S&P Global Mobility

Russia–Ukraine conflict: is palladium a potential black swan for already stretched auto supply chains?

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While alternative sourcing locations or substitute materials may exist, they won't be enough to avert production disruption should supply become constrained. In a pessimistic scenario some 7.5m units could be impacted in 2023.

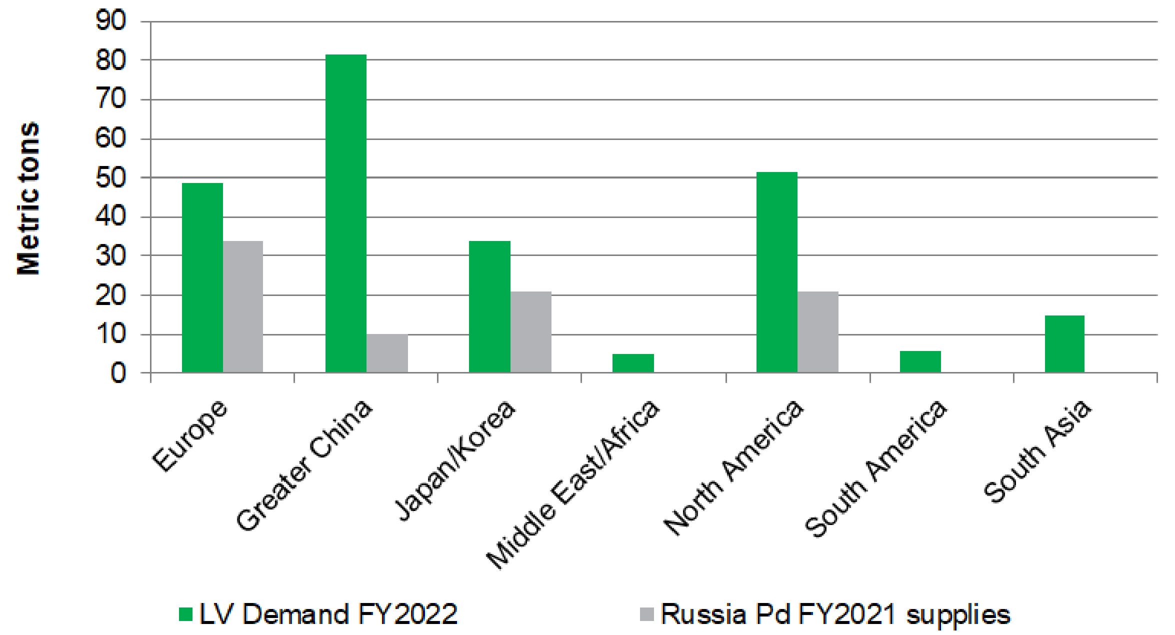
Several supply disruption concerns have been reverberating through the automotive industry since Russia's invasion of Ukraine, however few have the disruption potential of palladium, a critical raw material used in catalytic converters for emission abatement.

Palladium supplies are de facto already facing some logistical disruption since palladium is usually transported via passenger flights due to its high value and relatively low weight (only about 200 tons were produced in 2021). The closure of the airspace in most of Europe and North America to Russia-operated aircraft is forcing Russian palladium exporters to find alternative routes. Back in March 2020 when passenger flight capacity became constrained due to travel constraints, Russian exporters set-up dedicated cargo flights, however this is now also impeded by airspace closures.

To be clear, palladium exports from Russia are currently not directly sanctioned. However, the sanction environment, disruption to payment systems as well as the international business community's concerns of reputational and financial risk with doing business with Russia, are increasingly isolating Russia supply lines. Shippers, buyers, insurance providers and trade financing banks are among those reluctant to be exposed to Russia business dealings. Palladium is no exception.

This increases the risk of palladium supply disruption to the automotive industry. About 40% of the global palladium production is sourced from Moscow-headquartered Norilsk Nickel, the world's largest palladium and nickel supplier. The automotive industry absorbs some 90% of the annual palladium production.

