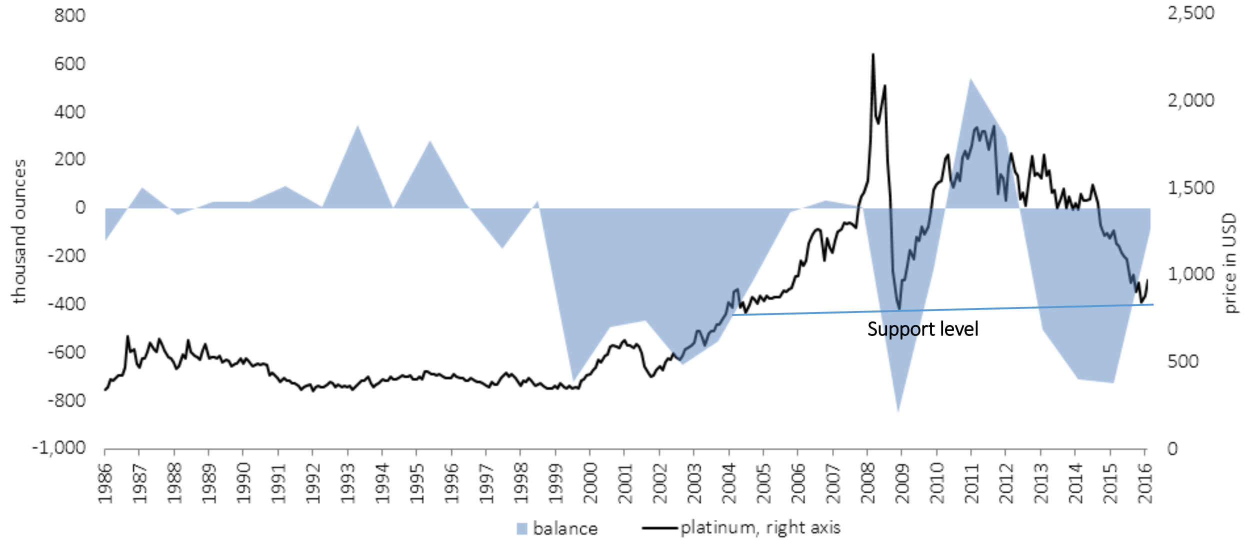


* Index consists of copper, aluminum, iron ore, tin, nickel, zinc, lead, and uranium price indices – rebased at January 1997
Source: IMF, Chicago Mercantile Exchange, Bloomberg, Index & Cie research

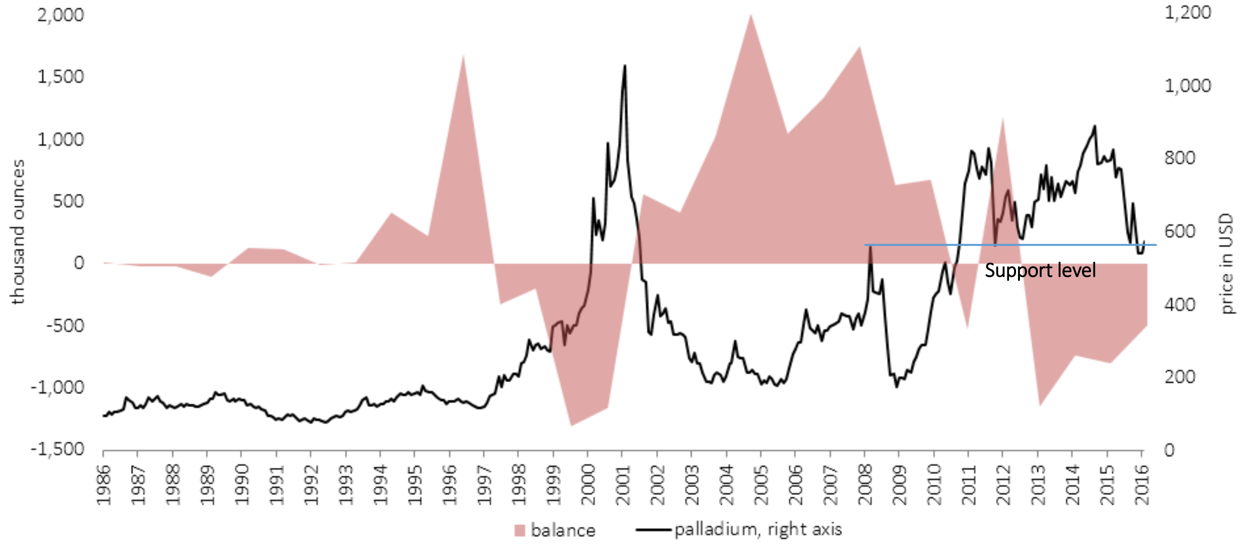
Palladium has instead followed a path on its own, only partially correlated to the general metals' trend. The two graphs below show the metals' prices against their respective fundamental balance for the past 30 years; both metals responded quite consistently with their underlying fundamentals, valued poorly in times of over-supply and adjusting upward when the market perceived an under-supply period would ensue. This is true until 2012 for platinum and 2014 for palladium, when prices started behaving in an opposite manner to their fundamental under-supply situations. Among various reasons for such de-correlation, the Street has been certain to attribute price weakness in the past 18 months to the investment side of demand becoming overly long, the depreciation of the Russian ruble and South African rand more than compensating miners' losses from the fall in US$-denominated futures prices and finally to sales of above-ground stocks to cover supply shortfalls.

30 years of price and balance

Platinum



Palladium

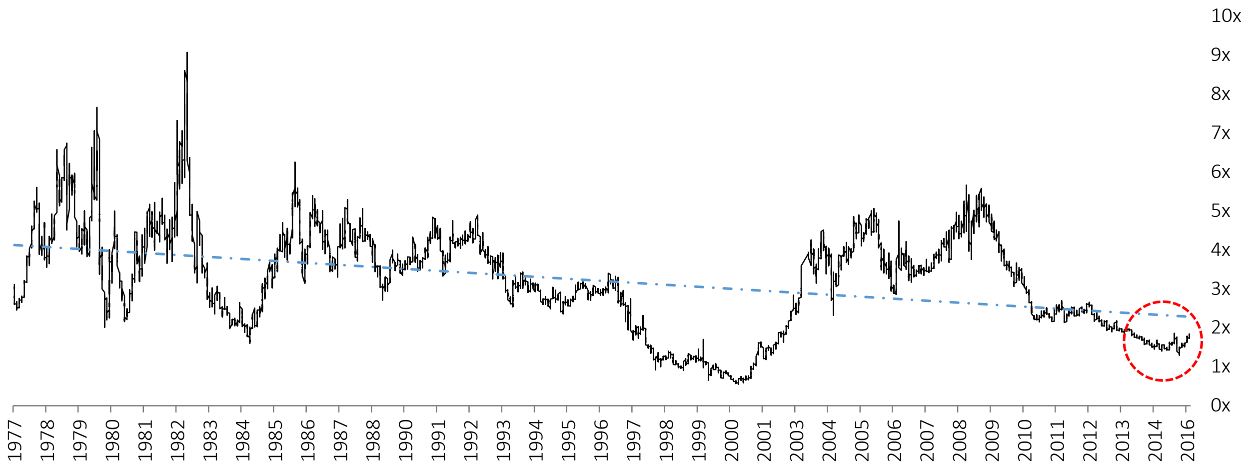


Source: WPIC, Chicago Mercantile Exchange, Index & Cie research

While we might agree with some of these motivations for a short-term interpretation of events, we think the only real long-term wildcard for PGM prices is above-ground stock for both metals, as discussed in the Supply Side part. We also feel the price weakness of the last 2 to 4 years is destined to revert sometime this year as the market realizes the underlying strong, long-term trends in the automotive consumption in China, and that the country will probably not crash economically or devalue its currency in an abrupt manner; the catalyst for this market realization could be annual vehicle manufacturing production in China for 2016, where we expect the number to be in line with the over 20m pieces trend started in 2012. In addition, our basic technical analysis seems to suggest a support level in both metals might have been reached, whereby the platinum one is comparatively stronger than that of palladium; in particular, the 2008 range of US$750-800/ounce of platinum reached again the past January could signal a psychologically relevant support has been touched, since we see the 2008 low as an undershooting dictated by fund managers unwinding their over-optimistic long positions.

From the current level, we see potential for the platinum to reach US$1,280-1,300 within the next two to three years, as the price shows a strong retracement tendency around the 50% Fibonacci band in the past ten years. This would correspond to a 36% overall upside potential, i.e. ~12% per annum for the next three years at current prices. Our view on palladium is not as clear, since the metal did maintain a lot of value in a downturn cycle for industrial metals. It is perhaps of interest to consider that there has been a mean-reverting long-term ratio between the two metals, as show in the graph below.