Light vehicle Palladium demand FY2022 (in metric tons)



Source: IHS Markit

Palladium is not the only concern for critical raw materials and inputs impacted by Russia's invasion of Ukraine. Semiconductor-grade neon, which is used in lasers for microchip production and of which Ukraine accounts for half of the world's supply, has been red-flagged even though it has not yet further hampered already severely disrupted semiconductor supply lines. Aluminium production, for which Russia contributes some 6% of global production, is also under scrutiny. The tightness of supply due to US sanctions against Russia's Rusal in 2018 coupled with new potential disruptions resulted in prices doubling vs. pre-pandemic levels. Nickel is also in focus due to its usage in stainless steel production used in exhaust systems as well as battery cathode manufacturing, as we pointed out in an earlier article. Concerns for several of these raw materials may gravitate more around pricing spikes rather than material disruption to automotive business continuity like palladium.

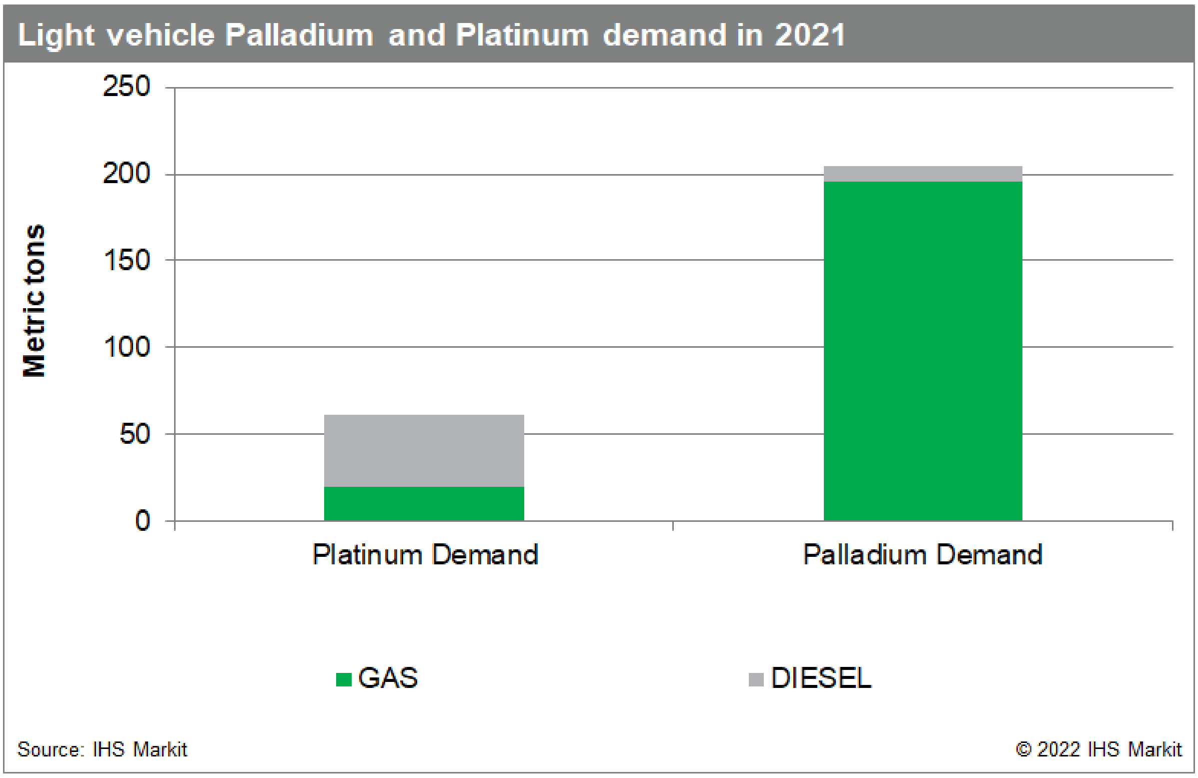
Palladium-Platinum choice affected by pricing and technological trade-offs

In order to understand palladium's market exposure, it's important to highlight the symbiotic relationship it has with other metals in the platinum group metals (PGM) category. Palladium and platinum were initially used as catalysts to convert carbon monoxide, nitrous oxides and any unburned hydrocarbons into carbon dioxide and water. A thin layer of these metals coats a honeycomb-like structure made of metal or ceramics integrated within the catalytic converter. As regulators turned their attention to NOx (nitrogen oxides) levels, rhodium was also added to the catalyst mix in order to "reduce" (remove oxygen) from NOx.

The proportions and quantities of platinum, palladium and rhodium in a catalytic converter vary based on many factors including the fuel type, the stringency of local emission standards, vehicle size, OEMs' aftertreatment strategy (size, number of stages of the aftertreatment system and their physical positioning relative to the engine) and the spot prices of the materials.