Price ratio of platinum/palladium

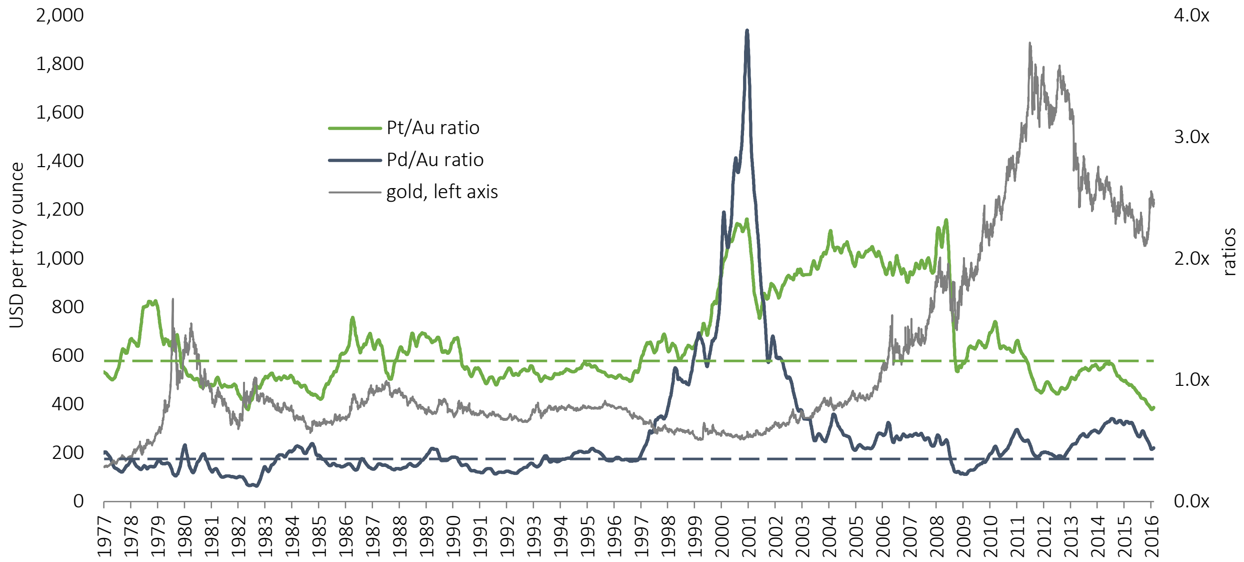


Source: Chicago Mercantile Exchange, Index & Cie research

The relationship has not been stable and might suggest that from a market price perspective the two metals are increasingly perceived as quasi-substitutes; this impression could be explained through the evolution of the two metals in catalytic converters and their current combined use – as the two metals are approaching the 1:1 ratio in the diesel oxidation application, so do their respective prices in 2000-2001. However technically imprecise and approximate this consideration might be since the two metals have each their own strengths and weaknesses, chances are that the market is mainly sensitive to headlines on the automotive demand component.

The market might also consider the two metals' price **paths relative to gold** in the past 40 years, as depicted in the graph immediately below. In particular, it seems feasible to trace a long-term average of a certain graphic significance, but hardly statistical given the high valuation for both metals during 1998-2008. We believe these ratios are the result of how much precious metal status the market assigns to PGMs, which is evidently a more relevant feature to platinum than to palladium.

PGM ratios with gold, US$ denominated continuous #1 contracts



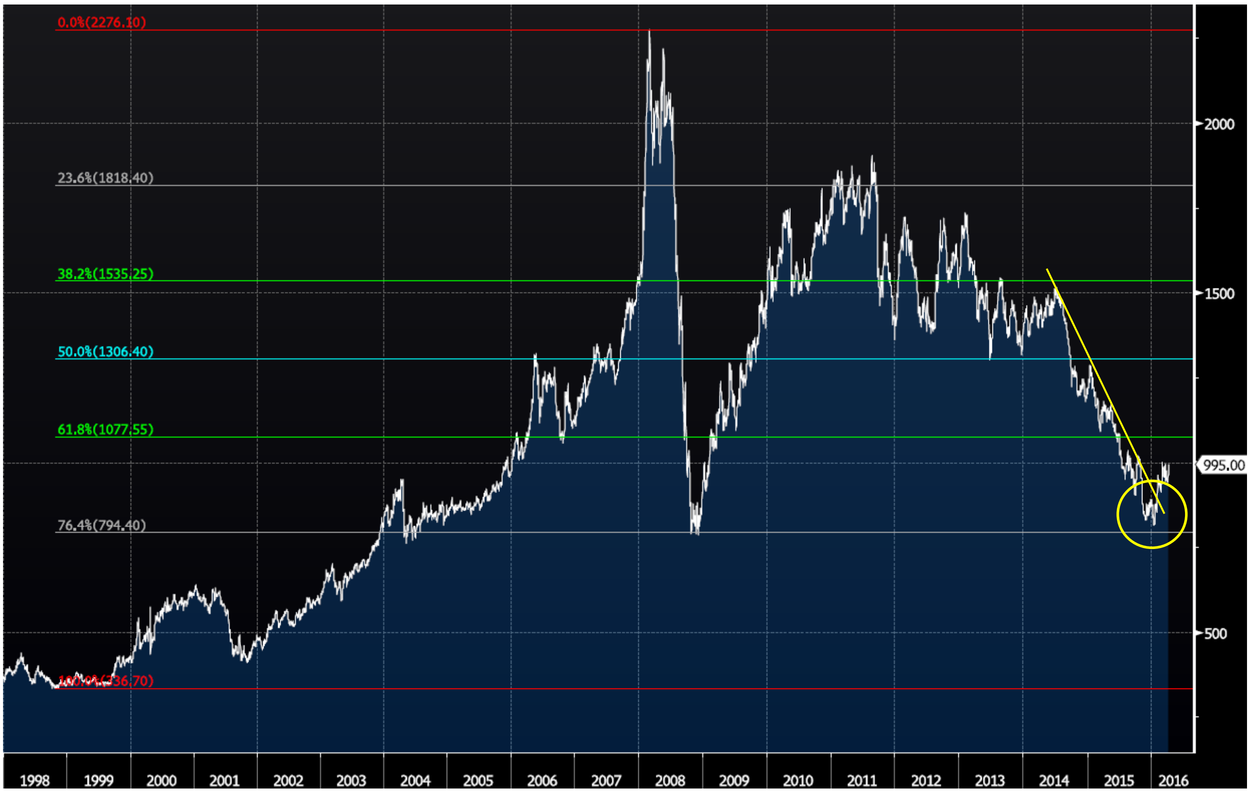
Source: London Metal Exchange, Chicago Mercantile Exchange