Between three to seven grams of PGM are used in a standard catalytic converter. Platinum has better thermal properties in oxygen-excessive conditions like those found in Diesel aftertreatment systems and is therefore the material of choice in Diesel engines. Exhaust temperatures average about 200°C in a Diesel engine, while a gasoline engine exhaust temperatures achieve 500°C. The lower the temperature the more PGM content will be required to trigger and execute catalysis.

Both platinum and palladium can be effective in gasoline engine catalytic converters, so the choice is normally made based on material cost or OEM specific strategies. A three-way catalytic converter (which deals with carbon monoxide, nitrogen oxides and hydrocarbons) used in a vehicle with a gasoline engine uses about 1.8 grams of platinum, 1.6-1.7 grams of palladium and 0.2 grams of rhodium. Hybrid vehicles contain more precious metals than non-hybrids since the engine is engaged for less time, meaning that aftertreatment systems need to be effective at lower temperatures.



While total palladium production is only slightly higher than platinum's (200 tons vs 180 tons respectively in 2021), the demand of palladium for catalytic converters is about three times higher than that of platinum. Pricing pressure has built up for palladium due to continued market deficits, while platinum production runs surpluses. Rhodium is a byproduct of platinum production and its production level is dictated by the profitability that miners achieve in platinum production. For each unit mined, about 60% of the content is platinum, 30% is palladium and about 9% rhodium.

Up until October 2017, there were efforts to reduce platinum content as its price remained higher than palladium's, however the opposite is now true. As of March 17th 2022 platinum traded at around $34.5 while palladium traded at $88.47, while back in September 2017 both palladium and platinum were trading around $30 per gram. For reference rhodium's price was $634 per gram but it did spike to $925 per gram back in April 2021 amid supply concerns. The spike in PGM prices resulted in a spike of thefts of catalytic converters in several countries, particularly targeting older hybrid vehicles, with second-gen Toyota Prius built between 2004-09 attracting lots of attention from specialized criminal gangs since 2020.

Alternative sources – all eyes on South Africa, but swapping will take time

Assuming disruption to palladium supplies materializes due to targeted sanctions from Western countries on palladium or by “self-sanctioning” from stakeholders in the palladium supply chain or Russia's decision to halt exports, palladium customers cut out of Russia supplies will be scrambling to secure supplies in other locations or try to reduce demand.

South-Africa will be the first place to consider. It has been a bright spot for the platinum-group metals (PGMs) (palladium, platinum, iridium, osmium, rhodium, and ruthenium) with revenues from these materials surpassing those of coal. What's more estimates point to the country having some 90% of the world's known reserves for these metals. South Africa accounted for some 72% of global platinum global production, 40% of palladium and 80% of rhodium. South Africa mines supplied some 80 metric tons of palladium in 2021 vs. Russia's 74 tons in 2021, respectively 40% and 37% of world’s total. Flooding at two of Norilsk’s facilities in Russia hampered production in 2021, resulting in Russia no longer being the top manufacturer. Palladium production has increased in South Africa by 6.5 tons between 2020 and 2021, but that growth rate will not be enough to cover eventual further losses to Russia’s supplies. Securing alternatives beyond South Africa is equally difficult since Canada, US and Zimbabwe only produced 44 metric tons in 2021 and their outputs stagnated in 2020 and 2021.

Another source of palladium is recycling, which yields about a third of the global demand needs. About 90% of palladium can be recovered from used catalytic converters, by either melting the ceramic portion of the catalyst into a slag from which the PGM metal fraction is collected in a metal bath or through aqueous leaching agents. The recycling segment has benefitted from high raw material prices, as already noticed with increased catalytic converter thefts. There are limits to the number of converters that can be processed through this secondary network and refining capacity constraints are also emerging. With consumers holding onto their vehicles for longer for lack of new vehicle inventory, a dramatic expansion of palladium recycling to compensate for Russia supplies does not seem realistic.

Material swapping could provide some hedging but is not a full solution

OEMs and catalyst substrate suppliers tend to evolve their solutions to optimize PGM content based on prices as well as emission standards. The pricing situation that emerged since 2017 did result in more thrifting of palladium and PGM materials. For example, Toyota with its substantial exposure to PGM content due to its hybrid volumes, introduced a new flow adjustable design cell substrate in 2017. This substrate, jointly developed with Denso, allow a reduction by 20% of its PGM content and was first deployed in the Lexus LC 500h. BASF introduced a Tri-Metal Catalyst for petrol engines in 2020 to offer a solution to increasing palladium prices by reducing palladium content in favour of cheaper platinum. This was jointly developed with PGM producers Impala Platinum and Sibanye Stillwater.