While we do not ascribe a high forecasting power to these ratios, there is a chance many market participants might see a current under-valuation of platinum and a mean-reverting price for palladium, both relative to the price of gold. This view could provide further support to our belief that platinum has been over-sold for quite some time now and it might be positioned well for a future appreciation around the average ratio with gold. The story around palladium is less clear cut, since this metal has better maintained value over the past 5 years.

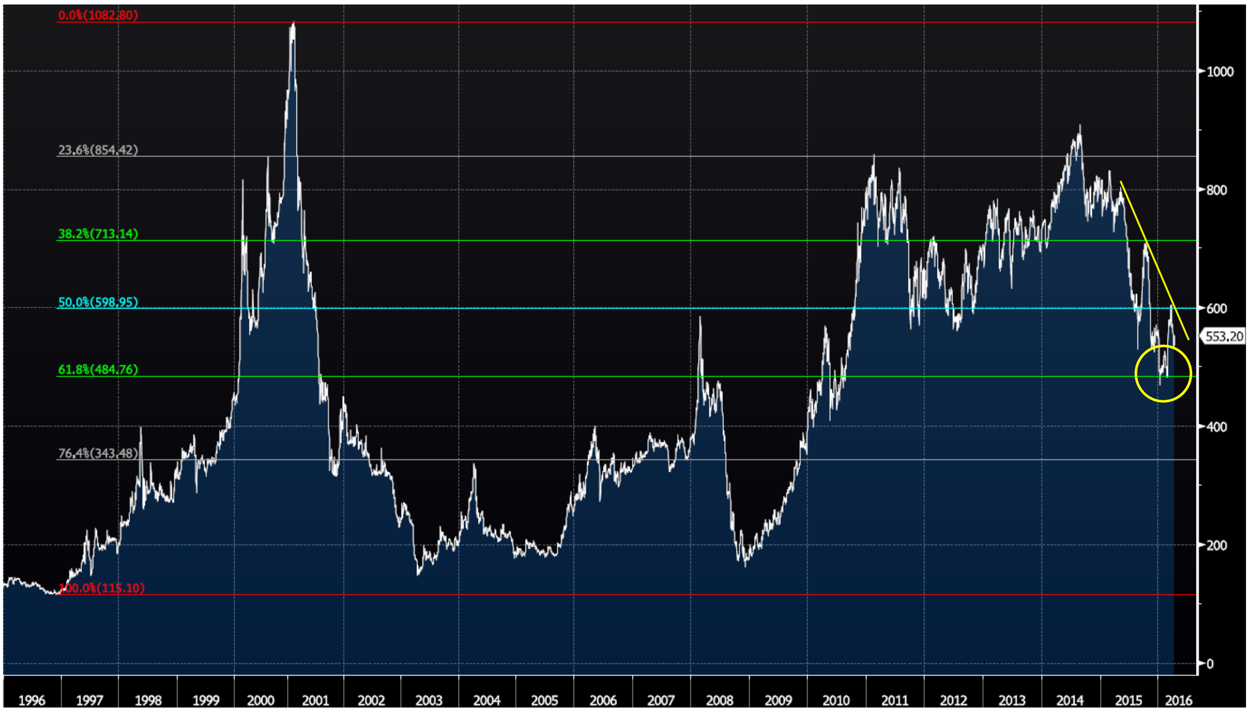
From a technical analysis perspective, we believe the **Fibonacci retracement levels** provide an interesting view of where and how the US$-denominated futures traded on the NYMEX. These levels are taken from an integer numerical series first described by Italian mathematician Fibonacci, where the next number is the sum of the previous two in a spiral-like fashion (1, 1, 2, 3, 5, 8, 13, and so on). These levels are usually tested multiple times by prices as supports or resistances over a long period of time, and can give an idea of future important levels. As shown in the following two graphs, **platinum**'s price has shown particular resilience to go below the 50% retracement in June and December 2013, and once tested for the third time it went straight down to 62% in 6 months and to 76% in 18 months. As mentioned before, the 76% retracement is psychologically important (see the yellow circle) and seems to signal a bottom of a 4-year long price decline as it also broke a downward trend (see yellow line). From here, we see platinum's price reaching US$1,280-1,300 within the next 24-36 months, with further room to US$1,500 once the 50% level is reached. **Palladium** has instead moved below the 50% level in December 2015 and since then has tested the 62% level (see the yellow circle); the price has markedly bounced back again to 50% and now seems to fall within this channel. However, unlike platinum's futures, palladium's price has not yet broken what seems to be a downward trend (see yellow line), so we expect the price to dwindle for a while within this channel before showing a stronger trend. This will happen as the Chinese automotive demand will show its real effects on the PGM markets, which could be some time this year.

Fibonacci retracements

Platinum US$ generic futures, since 1998 and including a bubble in 2007-2008



Palladium US$ generic futures, since 1996 and including a bubble in 2000-2001



Source: NYMEX, Bloomberg

V. Alternative exposure through related stocks

Investment exposure on PGMs might also be achieved mainly through PGM miners. Our present research also sheds some light on other interesting investment avenues, such as battery manufacturers and the entire lithium chain.

PGM miners – The aforementioned time lag between capital expenditure, production and earnings make investing now probably premature. Once prices start showing some support and begin to trickle down to miners' bottom line, then we would expect to see some mild improvement in earnings in the coming 4 to 5 years.
One name that calls our eye is Lonmin Plc, listed in the London Stock Exchange (in GBp): this South African miner has renegotiated its debt with creditors, cut around 80% of its workforce, closed money-losing mines and focused on the higher-yielding/lower-cost mines that can bring the company back into positive territory in the quickest time possible. This is a typical special situation in which a restructuring of some kind has happened in preparation for a new growth cycle in the underlying industry.
Other South African or Russian miners are either listed in local currencies such as South African Rand or Russian Ruble or mine PGMs as a by-product of nickel and other base metals; investing in these names entails (1) understanding industries different from that of PGMs and (2) being aware of the fact that these currencies can have a very substantial effect on investment returns even in case of a correct evaluation. For instance, the South African Rand has been depreciating against the US Dollar since 1977, thus creating the economic advantage for the miner but hardly the financial one for investor based in USD.

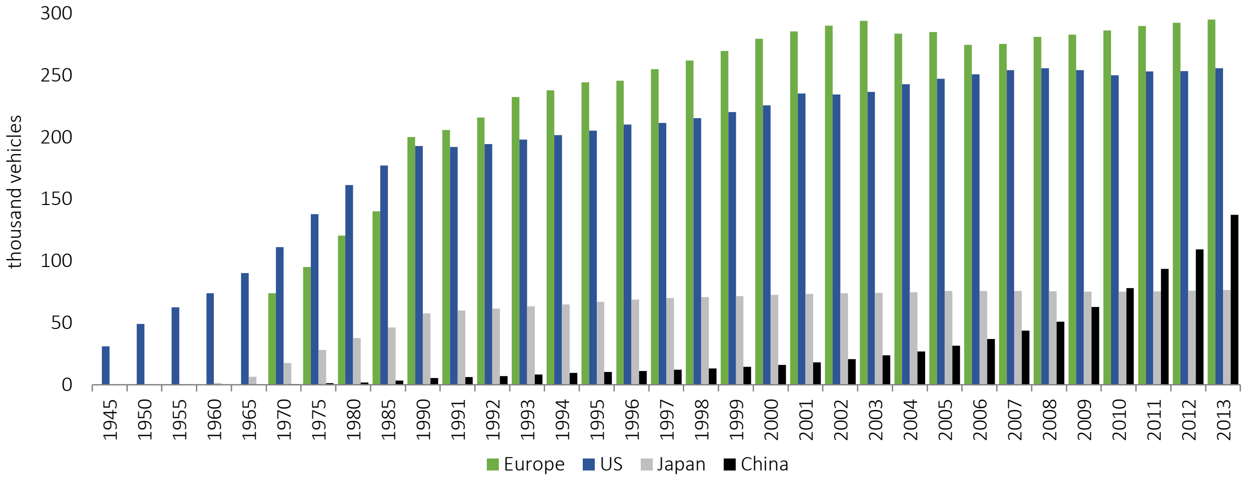
Battery manufacturers – This is indeed a space in which we are currently developing a view, since the battery industry is at the heart of the electric vehicle market globally. A name we like is Samsung SDI with its large market share and strong ties with Tesla (more for the headline effect than for its market reach through this commercial partner, since Tesla is a niche manufacturer of EVs). However, as mentioned the EV market is still in its infancy and many new entrants could disrupt the current (absence of) balance, while bankruptcies, spin-offs and M&A activity of existing players are likely to occur as the industry takes shape in the coming 5 years.

Lithium chain – We have developed an interest for the Global X Lithium ETF, which trackes the Solactive Index which in turn is an equity basket of companies involved in lithium exploration and mining, battery production and battery use as auto part.