Many other OEMs have been pursuing more close coupled catalytic converters (meaning placing the close-coupled metal can as close as possible to the engine) to reduce the time lag between engine switch on and the time at which the catalytic converter achieves full efficiency (so called “light off” time). The close-coupled substate drives some 70% of the PGM content because most of the emission abatement has to preferably happen in the upstream catalytic converter rather in the underfloor one.

The potential disruption to palladium supplies originating from war in Ukraine may suggest that swapping palladium for more platinum could be a viable route. OEMs have some flexibility to swap as much as 50% of the palladium content in Diesel applications with more platinum, however it is hard to completely remove palladium from the catalyst mix in light vehicle applications as it could result in substantial catalyst efficiency losses for current emission standards. In gasoline applications there is scope to reduce palladium usage, although this would require significant development work and would it difficult to outperform existing palladium-rhodium mixes. This is due to palladium outperforming platinum in most conditions, albeit by a small margin, which suggests that achieving similar emissions performance will require a greater platinum loading, even more so with increasingly closed-coupled set-ups.

Another avenue could be adjusting rhodium content. Everything else equal, increasing rhodium content brings more emissions performance benefits compared to increasing platinum or palladium, particularly in light of recent RDE (real driving emissions) and tightening of conformity factors. Rhodium usage is however also under scrutiny since this metal’s production is also in deficit and is considered a rather illiquid commodity with volatile pricing.

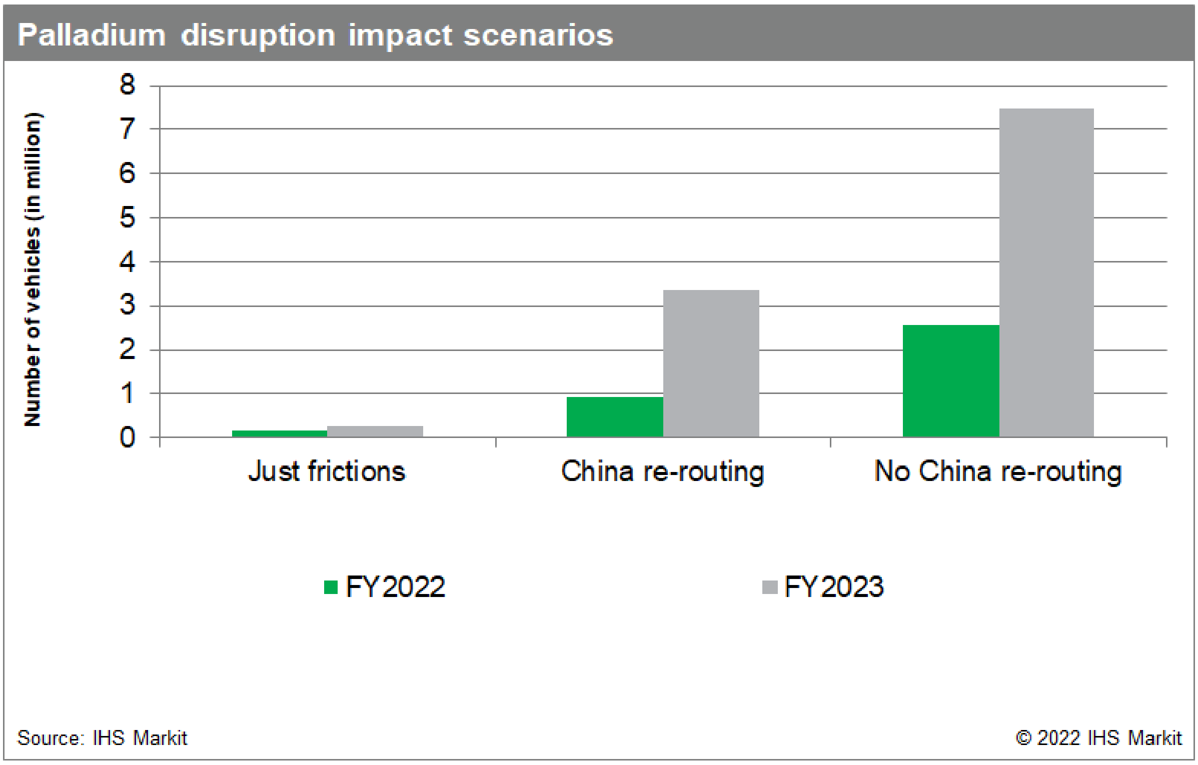
Re-certification requirements would hamper the shift in materials