VI. Appendix

Chart 1

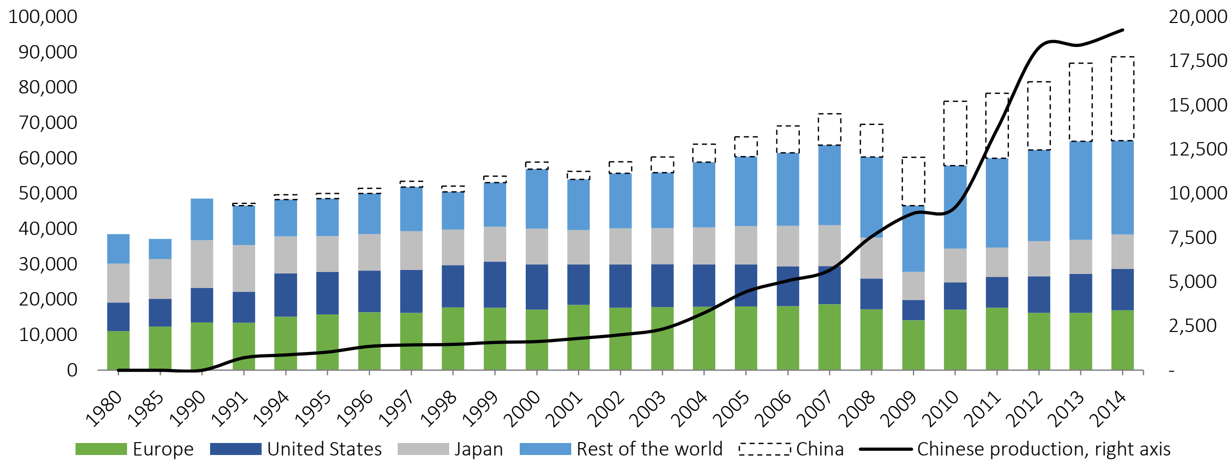
70 years of motor vehicle fleet evolution



Source: OICA, ACEA, RITA, JAMA, World Bank, Index & Cie research

Chart 2

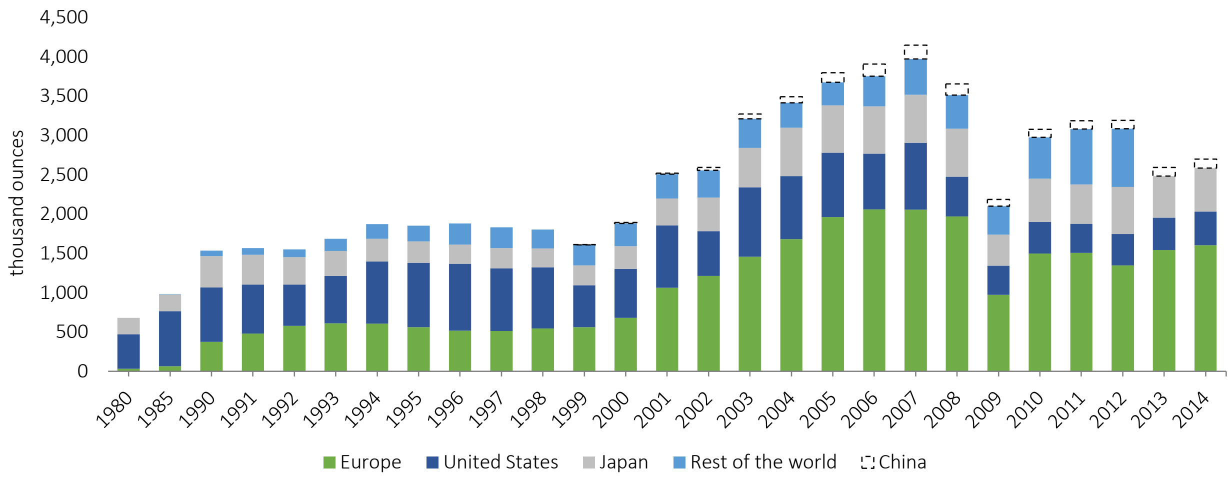
Global production, million vehicles



Source: OICA, ACEA, RITA, JAMA, Index & Cie research

Chart 3

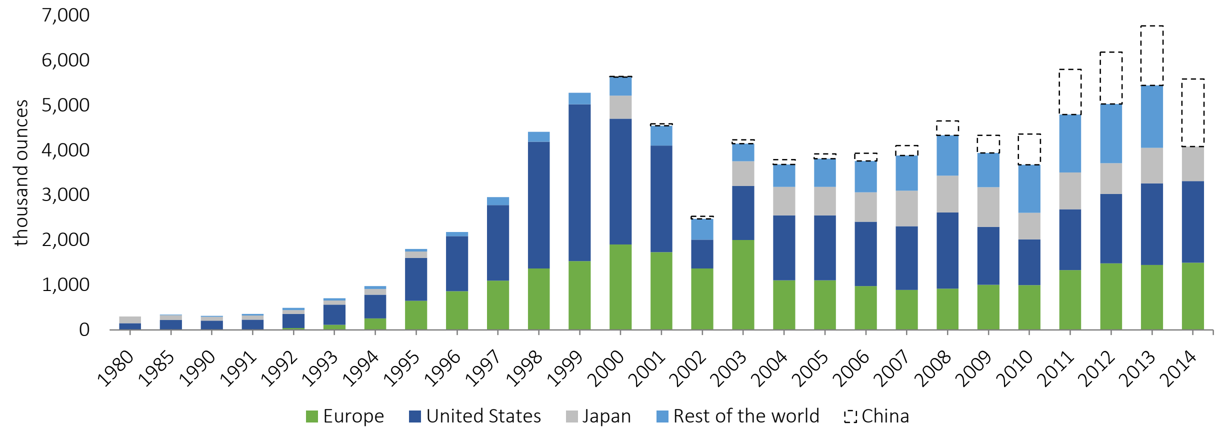
Platinum consumption, by country/region



Source: WPIC, Index & Cie research

Chart 4

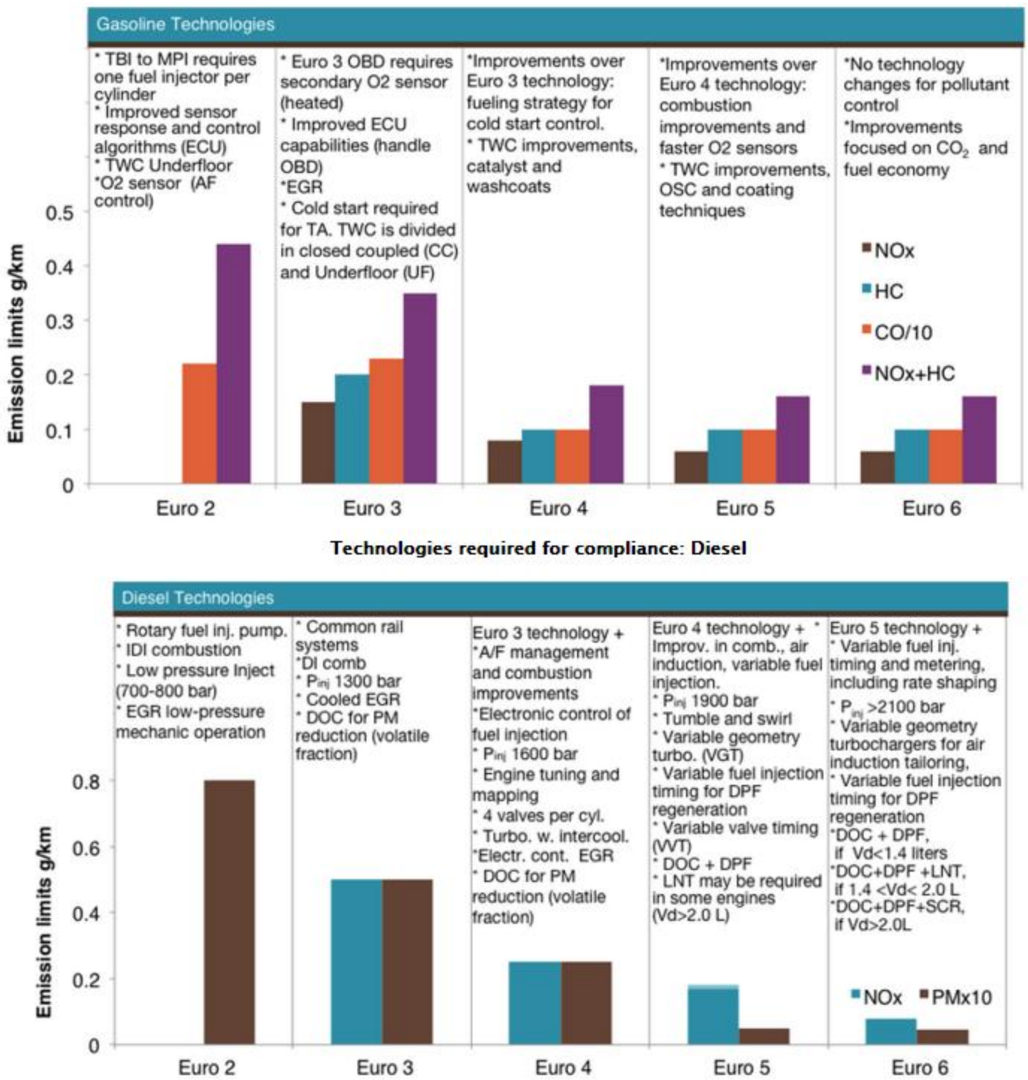
Palladium consumption, by country/region