Vehicle conformity certification processes implemented by the different countries are another barrier to changing catalyst substrate mix. Any major component that would impact emissions is considered part of the vehicle's local certification process, which in most jurisdictions takes between 18 to 36 months in normal circumstances. China is an exception thanks to a new vehicle conformity certification process introduced in March 2020, which allows changes to catalysts without compulsory certification schemes.

Several OEMs operating in China are thus exploring palladium thrifting measures, particularly in low PGM loading underfloor applications (as opposed to closed-coupled ones which require higher PGM loading). In other regions, such changes are still subject to lengthy re-certification processes, so the option to change substate mix is not immediately attractive. We suspect that unless OEMs are seriously concerned about an imminent disruption to their palladium needs, they will have limited appetite to fiddle with catalyst chemistry at a time when their engineering resources are being ramped up on battery electric vehicle development.

Auto production potential impacts range from modest disruption to severe supply constraints

The most likely scenario is that of a mild logistical disruption with frictions to trade and in general longer supply lead times ("just frictions" scenario). The impact from a volume perspective may be negligible (about 150K units in 2022 and 250K units in 2023). The reason is that most of the supply gaps can be managed by leveraging the fact that substrate suppliers like BASF, Johnson Matthey and Umicore have a diversified footprint with a more or less developed presence in South Africa. OEMs' catalytic converter inventory of about two to three months would act as a first line of defense and prevent disruption, however also in this scenario some pinch points may emerge, particularly at the tier-1 supplier level (canner). As the disruption works itself through the supply chain it may resulted in upwards pricing pressure.



A second scenario ("China-rerouting") is built upon the assumption that palladium is sanctioned by the US, Europe and Japan, but Chinese customers are still allowed (and feel comfortable to) purchase Russian palladium. In this case there is substantial disruption to OEM production, however the worst effects could be managed by combining a mild swapping of platinum usage with a reconfiguration of the supply chain.

Given that China's demand of the material (about 70 tons in 2021) is roughly in line with Russia's supply (74 tons in 2021), this may mean that technically there may be a path to balancing demand globally with customers able to source from Russia doing so and others resorting to other countries. However, such logistical reconfiguration will take some time to be put in place. OEMs' inventory of catalytic converters may last between eight to twelve weeks at current production levels and help soften the blow. Moreover, the supply chain lead time would probably give additional 6 months of funnel. Nonetheless it's hard to see how OEMs would be able to sail smoothly through such supply disruption. Under this scenario we some 0.9M units would not be produced in 2022 and as much as 3.3M in 2023.

A third, and more disruptive scenario, is one where Russia's supplies of palladium are included in the scope of sanctions and China-customers China-based palladium customers are not in a position to source from Russia due to sanctions ("no China re-routing" scenario). Under this "no China re-routing" scenario it will be difficult for other palladium producing countries to cover the auto industry's needs. In these circumstances we expect OEMs to pursue aggressive thrifting measures on palladium.

This will be more viable in China where regulation already allows faster adjustments to catalyst chemistry, however material swapping into platinum will not be enough to prevent severe disruption to car production. The real losses under this scenario would materialize in 2023 when some 7.5M vehicles might not be made due to palladium supply chain constraints. The reduction is milder in FY2022 with 2.5M lost.

Under all scenarios Europe would be the most exposed, followed by North America then Japan/Korea. This is confirmed by the fact that 40% of Russian exports of palladium went to Europe, while North America and Japan/Korea each absorbed about 24%.

Palladium disruption impact scenarios

Scenarios	Description	Volume impact
"Just frictions"	Frictions in palladium trade with longer logistic lead times	FY2022: 150K units FY2023: 250K units
"China re-routing"	Limited PGM material swapping reduces palladium demand. Within 12 months Russia to supply China demand and other countries to source elsewhere.	FY2022: 0.9M units FY2023: 3.3M units
"No China-rerouting"	Aggressive palladium thrifting. Further increase of recycling operations.	FY2022: 2.5M units FY2023: 7.5M units

Source: IHS Markit

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