Source: WPIC, Index & Cie research

Chart 5

European emission standards, gasoline and diesel



Source: European Commission Directives and Regulations

Table 1

Forecasting variables on Chinese automotive industry

		2015F	2016F	2017F	2018F	2019F	2020F	2021F
A. Population growth scenarios (UN stats), m								
1	Low variant 2020, No change 2025	1,370	1,376	1,382	1,388	1,394	1,399	1,404
	YoY growth	*0.4%*	*0.4%*	*0.4%*	*0.4%*	*0.4%*	*0.4%*	*0.4%*
2	Medium variant	1,376	1,387	1,399	1,411	1,422	1,433	1,436
	YoY growth	*0.8%*	*0.8%*	*0.8%*	*0.8%*	*0.8%*	*0.8%*	*0.2%*
3	Instant replacement (highest value)	1,385	1,406	1,427	1,449	1,471	1,489	1,495
	YoY growth	*1.5%*	*1.5%*	*1.5%*	*1.5%*	*1.5%*	*1.5%*	*0.4%*
B. Fleet growth scenarios, m								
1	1970-1980 Japanese growth	172	193	216	242	271	303	324
	YoY growth	*12%*	*12%*	*12%*	*12%*	*12%*	*12%*	*7.0%*
2	1970-1980 European growth	163	172	182	192	203	215	227
	YoY growth	*5.7%*	*5.7%*	*5.7%*	*5.7%*	*5.7%*	*5.7%*	*5.4%*
3	1970-1980 US growth	161	169	177	186	195	204	211
	YoY growth	*4.8%*	*4.8%*	*4.8%*	*4.8%*	*4.8%*	*4.8%*	*3.4%*
C. PGM loading scenarios								
1	Mirroring of Japanese 2000s	2.24	2.24	2.24	2.56	3.13	3.17	3.16
2	Mirroring of European 2000s	3.37	3.74	4.01	4.54	4.58	4.71	4.86
3	Mirroring of US 2000s	7.66	8.18	6.76	5.79	5.22	4.60	5.24
D. Palladium loading scenarios								
1	Mirroring Japanese 2000s	1.54	1.54	1.54	1.59	1.75	1.77	1.77
2	Mirroring European 2000s	3.44	3.82	3.92	4.47	4.21	4.24	4.50
3	Mirroring US 2000s	5.15	6.06	6.07	5.41	4.34	3.50	3.24

Source: OICA, ACEA, RITA, JAMA, United Nations statistics, World Bank statistics, WPIC, Index & Cie research

Table 2

Chinese automotive demand scenarios

	2015F	2016F	2017F	2018F	2019F	2020F	2021F
Bear case (A3, B3, C1, D1)							
Vehicles per 1,000 people	117	121	125	129	133	137	142
Vehicles added to the fleet post-scrap, m	19	15	19	18	20	20	20
PGM total demand, thousand ounces	1,333	1,249	1,613	1,654	1,961	2,179	2,276
Palladium total demand, thousand ounces	1,037	979	1,193	1,115	1,232	1,306	1,336
- % of total forecasted supply	11%	11%	13%	12%	13%	14%	14%
- % of total forecasted demand	11%	10%	12%	11%	12%	12%	12%
- % of autocatalyst forecasted demand	17%	14%	18%	16%	17%	18%	18%
Base case (A2, B2, C1, D1)							
Vehicles per 1,000 people	119	124	130	137	143	150	158
Vehicles added to the fleet post-scrap, m	20	17	21	21	22	23	26
PGM total demand, thousand ounces	1,435	1,382	1,780	1,851	2,211	2,481	2,865
Palladium total demand, thousand ounces	1,115	1,083	1,316	1,248	1,389	1,486	1,681
- % of total forecasted supply	12%	12%	14%	13%	15%	16%	17%
- % of total forecasted demand	11%	11%	13%	12%	13%	14%	15%
- % of autocatalyst forecasted demand	18%	16%	20%	18%	19%	20%	22%
Bull case (A2, B2, C2, D2)							
Vehicles per 1,000 people	119	124	130	137	143	150	158
Vehicles added to the fleet post-scrap, m	20	17	21	21	22	23	26
PGM total demand, thousand ounces	2,420	2,259	2,930	3,296	3,570	3,853	4,414
Palladium total demand, thousand ounces	2,472	2,309	2,863	3,242	3,285	3,471	4,082
- % of total forecasted supply	27%	26%	31%	35%	35%	37%	42%
- % of total forecasted demand	25%	23%	29%	31%	31%	32%	37%
- % of autocatalyst forecasted demand	39%	33%	42%	46%	44%	47%	54%
Maturity case (A1, B1, C3, D3)							
Vehicles per 1,000 people	126	141	157	175	195	217	232
Vehicles added to the fleet post-scrap, m	30	29	35	38	43	48	41
PGM total demand, thousand ounces	8,102	8,341	8,408	7,746	7,902	7,750	7,606
Palladium total demand, thousand ounces	5,450	6,175	7,555	7,232	6,569	5,896	4,699
- % of total forecasted supply	59%	69%	82%	77%	70%	62%	49%
- % of total forecasted demand	56%	62%	77%	70%	62%	55%	43%
- % of autocatalyst forecasted demand	87%	89%	112%	102%	89%	79%	62%

Source: Index & Cie research

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